PROCEEDINGS

OF

THE ACADEMY OF NATURAL SCIENCES

OF

PHILADELPHIA.

1900.

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THE ACADEMY OF NATURAL SCIENCES,
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1901.

THE ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA,
February 13, 1901.

I hereby certify that printed copies of the PROCEEDINGS for 1900 have been presented to the meetings of the Academy and mailed as follows :—

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" 97 to 128	"	April	16, 1900;	"	April	17, 1900.
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" 145 to 176	"	April	27, 1900;	"	May	1, 1900.
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" 449 to 484	"	September	26, 1900;	"	October	2, 1900.
" 485 to 500	"	October	31, 1900;	"	November	6, 1900.
" 501 to 532	"	November	6, 1900;	"	November	6, 1900.
" 533 to 580	"	November	10, 1900;	"	November	13, 1900.
" 581 to 596	"	November	22, 1900;	"	November	27, 1900.
" 597 to 612	"	December	11, 1900;	"	December	11, 1900.
" 613 to 628	"	December	13, 1900;	"	December	18, 1900.
" 629 to 644	"	December	14, 1900;	"	December	18, 1900.
" 645 to 676	"	December	29, 1900;	"	January	1, 1901.
" 677 to 692	"	January	28, 1901;	"	January	29, 1901.
" 693 to 740	"	February	5, 1901;	"	February	5, 1901.
" 741 to 772	"	February	9, 1901;	"	February	12, 1901.

EDWARD J. NOLAN,
Recording Secretary.

LIST OF CONTRIBUTORS.

With reference to the several articles contributed by each.

For Verbal Communications, Announcements, etc., see General Index.

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1900.

JANUARY 2.

MR. CHARLES MORRIS in the Chair.

Nineteen persons present.

The Council reported that the following Standing Committees had been appointed to serve during the ensuing year:

ON LIBRARY.—Dr. C. N. Peirce, Arthur Erwin Brown, Henry C. Chapman, M.D., Thomas A. Robinson, and Chas. Schaeffer, M.D.

ON PUBLICATIONS.—Thomas Meehan, Charles E. Smith, Henry Skinner, M.D., Henry A. Pilsbry, and Edward J. Nolan, M.D.

ON INSTRUCTION.—Uselma C. Smith, Benjamin Smith Lyman, Philip P. Calvert, Ph.D., Henry A. Pilsbry, and Charles Morris.

ON FINANCE.—Isaac J. Wistar, Wm. Sellers, Charles Roberts, John Cadwalader, and George Vaux, Jr.

COMMITTEE OF COUNCIL ON BY-LAWS.—Isaac J. Wistar, Theodore D. Rand, Arthur Erwin Brown, and Benj. Sharp, M.D.

The deaths of the following were announced:

Edward H. Williams, Thomas Mackellar and Charles P. Krauth, members; Elliott Coues and Henry Hicks, correspondents.

Mr. C. F. SAUNDERS made a communication on a botanical excursion to the Pine Barrens of New Jersey. The paper was presented for publication under the title "Through the Jersey Pines with Plant-press and Kodak."

JANUARY 9.

MR. CHARLES MORRIS in the Chair.

Twenty-eight persons present.

DR. THOMAS H. MONTGOMERY made a communication on recent studies of the Gordiaceæ (no abstract).

JANUARY 16.

The President, SAMUEL G. DIXON, M.D., in the Chair.

Twelve persons present.

A paper entitled "A Description of Microbdella biannulata, with Special Regard to the Constitution of the Leech Somite," by J. Percy Moore, was presented for publication.

The death of Carl Frederick Rammelsberg, a correspondent, was announced.

JANUARY 23.

The President, SAMUEL G. DIXON, M.D., in the Chair.

Nineteen persons present.

A paper entitled "Mallophaga from Alaskan Birds," by Vernon L. Kellogg and Shinkai I. Kuwana, was presented for publication.

JANUARY 30.

The President, SAMUEL G. DIXON, M.D., in the Chair.

Fifteen persons present.

The following were elected members:

Col. William E. Barrows, S. Mendelson Meehan, Catharine G. Dixon, William R. Reineck, and Florence Bascom.

The following were ordered to be published:

REPORT ON THE BIRDS AND MAMMALS COLLECTED BY THE McILHENNY EXPEDITION TO PT. BARROW, ALASKA.

BY WITMER STONE.

Through the courtesy of Mr. E. A. McIlhenny, I have been entrusted with the preparation of a report on the splendid collection of birds and mammals obtained by him during his sojourn at Point Barrow, August, 1897, to August, 1898.

It was originally intended to defer the publication of this paper until the issue of a general report of the expedition which Mr. McIlhenny has in view, but for many reasons we deemed it best to present it at once.

It will be understood that the following pages consist entirely of a study of the skins, and that Mr. McIlhenny's field notes are reserved for the subsequent report.

The material obtained is the finest yet brought from the Arctic regions, and the series are so full that the molts and variations of plumage in many of the birds, that have not previously been understood, are beautifully illustrated.

For convenience of reference, it should be stated that the expedition was in the North Pacific, July 5–22, 1897; at King's Island, July 23; Port Clarence, July 24–28; Point Hope, July 31–August 1; Cape Lisburne, August 1; Wainwright Island, August 3, and Pt. Barrow, August 10, 1897, to August 17, 1898.

BIRDS.

The collection of birds comprises 1,408 specimens, representing sixty-nine species. Of these nine were obtained on the northward trip at points south of Pt. Barrow, leaving sixty as the number actually secured at that locality.

Six species observed by Lieut. Murdoch[1] were not obtained, though they may have been seen, *i. e.*, *Olor columbianus*, *Numenius borealis*, *Tringa subarquata*, *Junco hyemalis*, *Clivicola riparia* and *Saxicola œnanthe*.

On the other hand, thirteen species were obtained which are not

[1] Cf. *Report of the Internat. Polar Exp. to Pt. Barrow, Alaska*, Washington, 1885.

recorded in Murdoch's list, *i. e.*, *Asio accipitrinus McIlhennyi*, *Contopus richardsonii*, *Calcarius pictus*, *Ammodramus sandwichensis alaudinus*, *Dendroica coronata*, *Budytes flavus leucostriatus*, *Hylocichla aliciæ*, *Rissa tridactyla pollicaris*, *Larus glaucescens*, *Phalacrocorax pelagicus robustus*, *Oidemia deglandi*, *Calidris arenaria* and *Limosa fedoa*.[2] One species, *Eudromias morinellus*, obtained at King's Island, is new to the North American fauna, and another, *Asio accipitrinus McIlhennyi*, seems to represent a new geographic race.

Gavia adamsii (Gray)—Yellow-billed Loon.

Twelve specimens of this species were obtained, ten of them were adults in nuptial plumage taken on the following dates: Males—June 30, 25, June —, 1898; September 25 (2), August 28 (2), August 30, 1897; Females—June 27 and July 21, 1898. None of these show any trace of molt, except No. 671 (September 25), in which the neck feathers are being lost.

A young bird, taken June 14, is in full juvenal plumage; white on the breast, belly and throat; lower neck dusky like the sides of the neck, above general color gray, feathers mostly blackish at the base with broad gray edgings, crown and back of neck gray sides with feathers tipped with brownish.

One adult specimen, September 29, has just completed the molt, and the new wings are only half grown: above glossy black with a tinge of green appearing "scaly" in certain lights, top of head and back of neck black, feathers on sides of neck slightly tipped with black.

The flight feathers in the Loons are evidently lost all at once, as in the Ducks.

Gavia pacifica (Lawr.)—Pacific Loon.

A series of forty-nine specimens. Twenty-five males—July 5, '98; July 11, '98; August 25, '97 (2); August 20, '97 (2); August 24, August 26, August 30 (8), August 31 (9), and twenty females—August 24, '97, (2); August 30 (5), August

[2] Only twelve birds were obtained in August, 1898, and only six mammals, *i. e.*, *Gavia adamsii*, *Dafila acuta*, *Tringa bairdi* (4), *T. subruficollis*, *T. canuta*, *Phalaropus lobatus* (3), *Budytes flavus leucostriatus* and *Spermophilus empetra* (6), so that with the above exceptions all August to December specimens were obtained in 1897 and all January to July specimens marked Pt. Barrow in 1898.

31 (11), September 16 and 20—these are all in more or less worn nuptial dress, some have a few new pinfeathers just showing their points, but molt is indicated more by the extreme looseness of the old body feathers than by the appearance of new ones. There is no trace of molt in the flight feathers. Four specimens are in full winter dress, though the primaries still show the traces of the sheaths at their bases.

There are no young birds.

Gavia lumme (Gunn)—Red-throated Loon.

A series of seventeen specimens.

Four are downy young taken August 3, at Wainwright Island. Twelve are adults: Males—August 15, 20 (2), 26, 30 (2), September 17, 1897, and females—August 3 (2), 26, 27, 30, 1897.

These show no molt whatever, though several are very much worn, especially No. 360 (August 26) and No. 776 (August 30). One female, September 17, has completed the molt, though the primaries still retain portions of the sheaths.

Uria troile californica (Bryant)—California Murre.

One specimen from King's Island, July 23, 1897, is referable to this race Measurements: wing 8 ins., length of culmen 1.62 ins., depth of culmen .55 in.

Uria lomvia (Linn.)—Brünnich's Murre.

Seventeen specimens represent this species. A pair taken May 23 are in full nuptial plumage. Twelve others (July 31, one female; August 1, six males and five females) are similar, but much worn, with the tips of the primaries often distinctly bleached.

A female, August 30, is molting. The entire series of remiges have been lost simultaneously, as in the Ducks, and the new feathers are just showing beyond the edge of the coverts. The back is about half molted, old feathers showing bleached brownish tips, the new ones jet black.

Two young in the down, July 28, 1898, are uniform dark plumbeous above, lighter below.

As the question of the relation of the Pt. Barrow birds to *U. l. arra* naturally presents itself I append measurements of the wing in a series of fourteen specimens. Seven males, 8.15–9 ins., average 8.77; seven females 8.45–8.75, average 8.60.

Cepphus mandtii (Licht.)—Mandt's Guillemot.

A most interesting series of twenty-seven specimens was obtained. Beginning with the late summer specimens, these may be described as follows:

August 30, old breeding bird, very much worn and with wing feathers much bleached. A few white feathers on the breast and neck, but no further molt.

Ten specimens, August 15 (2), August 21, August 28, August 30 (4), August 31, September 15, have lost all or nearly all the remiges, they evidently fall almost simultaneously, but the primary coverts persist. This series shows varying amounts of new white feathers, both above and below. One taken August 15 shows none at all, and in none is there more white than black.

Four specimens, September 17 (2), September 7, September 8, show the new remiges about half-grown, with the body feathers about half white and half black.

Two specimens, March 10 and 11, are in adult winter plumage, pure white below, interscapulum black with white edges to the feathers.

Two others, March 10 and 28, illustrate the spring molt of the body plumage; about one-half of the black feathers have appeared.

Eight young (birds of the year), September 23, January 11 (2), Februay 6, March 10, March 24, March 28, March 30, exhibit much variation in the amount of black on the head and black spots on wing coverts. All have narrow black tips to white feathers of the abdomen. None of these birds show any trace of the spring molt which was well under way in the adults at the time that most of these were taken.

Lunda cirrhata Pall.—Tufted Puffin.

Two females, August 1. Cape Lisburne.

Fratercula corniculata (Naum.)—Horned Puffin.

Four males and four females. Cape Lisburne.

Cyclorrhynchus psittaculus (Pall.)—Paroquet Auklet.

Three females, July 23. King's Island.

Simorhynchus pusillus (Pall.)—Least Auklet.

One specimen, secured August 30.

Stercorarius parasiticus (Linn.)—Parasitic Jæger.

Twenty-two specimens represent the dark phase of plumage: 1897—July 24, August 20, August 24 (2), August 30 (3), August — (2), September 9; 1898—June 1, June 17 (2), June 27 (2), July 7, July 8 (4), July 9 (2).

These are very uniform in plumage and exhibit no molt. Two are slightly mottled below with light crossbars, and two others have barred under wing coverts, but from the worn condition of the plumage they appear not to be birds of the year.

The light phase of plumage is illustrated by nine specimens: 1897—July 24 (2), August 20, August 24, August 30 (3), September 9 (2). These show no variation.

Stercorarius longicaudus Vieill.—Long-tailed Jæger.

Fourteen specimens secured 1898: June — (2), June 11 (2), June 17 (4), July 2, July 8, July 13 (4).

These are all quite uniform, except one male taken July 13 (No. 1,302). This is slightly mottled across the breast, the under wing coverts are barred with white and black, and some of the tail coverts similarly barred, the back is sprinkled with dull brownish feathers. Some of the feathers forming the white collar are barred with dusky and some of those on the head have whitish edges. All the feathers are worn and the bird has evidently passed the winter in this dress.

Stercorarius pomarinus (Temm.)—Pomarine Jæger.

The light phase of plumage is represented by a series of forty-six specimens: 1897—July 24, August — (5), August 14 (8), August 15 (2), August 20 (10), August 24 (2), August 30, August 26, August 27; 1898—May 23 (3), May 30, May 31 (6), June 2, June 4, June —, July 3, July 8.

Twenty-nine are in the dark phase: 1897—August 20 (2), August 30 (4), September 20; 1898—June — (3), June 6, June 8 (2), June 11, June 12, June 14 (3), June 23, June 28 (2), July 3, July 8 (7).

There are also twelve young in the down, making total of eighty-seven specimens.

While the August specimens of both phases are molting some of the body plumage, there is no trace of molt in the flight feathers. The variations of plumage exhibited are as follows: Of the white series twelve have the under tail coverts barred and the lower belly and thighs more or less white, the lightest of all (No. 208, August 15, 1897) having only a trace of dark shading on the belly and only the tips of the under coverts black; there is scarcely any black on the breast and the bars on the sides are restricted to the sides of the chest, there is a broad white collar on the hind neck and considerable white on the upper tail coverts.

No. 864, male, May 23, 1898, while uniform dusky on the lower belly, is even whiter on the breast than the last specimen described. There are no black spots on the breast, and only slight traces on the sides of the chest; and no white on the tail coverts either above or below.

Other specimens have the whole breast very broadly spotted. Two (1,240 and 1,211, July 8 and 3, 1898) have the under coverts barred; the back of the neck is black with white bars, and the upper tail coverts marked with white. Throat streaked longitudinally, breast and sides strongly barred, and lower belly dusky mixed with white. The only really white area being in the centre of the abdomen and even here the tips of the feathers are dusky. In the dark series, some specimens are uniform deep sooty, with the head glossy bluish black; others have a golden tinge to the collar; some have the breast feathers obscurely barred, and tipped with purplish or buff.

One bird of the year (September 20, 1897) has the feathers above tipped with pinkish buff, while those of the lower surface, including the under tail coverts are transversely barred with pink and dusky, the bars being very broad and distinct on the coverts.

The downy nestlings may be grouped in three series:

A. Average length 5 ins. July 6, July 10, July 27 (3).

Almost uniform plumbeous; down long like that of a young gull.

B. Average length 8 ins. July 10, July 27 (2).

Similar, with remiges and some body feathers just sprouting.

C. Average length 12 ins. Wings about one-quarter grown, banded feathers on back and breast, but body still well covered with down.

Larus barrovianus (Ridgw.)—Pt. Barrow Gull.

A study of the fine series of thirty-seven specimens confirms Mr. Ridgway's views of the changes in plumage which this bird undergoes.

The series may be grouped as follows:

(A.) Five birds of the year are mottled above with gray, pale buff and white, with more or less gray on the under parts. These specimens are as follows:

578. September 17, wing 16 ins., plumage very dark.
579. September 17, wing 18.40 ins.,
648. September 23, wings 17.25 ins.,
651. September 23, wings 17.50 ins.,
665. September 28, wings 18.20 ins.,

(B.) Nine specimens represent adult birds in the first breeding season. These are nearly white with some buff and dusky mottled feathers on the back and with mottled wing feathers. The dark feathers are not remnants of the juvenal plumage, as would at first be supposed, as fall specimens show them still in the pinfeather sheaths just like the white ones.

The following are in this plumage: June 1, August — (3), September 5 (5). The September specimens are molting the remiges, and the new feathers are white like the old ones, and not gray like those of old adults!

(C.) Four specimens, older birds, or perhaps birds of the same age as the last, but for some reason more advanced in plumage, have the backs partly pearl-gray like fully mature specimens, but are otherwise like the last lot.

July 24.—Molt of wings nearly completed.

Another is very pure pearl gray above, but with the new plumage there are a number of the sooty feathers characteristic of the young bird!

August 20.—Very light above; molt of wings advanced to second primary, old and new remiges pure white, color below dark.

September 5.—Molt advanced to first primary.

(D.) Sixteen specimens are in the normal adult plumage, with no dusky feathers, except a few streaks on the heads of two specimens (September 5). These were taken June 2, June 17, July 24, August 1, August 11, August 24, September 5 (3), September 12, September 17 (2), September 24 (2), September 25, October 5.

(E.) Three others are very peculiar and are perhaps very old individuals. Two females, taken June 8, are pure white all over, with just a tinge of pearl on the back and middle wing coverts.

Another female, August 27, is similar, but is darker below and has slight dusky streaks on head and tail.

Three young in the down, July 13, are grayish white mottled obscurely on the back with plumbeous, face and head distinctly spotted with dark plumbeous.

The plumages of this species are very puzzling, the birds of the year (A), and the normal adults (D), with plain pearl mantle, pure white bodies and gray primaries, are easily picked out. There remain, however, a number of others which may be grouped in three lots: (B) White birds with no pearl mantle, but with many dusky feathers above similar to those of birds of the year, and with pure white primaries ; (C) Similar to the last, but with a more or less perfectly developed pearl mantle; (E) Pure white birds with only a trace of pearl and with white primaries.

Individuals of (B) and (E) occur in the breeding season along with normal adults (D), so that it seems likely that (B) and (C) are breeding birds of the first year, differing individually in the state of advancement of their plumage, or perhaps they represent birds of one and two years of age. The curious point is that those which are molting are acquiring white primaries like those they are shedding, instead of pearl gray ones like those of the adult!

(E) may be regarded as extremely old birds or perhaps abnormal specimens, differing in their very pale plumage and white primaries. The possibility of (B), (C) and (E) representing another species is apparently not worthy of consideration.

Larus nelsoni Hensh.—Nelson's Gull.

One male specimen, taken September 5, has the head streaked with dusky, the mantle plain pearl, wing molt advanced to the outermost primary, which has not yet been cast.

Larus glaucescens Naum.—Glaucous-winged Gull.

One male secured July 24 at Pt. Clarence is in the molt. It has a very dark mantle ; four outer primaries are the dusky ones of the first year, the rest having been renewed, but only partly grown. The tail is dusky.

Another specimen, a bird of the year, is doubtfully referred to this species. It is a male secured August 15, and is in the molt. The plumage above is very dark for a gull of this sort, much darker than any juvenal *L. barrovianus*, and exceedingly varied with pinkish, dark brown and white, a few pearl-gray feathers also appear on the back. Below dusky. Old primaries dull brown, probably bleached, new ones deep black, inner ones grayish with black ends and light tips.

Xema sabinii (Sab.)—Sabine's Gull.

Ninety-four specimens representing only adults and birds of the year, with no molting specimens, are in the collection. Birds of the year were taken August 14 (2), August 15 (4), August 20 (3), August 24, August 30 (7), August 31, September 7, September 8, September 9 (28), September 17. Full-plumaged adults, June 23 (3), June 27, July 31, August 3 (2), August 14 (3), August 15 (4), August 20 (3), August 30 (3), September 9 (17).

The above mentioned adults are practically identical and though August birds exhibit some new feathers, with sheaths at their bases, there is no general molt, and no trace of it in the wings.

Eight other specimens, taken August 3 (5) and August 15 (3), are probably breeding birds of the first year. They show a considerable variation, one extreme having white feathers scattered all over the gray, especially on the throat, and the black collar broken with white; the other extreme having the throat entirely white, forehead and cheeks mainly so, nape spotted with gray, and a broad blackish collar on the hind neck.

These birds look exactly like molting specimens, but examination shows no trace of molt and all the feathers are in exactly the same condition. It is such series as this that have frequently misled ornithologists into the belief that the feathers were actually changing color, while, as a matter of fact, the pied plumage, often different in every individual, is nevertheless permanent and unchanged from the time it is assumed until the next molt.

Rissa tridactyla pollicaris Ridgw.—Pacific Kittiwake.

The series resolves itself at once into three lots, nestlings, birds of one year, and those of more than one year. There are none in juvenal plumage. Eight downy specimens taken at Cape Lisburne, August 1, 1897, are pure white below, and on the head and wings; back and rump gray.

The bird in the first breeding season, as I take it, is grayish on the head, and has a brownish collar on the hind neck, and brown feathers all along the wing from the bend to the extreme tertials. The primaries are also browner than in the adult, the white on the outer ones being restricted to the inner part of the inner web.

A specimen taken July 9 illustrates this plumage, and is just starting to molt. Nine others, August 15 (4), August 24, August 30 (4), illustrate the assumption of the full winter adult plumage.

Five specimens, June 2, July 25, July 27 and August 1 (2), are in adult nuptial plumage, with pure white heads while seventeen others, August 1, August 14, August 15 (3), August 20 (3), August 24, August 30 (7), August 31 are old birds in annual molt.

One very curious specimen taken August 14 is very pale, being much lighter than the ordinary adult. The wings also are much lighter and there is no brown or black on any but the two outermost primaries, and there only on the outer web. This is an exactly parallel case with the two white *Larus barrovianus*, and is probably a very old bird, or an abnormal albinistic specimen.

Pagophila alba (Gunn.)—Ivory Gull.

One male in nuptial plumage was secured June 2, and seventeen adults just completing the molt, August 28 (2), August 30 (2), August —, September 1 (11), September 17.

Three young of the year agree well with Ridgway's description (*Manual N. A. Birds*), but the sides of the face, throat and top of the head are somewhat spotted with gray. These were taken September 7, 16 and 25.

A note on the label of a September specimen (482 ♀ juv.) states that the breast and abdomen were rose-tinted.

Rhodostethia rosea (Maegil).—*Ross's Gull.*

Three specimens of this rare bird were obtained: No. 501, Sep. 9, 1897, a young male like the second plate in Murdoch's Report; No. 649, Sep. 23, 1897, an adult male in winter plumage, like the first plate in the above work, but with a concealed black collar; and No. 1,245, June 9, 1898, an adult male in full nuptial plumage, bright pink below, white on the head and neck above, and a delicate black collar encircling the neck.

Sterna paradisæa Brünn—Arctic Tern.

Ten adults taken June 23 (3), July 24, 27 and 31, August 14 (2), August 30, September 7, are quite uniform in plumage and show no signs of molt whatever. This seems to render it doubtful whether these birds molt at all before their autumnal migration. Birds of the year are represented by a beautiful series representing all stages from the recently hatched nestling to the fully plumaged fall bird. The downy young (July 10) is mottled above with dull black and buff, with two well-marked longitudinal patches of the former on the head. The throat is dark plumbeous and the rest of the lower surface snowy white.

Eight specimens illustrate the growth of the young bird until the flight feathers are about half-grown and the plumage of the back and breast about half attained, the head and throat still remain covered with down, true feathers showing only on the ear coverts. The throat at this period is much lighter and the down on the belly is not so white (series secured July 26 (4), July 27, August 21 (2).

The full-grown bird of the year is represented by six specimens, August 14, August 30, September 7 (3), September 9. The youngest of these has the feathers of the back broadly bordered with dull black and buff, exactly the shades of the downy young, while below the neck is tinged with buff.

These tints all wear away by abrasion and bleach out as the bird grows older, and the later specimens show very indistinct plumbeous and whitish borders.

Diomedia nigripes Aud.—Black-footed Albatross.

Eleven specimens were secured July 5 and 11, five males and six females.

The principal variation exhibited by this series is the presence of buff edgings to the feathers on the belly of many of the specimens, and the pied appearance of the upper surface owing to the irregular mingling of feathers of different ages and different degrees of bleaching. One specimen is nearly white on the lower belly and between the legs.

Seven of the birds are molting the primaries; four of these are progressing in the usual way, the innermost quill being renewed first, but the others exhibit an exceptional order of molt. In Nos.

2 and 10 the second, third and fourth primaries are only partly grown, the old feathers having been but recently cast, but the first primary (outermost) and the six inner ones are of the old plumage. In No. 3 the fourth, fifth and sixth feathers have been renewed and are only half grown, but the others have not been molted, while in No. 5 the first and second are renewed, but none of the others. Furthermore, they are full-grown in one wing and only partially so in the other.

Branta nigricans (Lawr.)—Black Brant.

A series of seventeen specimens.

Five breeding birds, June — (2), June 6 (2), June 5, are brownish black, lighter than fall birds. Feathers mottled below with pale edgings and much worn, especially on the sides. One example seems younger than the others, and has whitish tips to the wing coverts. It is probably a one-year-old bird. Three fall specimens, August 24, September 17, September 20, are blue black below with no lighter edgings. A scattering of old brownish feathers remains on the upper parts, but the molt is apparently over. One bird of the year, August 30, has white tips to the wing coverts and feathers of the lower surface, while the general coloration is grayish, and there is no white collar.

Eight downy young, July 10, are rather light plumbeous, paler in the middle of the abdomen and nearly white on the throat. There is a rather obscure dark breast band, and narrow black and white ring on hind neck, while the top of the head is blackish.

Chen hyperborea (Pall.)—Lesser Snow Goose.

A male and female taken June 30 are in very worn plumage, the tips of the primaries in the female being bleached to a light brown, though the covered portions remain jet black.

Anser albifrons gambeli (Hartl.)—White-fronted Goose.

Two specimens were obtained. A female, June 3, is in good plumage with a few black feathers on the lower parts. Another, June 14, is very much worn, but otherwise similar.

Merganser serrator (Linn.)—Red-breasted Merganser.

Two males secured July 27, at Pt. Clarence, are of much interest, being in the summer molting plumage.[3] They are like the

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[3] See Stone, *Proc. A. N. S.*, 1899, p. 467.

nuptial plumage except the head and neck, which resemble the dress of the female; crest dull brown, breast dull gray, many of the black head feathers and pink and black breast feathers of the nuptial plumage still remain, but are easily brushed off, being just ready to drop. The flight feathers have not yet been molted.

Somateria v-nigra Gray—Pacific Eider.

A series of twenty-five specimens beautifully illustrates the plumage changes of this species. The females include three adult breeding birds, May 31 and June 3 (2), and five worn breeding specimens, August 24, August 30 (4).

In the latter the tips of the wing feathers are bleached almost white, while the feathers of the belly are sooty with the bars nearly obliterated. These may possibly be new feathers as they are much less abraded than those of the breast where the bars remain distinct.

A number of the wing coverts and scapulars seem to be renewed at a spring molt, as in the June birds some are full and dark while others, side by side with them, are pale and worn. The same difference can be detected in August specimens, where the former feathers are slightly worn and the latter are exceedingly abraded, only the dark central portion remaining. These feathers may, however, possibly persist through the winter from the last year's plumage, as indicated below.

One specimen, taken September 24, has completed the molt, and the new wings are about half grown. A few old feathers remain on the breast. The belly is plumbeous and very mottled and irregular in appearance as if only half through molting. No barred feathers are to be seen such as constitute the spring plumage, so it is probable that the molt of the belly is the last to be completed.

The male series consists of eight breeding specimens, May 31 (2), June 2, June 3 (5), and seven birds in the transition plumage with wings fully molted and the new feathers half grown; these were taken September 17, September 23 (5) and October 6. One other, August 20, retains the old wing feathers, and has not quite acquired the full transition plumage on the head, remains of the nuptial feathers being seen on the lores and crown.

The last of the series, October 6, shows the new winter plumage supplanting the dull transition dress. The breast is nearly molted, but is still flecked with brownish feathers, while the new green feathers of the face may be seen just bursting from the pin-feather sheaths.

The transition plumage is as follows:

Belly and wings as in nuptial plumage. Head and neck dull brown, streaked with black, with indistinct lighter areas on the head, breast mottled, feathers generally white in centre, black at tip and barred with brown, some all brown and some all white. Scapulars blackish or brownish, varied with white.

Somateria spectabilis (Linn.)—King Eider.

The King Eider is represented by a series of 107 specimens.

Twelve are downy nestlings, uniform plumbeous, except for a lighter area on each side of the face. There is no marked difference in the plumage of the young Eiders, though each of the four species can be told at a glance by the feathering at the base of the bill, this character being quite as distinct as in the adults.

Three others, August 1 (2), August 18, have the down about half replaced by the juvenal plumage.

The young of the year include fifty-one specimens, August 30, September 5, September 6 (4), September 8 (3), September 17 (39), September 24 (3). These exhibit no variation except that the males are less buff below, with the tips of the feathers inclining to white, while all the breast feathers have distinct white cross-bars as well as black ones.

Of the adult females there are six in full nuptial plumage, taken May 23; three in worn plumage, August 1, August 11, August 24, and six which exhibit more or less molt in the body plumage. None are renewing the flight feathers, which are often exceedingly worn and bleached. These were taken August 10, August 24 (3), August 30, September 17.

Of the adult males twenty-three are in full nuptial plumage, May 23 (15), May 26 (4), May 27 (3), June 1 (1). The last is peculiar in having the V on the neck open in front, forming two separate streaks. Two later specimens, August 24 and 30, illustrate the change to the transition plumage. The breast is speckled all over with the new brown white and black barred feathers, the interscapulum is largely speckled with black, and the head and neck are being covered with dull brown black-tipped feathers. The pattern of the green and blue areas, as well as the black V are still clearly apparent, though the feathers which remain on these parts are very easily displaced.

Another specimen, August 24, has fully assumed the transition plumage, but in none of the three has the molt of flight feathers begun, they are very much worn and bleached.

Arctonetta fischeri (Brandt)—Spectacled Eider.

Thirty-six specimens represent this species. Five downy young taken July 28 are plumbeous with the spectacle-like mark clearly indicated in dull buff.

Nineteen are birds of the year, taken September 8 (7), and September 17 (12). They are black above, feathers broadly edged with fulvous buff, except sometimes on the rump. Head and neck narrowly streaked with black and buff, with throat and large eye patch plain ochraceous; below vinaceous buff finely vermiculated and irregularly banded with blackish.

They differ from the adult female in being irregularly mottled below instead of distinctly cross-barred, and in the lack of light cross-bars on the rump.

The adult female is represented by five specimens, one June 2, in full nuptial plumage, the rest August 30 and September 8 (3), showing much wear and bleaching and some renewal of body feathers, but no molt on the wings.

Of the adult male there is a series of seven in full nuptial dress, May 31, June 1, June 3, June 22, June 27 (2), June —.

These vary much in the depth of green between the eye and the bill, some being very pale and some brownish olive.

One interesting specimen taken September 17 is in the transition plumage, and the new flight feathers are just full grown. No similar specimen has ever been described so far as I am aware. The head and neck are gray streaked with black, front and cheeks whitish, eye spot gray, centre of throat white, more or less brown black-barred feathers on the breast, back and scapulars largely gray, some white beneath the shoulders. Lower parts gray.

Eniconetta stelleri (Pall.)—Steller's Duck.

Sixty specimens are contained in the collection. Twelve are downy young taken July 28. They are much darker than the young of the other Eiders.

Twenty-three are birds of the year, August 30 (14), September 4 (4), September 5, September 8 (2), September 17, and one without data.

They have no black on the throat, lower parts are transversely barred with black and chestnut, the individual feathers being white at the base, with a black band and chestnut tip. The black band is sometimes transverse, sometimes curved, and sometimes forming an angular V-like spot; this variation causes much difference in the appearance of the plumage of different birds.

The adult female is represented by nine specimens, June —, June 9, August 11, August 26 (5), August 30. They show much variation in the markings of the under surface, and the late August specimens exhibit molt in the body plumage, but not in the flight feathers.

Thirteen adult males in nuptial plumage were taken as follows: June 25 (4), June 27 (2), June 22 (2), July 2, June 9 (2), June 13 (2).

One peculiar male, June 25, is exceedingly worn; speculum dull brown without a trace of blue; whole plumage dull and mottled, eye region and cheeks whitish, as is also the breast. Throat black but not glossy. This bird appears like a bird of the year which never molted properly in the spring.

Clangula hyemalis (Linn.)—Old Squaw.

Forty-four specimens.

Eight downy young collected July 28, to illustrate variation with age may be grouped in three lots.

A. Throat and belly white, with a brownish breast band. Glossy black above, with a brownish cast caused by mixture of brown filaments. A black mark below and behind the eye.

B. Browner and more faded, abdomen darker owing to plumbeous color of later down.

C. Whole lower surface with strong plumbeous cast, quills not yet sprouted.

Ten birds of the year are in the familiar plumage representing that stage, September 8, September 16 (2), September 24 (7).

Adult females were taken, June 8 (2), July 31, September 8 (2), September 24, October 5. The fall specimens have nearly completed the molt. The October bird has the head nearly pure white with very obscure crown and cheek patches.

There are nineteen adult males. Of these, five are in nuptial dress, May 31, June 2, June 8 (3). One of these has the top of the head white, some black, some intermediate.

Three taken August 24 are in the molt. The wings are nearly full grown, and the tail about one-half; the sides of the body are deep pearl gray.

Six others, August 24, August 30, September 8 (3), September 17, are similar, but the neck and breast are more mottled with new feathers and the pearl gray scapulars are beginning to appear. Other specimens are as follows:

September 17 and 24 (3), scapulars all pearl gray, head and neck nearly white, except cheek patch.

October 8, head and neck almost pure white, no cheek patch.

These species apparently acquire no "transition" body plumage during the molt of the flight feathers, as is the case with many ducks.

Oidemia deglandi Bonap.—White-winged Scoter.

One male in full nuptial plumage, taken June 22.

Phalacrocorax pelagicus robustus Ridgw.—Violet-green Cormorant.

One male specimen taken June 8, at Pt. Barrow. It is entirely destitute of white plumes.

Grus canadensis (Linn.)—Little Brown Crane.

Two specimens, still in worn, very rusty plumage, taken June 25.

1,163 — length of culmen, 3.60; wing, 17.75 inches.
1,164 ♂ length of culmen, 3.50; wing, 16.50 "

Crymophilus fulicarius (Linn.)—Red Phalarope.

A series of eighty-five of these birds is in the collection, which illustrates very nicely most of the stages of the molt.

Twenty adult males in nuptial plumage obtained June 3 (3), June 4 (13), June 7 (2), June 8, June 23, exhibit considerable variation in plumage. Not a single specimen is uniform rufous beneath, though one (1,158) is very nearly so. The majority have a considerable sprinkling of white feathers, and in several there are more white than rufous. The lightest specimen has some gray feathers scattered over the back, while the throat and sides of the face are white. Others have these parts more or less gray, while the back is uniformly streaked with black and buff. The darkest of all has the sides of the face chestnut rufous and the gray throat much restricted. These light feathers are not indications of molt, but were evidently acquired at the same time as the rest of the plumage.

The adult female is represented by a series of eleven taken June 4 (10), June 23. There is much less variation than in the male, and a greater tendency to uniform coloration below, four of the specimens being without any white.

Two males, taken July 31, and five secured August 3 are molting the body plumage, and show all gradations of gray mottling above and white beneath, while a female (171), taken August 14, is entirely gray and white, except a few rusty feathers on the belly and vent, and striped ones on the rump. In none of the above males is there any trace of molt of the wing feathers, and in all but one they are in good condition, not perceptibly more worn than in the June specimens.

In the female the three outer primaries are distinctly fresher and darker than the others, and the middle pair of rectrices are being renewed, as well as the three inner primaries on one wing.

In another molting male (285), taken August 20, the same difference is seen in the outer primaries, and, furthermore, the fresher feathers still have the sheaths around their bases, showing that they have just been renewed, and the same is true of the three innermost primaries. This molt is, however, only seen in one wing, the other retaining the old feathers throughout. In body plumage this bird has nearly finished the molt.

Birds of the year are illustrated by eight downy young, July 3 and 4 and 27 (4), and 37 in the juvenal plumage, taken July 24, August 3 (4), August 10, August 24 (16), August 26 (10), August 30 (2), September 5, September 8 (2). Those taken July 24 and August 30 still retain traces of down about the head, while the later ones all show more or less gray feathers above, though none appear to have completed this molt. There is no molt in wing or tail, and the long black buff-edged tertials seem to be retained through the winter, which thus serve as an easy distinguishing mark in separating them from winter adults in which these feathers are gray. The dark tinted feathers across the breast also serve to distinguish them.

Phalaropus lobatus (Linn.)—Northern Phalarope.

Three specimens were obtained, an adult male in full nuptial plumage, June 15; a very much worn specimen, July 27, and a bird of the year, July 28, which still retains a considerable amount of down about the head. Three full-grown birds of the year, August 7 and August 17 (2), 1898.

Arenaria interpres (Linn.)—Turnstone.

Three typical breeding birds were taken respectively May 29 (♂), May 31 (♀), June 2 (♂). Two others secured July 11 (♂ and ♀) are more worn and the female is beginning to renew the plumage of the back, the new feathers being exactly like the old ones. Unfortunately, no later adults were obtained.

A large series of young are in the collection. One secured June 4, 1898, at Pt. Barrow, and two July 24, 1897, at Port Clarence, are still decidedly downy about the head and neck, though otherwise the juvenal plumage is well advanced.

Fourteen others are practically uniform and are in full juvenal plumage, taken as follows: August 10 (5), August 13 (2), August 14 (2), August 20, August 26, August 30, September 4 (2).

Eudromias morinellus (Linn.)—Dotterel.

One specimen taken at King's Island, July 23, 1897, an adult female, just beginning the molt. The three outer primaries still remain, and but little body molt is yet apparent.

This is the first record of this species for North America; in fact, it seems to be very rare even on the Asiatic coast. One was recorded by Cassin from Japan, but Mr. Swinhoe, who reviewed his paper in *The Ibis*, 1863, p. 444, seriously doubted the correctness of the identification, with no reason whatever. The result is, that wherever the record is cited it is queried. The specimen referred to is still preserved in the Academy's collection, and is unquestionably a Dotterel in first winter plumage.

Squatarola squatarola (Linn.)—Black-bellied Plover.

Only six specimens were obtained, but they are quite interesting as throwing some light on the vexed question of the molt in this species.

An adult male and female, obtained June 26, have lost the two innermost primaries and are renewing the plumage of the back, the new feathers being gray edged with whitish. Two other males, July 26, 1898, are in about the same condition. Another specimen, taken August 20, has a considerable number of similar feathers on the back, but there is no sign of molt and the primaries are so worn as to make it extremely unlikely that they were recently acquired. Another bird in the Academy collection, No. 34,545, Buckland river, Alaska, August 1, 1895, has gray feathers scattered through the plumage of the back, but no other trace of molt, and is very close to some of Mr. Brewster's black-bellied fall specimens, from the New England coast, which were courteously loaned to me for examination.

All the birds above mentioned have black bellies and show no indication of shedding this plumage, although some of them (notably some in Mr. Brewster's series) have acquired some white feathers. These may, however, have been similarly colored in spring as we often see mottled birds at this time.

While it seems doubtful whether the flight feathers are always molted during the sojourn of the bird in the far north, it is certain that in some cases a part of them, at least, are renewed. Furthermore, all the material which bears upon the question of the molt of the adult indicates that a number of gray feathers are acquired on the back after the breeding season, though the molt is far from complete, and that the black under surface is retained at all seasons, probably becoming purer with age. This is the theory advanced by Mr. Mackay (*The Auk*, 1892, p. 143), and the material before me corroborates it in every instance.

The sixth specimen obtained is a bird of the year, with round yellow spots above and triangular shaft streaks below.

Charadrius dominicus Müll.—American Golden Plover.

Twenty-eight specimens of this bird are contained in the collection representing various ages and plumages.

Between the adult male and female, I fail to detect any appreciable difference in plumage. Eleven adults taken June to August serve to illustrate the beginning of the annual molt. One taken June 1 and two secured June 2 show no evidence of molt whatever, and may be regarded as typical breeding birds. They are uniform black below, but show great variation in the plumage of the upper surface, many of the old abraded winter feathers being still retained, as already noticed by Nelson, while some of the earliest acquired spring feathers are already beginning to fade and become ragged. Four later specimens (June 18, 27 (2), 28) show much greater abrasion, and a general bleaching of the yellow spots to whitish, while beneath the plumage of the back and head new feathers are everywhere to be found, beginning to expand.

In the next series (July 24, 27 and August 1), these feathers are fully grown and a number of white and gray feathers are scattered over the breast and belly. There is, however, no trace of molt in the remiges, rectrices or greater wing coverts in any of the birds, and it seems that they are not lost till later. One of the birds secured August 1, while much mottled with light feathers below, has undergone scarcely any molt on the back, where the plumage is mainly composed of the much abraded spring feathers.

Sixteen specimens are in full fall plumage (August 1, August 18 (8), August 20 (7)). They vary considerably in the brightness of the yellow spots and the extent to which they are abraded, but cannot be separated into old and young (if both *are* contained in the lot?) by any tangible character. There is no trace of old feathers on a single specimen, while all have apparently molted the flight feathers. The bellies are without a trace of black.

One nestling is bright golden above mottled with black, whitish on the back of the neck and everywhere below.

Tryngites subruficollis (Linn.)—Buff-breasted Sandpiper.

One female specimen obtained June, 1898, in full nuptial plumage, and a male, August 13, 1898, in winter plumage.

Tringa canutus Linn.—Knot.

Six specimens in full first winter plumage taken July 31 (5) and August 17.

Tringa couesi (Ridgw.)—Aleutian Sandpiper.

Three specimens in winter plumage were obtained at Port Clarence, August 22, 1898.

Tringa alpina pacifica Coues—American Dunlin.

A fine series of sixty specimens of the Dunlin is contained in the collection, and as the adults are represented throughout the molting season, the change of plumage in this species is excellently illustrated.

Nine adults, June 2 (2), June 4, June 7 (2), June 8 (4), represent the height of the nuptial plumage and are like the latest spring migrants on our coasts.

One taken June 27 illustrates the beginning of the molt, having shed the five inner primaries. The new feathers which have not yet broken from the sheath seem to be all at an equal stage of development. The next specimen, taken July 31, shows the two outermost primaries about half grown, while the others are fully grown. In this bird, too, the wing coverts have all been renewed, and upon raising the plumage on the back many new feathers are to be seen, the earlier specimen showed no trace of a molt, except in the primaries.

A series of fourteen molting adults (August 10 (2), August 13 (4), August 18 (3), August 20, August 24 (2), August 26, September 1), resemble the last in the molt of the wing, though the later ones have all the remiges fully grown. The extent of the body molt is very variable, some of the later specimens being still quite rusty above, while earlier specimens are quite gray, all still show the black on the belly, though one taken August 24 has nearly lost it.

Eight downy young were collected July 6, 8, 10 and 23. They are mottled with chestnut, black and buffy white above with little buff dots scattered about on the tips of the plumes. Forehead whitish with a central black stripe forking into two on the top of the head, and passing into chestnut brown, broad buffy white superciliaries, which unite below the occiput, and tawny postocular stripe, strong buff wash below the eye. Under parts white with a buff collar across the neck.

One young bird, taken July 16, has the body well covered by the first winter plumage, but is still quite downy on the head, breast and flanks. The remaining twenty-eight are all fully grown, and in the usual winter plumage, August 10 (5), August 21 (8), August 24, August 18, August 20, August 26 (6), September 1 (5), September 4.

Tringa maculata (Vieill)—Pectoral Sandpiper.

A series of twenty-six specimens was obtained. Ten are breeding males, with the throat sack enormously extended, spreading the feathers to such an extent that the black bases are clearly visible.

These were obtained May 30 (2), May 31 (2), June 2 (4), June 8 (2). Six female specimens in nuptial plumage were secured May 30–June 7, and a much worn specimen was obtained July 31, which is beginning to molt the plumage of the back and breast, though there is no evidence of molt elsewhere.

Five specimens are in winter plumage (July 31 and August 20 (4)). These show no variation, except that No. 288, August 20, is more deeply colored on the breast than any of the others. I am uncertain whether these are adults or birds of the year. If the former, then this species molts before migrating southward, like *A. alpina pacifica,* but not nearly so early.

Four downy young are labelled *T. maculata.* They do not differ from young *T. alpina pacifica,* except in rather darker coloration.

Tringa bairdii Coues—Baird's Sandpiper.

A large series of breeding birds was obtained as follows: May 28, May 30, June 2 (3), June 7, June 8 (7). These are quite uniform in plumage, though the later ones are a little more worn.

Three specimens, taken June 11, June 15, June 27, show more or less new body feathers both above and below, when the old plumage is raised, and another secured July 11 has nearly completed the molt of the head, breast and back. In none of these, however, is there a trace of molt on the wings or tail.

Eleven birds in first winter plumage were secured, July 31 (8), August 1 (2) and September 4. These differ from the winter plumage of the adults in the conspicuous white margins to the feathers of the back and the greater amount of streaking on the breast.

Ten young in the down were taken July 16, 18 and 27; they are darker than young Dunlins, with the brown tints darker and not so rufous, while the light mottlings are whiter and less tinged with buff. Two others taken August 1 are intermediate between the down and first winter plumage.

Tringa friscicollis Vieill.—Bonaparte's Sandpiper.

Five of these birds were taken as follows: June 2, June 8 (2), June 14 (2). All are in full nuptial plumage, and show no sign of molt.

Ereunites pusillus (Linn.)—Semipalmated Sandpiper.

A series of thirteen specimens was obtained. A breeding bird, June 6, is rather worn, without a trace of chestnut tints on the plumage. Two others, obtained July 8, show a considerable renewal of the plumage of the back, but no molt in the flight feathers. A female from Port Clarence, July 24, is similar. The other specimens appear to be birds of the year, one from Pt. Barrow, August 12, and another, Port Clarence, July 24, still retain much down about the head, while two others from Point Hope, July 31, and one from Port Clarence, July 24, are in full winter plumage; also July 31, 1898 (4). The shortness of bill in the Pt. Barrow birds is extreme, measurements being as follows: No. 1,243, .65 in.; No. 1,028, .74; No. 1,242, .70 inches.

Those from Point Hope measure No. 88, 1.00; No. 87, .80; and from Port Clarence, No. 29, .74 inches.

Limosa haemastica (Linn.)—Hudsonian Godwit.

Two specimens, obtained July 14, are slightly mottled with new gray feathers above and below, and show a number of pin-feathers beneath the plumage, but there is no indication of molt in flight feathers.

Limosa fedoa (Linn.)—Marbled Godwit.

One bird of the year, obtained August 26.

Calidris arenaria (Linn.)—Sanderling.

Six breeding specimens, June 6 and 7, and one bird of the year, August 27.

Macrorhamphus scolopaceus (Say.)—Long-billed Dowitcher.

One adult female in worn nuptial plumage, secured June 30, and twelve birds of the year, taken August 1, August 20 (8), August 24 (2), August 26, represent this species.

The bills of the latter series range from 2.25 to 2.95 inches, but there is no variation in the plumage.

Lagopus rupestris (Gm.)—Rock Ptarmigan.

Four specimens only were collected.

One male, taken in April, is in worn winter plumage, while two others, June 25 and 29, are extremely worn, and of a dirty brownish white. There are new brown feathers on top of the head and on the back, but apparently no general molt, and considering the very late date it seems that the molt must have been arrested in some manner in these specimens.

A female, taken June 26, is in almost full nuptial plumage, but retains a few white feathers below. There is no molt of the flight feathers.

Lagopus lagopus (Linn.)—Willow Ptarmigan.

Sixteen adult specimens illustrate the winter and nuptial plumages.

Twelve of these, October 6 (2), October 15 (3), October 9 (7), are white, with a few old rufous feathers about the head. Two others, January 11 and March 21, show effects of wear, but are still in the white dress.

The next specimen, April 18, is very much worn with many new rufous feathers coming in on the head and neck, while in the last, June 22, the nuptial plumage is completed except a few old white feathers on the belly.

In none of these is there any indication of a spring molt of the primaries, secondaries or greater coverts.

Falco rusticolus gyrfalco (Linn.)—Gyrfalcon.

Two specimens, September and November 7, 1897.

The former has scarcely any transverse barring above, and is very dark below. The latter is strongly barred above with buffy, and is white below streaked with dusky.

Asio accipitrinus mcilhennyi Stone—Arctic Short-eared Owl.

A series of nine males and two female Short-eared Owls were secured, June 2–22; have already been described (*Proc. Acad. Nat. Sci.*, 1899, p. 478).

Nyctea nyctea (Linn.)—Snow Owl.

Eleven adults, taken June 3–27, are contained in the collection. Six of these are marked male and four female, while one is unsexed. There is great variation in the amount of dark barring on the plumage, but the nearly pure white ones are always males, and the darkest ones always females; among the intermediate specimens there are two specimens, one male and the other female, which are almost alike in plumage.

Three of the sexed females are nearly denuded of feathers on the breast and abdomen, but the other as well as the unsexed specimen which, from its measurements appears to be a female, are well feathered and were evidently not nesting.

The whitest example is No. 1,089, taken June 12, the only markings on it are small black tips to the outer primaries, a few dull streaks on the crown, and an obscure grayish spot on the wing-coverts. The lightest female is decidedly white, interscapulum, back and rump pure white, tail slightly spotted, wings and coverts irregularly but not heavily barred, beneath the bars are few and faint, and confined to the middle of the abdomen. No molt was observable in any of the series. The wing measurements are as follows:

			Ins.				Ins.
1,115.	♂,	June 16,	16.00.	992.	♀,	June 3,	17.75.
1,192.	♂,	June 27,	15.50.	1,127.	♀,	June 17,	17.00.
1,090.	♂,	June 12,	16.00.	1,128.	♀,	June 17,	17.10.
1,089.	♂,	June 12,	15.60.	999.	—,	June 5,	17.80.
1,117.	♂,	June 17,	15.25.	1,051.	♀,	June —,	17.10.
1,118.	♂,	June 17,	15.25.				

A series of twenty-four nestlings in various stages is of particular interest as it illustrates two distinct conditions of the downy plumage.

The birds may be grouped in four lots:

A. Average length of skin 4.25 ins., June 25 (1), July 6 (5), July 10 (2). Pure white down all over the body, the largest individuals showing dusky traces on the wings.

B. Average length 6.50 ins. July 6 (9). White down not continuous over the body, all the feather tracts distinctly dusky with the new plumbeous down.

C. Average length 8 ins. July 6 (3), July 10 (2). Prevailing color dusky plumbeous, plumes all tipped with white, these tips being, of course, the earlier white down.

D. Average length 12 ins. July 10 (2). Thickly covered everywhere with plumbeous down, much of it with white tips. Some fluffy banded plumbeous scapular feathers and the wing quills just sprouting.

Horizopus richardsonii (Swains.)—Western Wood Pewee.

One female secured July 1, 1898, materially extends the northward distribution of the species. This bird is interesting, as it is renewing the outermost primary of the left wing which had evidently been accidentally lost. Instances of renewal of rectrices are common, but this is the first instance that has come to my notice of the renewal of a remex.

Calcarius lapponicus alascensis Ridgw.—Alaskan Longspur.

The Longspur is represented by a series of ninety-nine specimens, eighty-one from Pt. Barrow and eighteen from Port Clarence. Compared with a series of Greenland birds, they are perceptibly lighter on the upper surface, the black lines being much narrower. In no other respect, however, can I see any material difference, and the absence of rusty tints on the wings does not seem to be a constant character.

Twenty-eight breeding males (May 28 (16), May 30 (9), June 2 (2), June 11 (1)) present a very uniform appearance. In nearly all the chestnut of the neck, black of the throat and light post-ocular stripes are very clear and have entirely lost the buff edgings. In many, however, the light tips remain on the lowest of the black breast feathers and in none is the black cap entirely pure.

Nine breeding females (May 28 (5), May 30 (2), June 2 (1), June 14 (1)) show considerable variation in the brightness of the black chest band and the chestnut collar, and in all but the last abrasion is much less advanced than in the males. It seems probable that the dull specimens are younger birds.

Six males secured at Port Clarence, July 24 and 25, are in the midst of the molt. In three of these the fourth primary has just been shed, in the others, the third, second and first respectively.

In the first two specimens the three old outer rectrices are still retained, in next two only the outermost pair, and in the last the entire tail has been shed. One or two of these birds show the culmination of the abrasion on the crown, which is pure black, a condition not noticed in any of the June specimens. It is evident that this process continues until the molt is actually under way. Another point of interest is that many of the new feathers on the chin are white almost or quite to their bases, while these feathers in May and June specimens are jet black, indicating a slight molt in spring, which is well known to occur in many *Fringillidæ*.

Two molting females from Port Clarence, July 23 and 24, are in the same stage as the first males above referred to.

Nineteen specimens are in the juvenal plumage and thirty-five in full winter dress.

Four specimens (July 8, 18 (2) and 27) have only half-grown tails, while two secured at Port Clarence, July 24, are in perfect juvenal plumage, the molt to winter plumage follows almost immediately, as all the other birds (July 24 to August 18) show it in progress. The new feathers first become noticeable on the rump, and the molt is well advanced here before it is apparent on the lower surface.

The fall specimens are separable at once into males and females by the large amount of black on the breasts of the former, but I fail to distinguish birds of the year by any external characters. Indeed, the only noteworthy variation seems to be an occasional increase in the black on the chest of the females, a tendency toward the plumage of the male not infrequently noticed in various birds.

Calcarius pictus (Swains.)—Smith's Longspur.

One male secured June 11, 1898, presents no peculiarities. Wing measures 3.58 ins.

Passerina nivalis (Linn.)—Snowflake.

A series of forty-three specimens, all from Pt. Barrow, except three immature birds taken on King's Island. These correspond excellently with a series of Greenland birds obtained on the Peary expeditions, and now in the collection of the Academy, and show no tendency whatever toward *P. nivalis townsendi* Ridgw., of the Aleutian Islands.

Of nine breeding males, taken May 3 to June 11, 1898, six are nearly uniform in coloration, the heads being pure white, and the interscapulum with only slight whitish edgings, these having practically disappeared in the latest specimen in the series. In none of these is there any trace of brown or rusty tints, though the remaining three show this to a varying degree. No. 853, May 3—the earliest specimen—exhibits slight rusty tips to the feathers of the head and the innermost wing coverts, as well as a spot of rusty on each side of the breast. In No. 856, May 6, the rusty is confined to the wing coverts and the rump, while in 855, May 6, the whole upper surface is suffused with rusty. The abrasion of the tips in this bird seems to have been delayed for some reason, and it forms a striking break in the series which otherwise illustrates beautifully the gradual progress of this abrasion during the month covered by the specimens.

Two breeding females, May 30 and July 3, show practically no trace of rusty tints; the later bird, though very much worn, shows no indication of molt.

Only five adult males illustrate the molt, and the early fall plumage. One of these (302, August 21) is in the midst of the molt, six new primaries are full grown and the others of varying lengths, the old ones being all shed, the old secondaries still remain, while the tertials and nearly all the body feathers are new. Three specimens, taken August 26, and one September 4, are in full fall plumage, the remains of the sheath on the outermost primary being the only sign of molt.

Nine females are in full fall plumage, of which four (August 26 (2), September 4 and September 11) retain remains of the sheath on the base of the outermost primary, while the rest (August 30 (2) and September 4 (3)) show no trace of it, and may be birds of the year.

Eighteen unquestionably immature birds illustrate the changes from the nestling to the full fall plumage.

Five nestlings, July 10, Admiralty Bay, were collected to show the progress of plumage growth. The youngest is quite white down the centre of the abdomen and brownish on the sides, the older birds exhibit a buffy suffusion over the whole lower surface. The neosoptiles on all are dull plumbeous.

Three males from King's Island (July 23) are in full juvenal plumage, though in two of them the tail is not fully grown. Four specimens (August 15, 21, 24, September 3) illustrate the progress of the postjuvenal molt on the back and rump, while in two others, August 21 and September 3, it is completed.

Of two immature females taken August 14, one is beginning to molt, while the other has finished, and the same is true of two secured August 21.

In examining this series, I discovered that the primary coverts were an excellent index to the sex and age of the bird, as they are always white in the male—even in the fledgling—and dull black in the female. Young males always have a spot of black on the tip of each feather, the pure white feathers replacing them at the first *annual* molt. By this means we can separate the male and female fledglings, and distinguish the males of one year from the older individuals in the spring-breeding series.

Acanthis hornemannii exilipes (Coues)—Hoary Redpoll.

A series of sixteen specimens taken June 18–26 exhibits very little individual variation. One male is bright rosy pink over the whole breast and down the sides, as well as on the rump, but the others, both males and females, present a very uniform appearance. Unfortunately, none were secured in the molt.

Ammodramus sandwichensis alaudinus (Bonap.)—Western Savanna Sparrow.

Six breeding specimens, taken June 7 to July 27, and three in winter plumage, August 26 and 27, illustrate this species. None of them show any trace of molt.

Zonotrichia leucophrys nuttalli Ridgw.—Nuttall's Sparrow.

One female specimen, secured June 10, 1898, is typical in every way. Wing measure 2.90 ins.

Dendroica coronata (Linn.)—Myrtle Warbler.

One male obtained from a native near Pt. Tangent, June 3, 1898.

Budytes flavus leucostriatus (Hom.)—Siberian Yellow Wagtail.

One adult male obtained June 11, 1898, a young bird just completing the molt into the winter plumage, and another young, August 8, 1898.

Hylocichla aliciæ (Baird)—Gray-cheeked Thrush.

An adult female, found dead on the ice near Pt. Tangent, May 27, 1898, and a male secured June 10, 1898, at Pt. Barrow. The latter is in exceedingly worn plumage, the ends of the primaries where they project successively one beyond the other being so bleached that the pattern of the covering feather is clearly marked on each.

MAMMALS.

Twenty species of Mammals are represented in the collection by 855 specimens. Seventeen of these are given in Murdoch's paper, though the nomenclature varies considerably. Of the other eight mentioned by that author, the Red Fox, Wolverine, Barren-ground Bear and Mountain Sheep were given on the basis of skins, etc., in possession of the Eskimos, and were admittedly not obtained at Pt. Barrow, while *Elephas* was of course fossil. The other species were the Ribbon Seal, Narwhal, and Killer Whale. Of these no specimens are in the McIlhenny collection.

Three other species were, however, secured, which are apparently reported for the first time from Point Barrow, the Fur Seal, Least Weasel and Canada Lynx.

Balæna mysticetus Linn.—Bowhead Whale.

Portions preserved in formaline.

Delphinapterus leucas (Pallas)—White Whale.

One skeleton and ten skulls, one an embryo. Mr. McIlhenny's measurements show the average length of males to be 15 ft. 3 ins. (ext. 16.4–12.1), and of females 12 ft. 11 ins. (ext. 13.9–11.7).

Rangifer arcticus (Rich.)—Barren-ground Caribou.

A series of twenty-four of these animals was secured ; three skeletons, eight skins with skulls and thirteen additional skulls.

Some of the horns are in the velvet, which is dark blackish brown, with scattered white hairs near the basal portion.

The youngest examples have straight or slightly incurved "spike" horns eight to eleven inches long. The next has the horns incurved, thirteen inches long (chord measurement) with a forward tine six inches long near the base. Other horns of the same size are slightly forked at the tip with the forward tine also sometimes forked; while one specimen has the tip of one horn somewhat flattened. Another specimen slightly larger has a well-developed fork to the main horns, while the adults vary very much.

A comparison of this series with a number of skulls from Greenland fails to show any tangible difference either in the characters of the cranium or the antlers No doubt there are satisfactory differences in the coloration, but lack of skins of the Greenland animal prevents me from making comparisons.

In color the adult skins do not vary to any great extent; No. 299, ♀, March, 1897, is nearly white on the neck and head, the ears and portions of the face and top of head are brownish gray, the middle of the back from shoulders to rump is brownish gray, as well as the legs, sides, under parts, tail and buttocks white, a well-defined dark, narrow lateral band about three inches from the dark dorsal area. Feet white, the brown color running down the middle of each toe to within an inch of the hoof, but much paler than elsewhere on the legs. No. 292, ♀, March 15, 1897, is in much fuller coat, with hair much longer and everywhere lighter, owing to a "frosting" of white hairs. The lateral stripes are not so well defined, and the feet are pure white. The horns of this specimen are in the velvet.

Two of the calves are uniform, dark smoky gray, while the third is varied with white on the rump, face and legs.

Lepus tschuktschorum (Nordquist.)—Alaskan Polar Hare.

One skeleton of a male obtained April, 1898, on the Ikpikpun river.

"Length, 28.5 ins; hind foot, 7.5; tail, 4.62; ear, 4.25." Skull, total length, 112mm; greatest breadth, 57; greatest breadth of nasals, 24.

Ovibos moschatus (Zimm.)—Musk Ox.

One weather-beaten skull picked up on the tundra.

Lemmus trimucronatus (Rich.)—Alaskan Lemming.

Mr. McIlhenny's magnificent series of 606 skins furnishes abundant material for studying the variations in this species due to age and season.

Two points are at once noticeable upon arranging the specimens according to dates of capture, first, that some young seem to be born every month in the year, and second, that during the four months (August to November) of the expedition's stay at Pt. Barrow only young Lemmings (probably all born that year) were obtained. The latter fact may be merely due to lack of knowledge of the habits of the adults, but owing to the fact that such large numbers of old ones were taken later on, and but few young, it may have something to do with the erratic habits of these curious rodents. The former fact is no doubt accountable for some of the peculiar individual variations in pelage which are seen in the series.

Beginning our study of the series with the first that were obtained, August, 1897, it will be convenient to consider them month by month.

August.—Six specimens, all young, three to five inches long and poorly haired, black and yellow hairs closely mingled over the upper surface with a rufous patch on the rump, blackish under fur everywhere showing through. Below buff with dark under fur very conspicuous.

September.—Fifty-four specimens, twenty-six like the above, twelve younger (three to four inches long), grayer and less rufous, some with only a trace of the latter tint. Sixteen show the transformation from the dull reddish rumped pelage above described, to a full long-haired pelage of bright yellow buff, brightest on the rump and dusky on the head, below buff with the plumbeous under fur nearly obscured. This I consider to be the regular first winter pelage. Many of this series show the bright yellow-buff hairs about half-grown pushing up through the dull juvenal pelage.

October.—Twenty-two specimens. Three of the earliest (gray) stage, eight of the next (red-rumped), and nine of the winter, though many of the latter are not yet fully molted. Two others are peculiar in being very gray above with no trace of the rufous tint on the rump; they are, however, acquiring the yellow-buff winter pelage. One November specimen is similar and shows distinctly the new buff pelage coming in, though the old pelage is very gray and like that of a very young individual. These specimens were probably born very late in the season, and the juvenal pelage never attained its full development, the molt to the winter dress occurring much earlier in life than in those born in June or July.

November.—One specimen described above.

December.—Three specimens, one like the above and two in full winter pelage, though larger than any so far considered (*i. e.*, 5.80 ins. long).

January.—Eight specimens. Three young like those last described, but farther advanced in the molt, and five in full winter pelage.

February.—Nine specimens. Three in absolutely first pelage, gray, fur much longer and thicker than in summer-born young (length 3.87 ins.). One larger individual molting, and five in winter pelage, duller and more faded than early fall examples.

March.—Twenty-three specimens. Eight small ones in first pelage, similar to summer young, but rather paler and with denser fur. Two molting and thirteen in adult winter pelage (length 5.13–6.83 ins.).

April.—Sixty-eight specimens. Three are well-grown young, with a trace of the rufous rump patch. Sixty-one are in winter pelage or in the spring molt, many of them very ragged with the gray under fur exposed in places. Four have about completed the molt. These have the hair shorter than winter specimens, and are darker colored with the whole rump bright ferruginous.

May.—Two hundred and sixty-four specimens. Twenty are young of various ages, some very small, the oldest showing distinctly the accession of the rufous pelage on the rump, replacing the original gray. Thirteen are in the red-rumped juvenal pelage, and two hundred and thirty-one adults, some still in the ragged winter pelage, some completely molted, and others in transition.

June.—One hundred and forty-eight specimens. Nine young of various ages and one hundred and thirty-nine adults, nearly all in fresh summer pelage.

The four pelages of *L. trimucronatus* that seem to be normal are described in detail below, the colors being compared with Ridgway's *Nomenclature*:

1. The Gray young (No. 168, February 5). Hair brown, slightly tinged with buff in the middle of the back, and with many of the hairs tipped with black. Beneath paler.

Length 97 mm.; tail 12; hind foot 17.

2. The Red-rumped young (No. 46, September 6). Hairs over the anterior part of the back and head raw umber and black finely mingled, some with a golden lustre; rump and posterior parts dark chestnut, sides pale tawny. Below cinnamon rufous, with the gray under fur conspicuous.

Length 124 mm.; tail 18; hind foot 17.

3. Adult summer (No. 657, May 31). Forward part of body russet and black very finely mingled, shading to very bright chestnut almost hazel on rump, sides tawny ochraceous. Beneath ochraceous buff.

Length 155 mm.; tail 24; hind foot 21.

4. Adult winter (No. 161, January 27). Anterior portions clay color with black hairs finely intermixed, rump and posterior parts, ochraceous, below cream buff.

Length 148 mm.; tail 23; hind foot 22.

Dicrostonyx hudsonius alascensis subsp. nov.—Alaskan Pied Lemming.

The seasonal and individual variations in *Dicrostonyx*, as shown below, is very great, and renders any division into geographical races difficult without extensive series from a number of localities. The material before me, however, indicates that the form inhabiting Alaska and the northwestern part of British America is separable from the *Dicrostonyx* of Labrador, to which the name *hudsonius* belongs. The type specimen (No. 821, Coll. E. A. McIlhenny, Pt. Barrow, Alaska, ♀, June 8) may be described as follows: Anterior portion of upper surface, rich chestnut, with whitish mottling due to the light bases of the hairs showing through, rump blackish and gray mottled with white, a blackish median dorsal stripe extending to the nose, face gray, ear patches strongly chestnut. Sides and under parts strongly tinted with rusty, with chestnut across the breast between the forelegs; feet white.

D. hudsonius (three specimens in Coll. E. A. and O. Bangs, Hamilton Inlet, Labrador, August 10–19, 1895) differs in its nearly uniform grizzled gray pelage, and almost total absence of chestnut, this color appears only at the base of the fore legs, on the ear patches, and as a slight tint on the sides of the body, but is nowhere as rich as in *alascensis;* the feet are gray or blackish, instead of white, and the under parts are darker. While it is quite probable that the Labrador Lemming is subject to greater variation than shown by the material before me, it also seems evident that it is a much grayer animal at all times than the Alaskan form. The grayest specimen of *alascensis* has more chestnut coloring than any of Mr. Bangs' series or Labrador specimens in the National Museum collection, and the black and gray mottling is much coarser.

There is no tangible difference in the skulls of the two forms. Their measurements follow:

	Length.	Tail.	Hind Foot.
D. hudsonius, No. 4,166 (Bangs), Hamilton Inlet, Labrador, ♂, ...	150 mm.	8	21
D. h. alascensis, Type, No. 824 (McIlhenny), Pt. Barrow, Alaska, ♂, . .	132		18
D. h. alascensis (largest spec.), No. 496 (McIlhenny), Pt. Barrow, Alaska, . .	165	21	19

A series of forty-eight specimens was obtained, which vary considerably in size, but are all apparently adult.

October and *November* (October 11, November 3, November 13).—These three specimens are decidedly white. The first two show traces of the dark summer pelage everywhere under the long silky winter coat and on the back of the neck, ears and top of the head, the old pelage still remains intact. The last specimen is entirely white, but with a pinkish tinge produced by the partially covered chestnut hairs remaining from the summer coat.

January and *February*.—Two specimens, both pure white with long silky hair.

March.—Seven specimens. Five pure white and two showing the beginning of the spring molt. The latter are white, with a general pinkish tinge produced by the dark hairs of the new summer coat; two have dusky lines between the shoulders, and one has well-defined pinkish bands from the eyes to the rump where they join and continue as one band to the tail, there are also rusty spots at the base of the fore legs.

April.—Ten specimens. Four are pure white, and one white with a dusky area on the head and across the occiput, ending in a longitudinal stripe on the forepart of the back. These dark marks are apparently not produced by the ingrowing summer hair. The other five are beginning the molt though the prevailing color is still white.

May.—Sixteen specimens. One pure white (May 26), one with several round spots of chestnut on the back of the neck, but otherwise white, evidently injured late in winter or early in spring, the new hair coming in dark. Two others have the centre of the back more or less dark, with a well-defined median dark stripe. Ten others are white beneath and on the sides, gray on the head, rump and middle of back, rest of upper surface rusty, inclining to chestnut, with a dark median stripe. These average 132 mm. in length, and are dull in appearance compared with June specimens, probably due to scattered short white hairs in the pelage.

Two large ones, average length 160 mm., are much more chestnut than the above series, one is in complete summer pelage, the other is white below with the whole posterior part of the body veiled with the long white winter hairs.

June.—Ten specimens all in summer pelage, though varying much individually. All are rusty beneath with the gray under fur conspicuous. Above the normal pelage appears to be mottled chestnut and white on the anterior half of the body, the white being confined to the basal part of the hair and more conspicuous in some than in others, posterior half iron gray or black, with more or less white bases to the hairs, face gray, nose black, feet and tail white. On some specimens there is a median black stripe. The most extreme specimen has a complete median stripe from nose to tail, and the whole back mottled with black and gray, giving it a grizzled appearance, while the hairs over the shoulders and on the ears are chestnut, and a few on the forepart of the back are chestnut tipped. In size this June series averages 137 mm., the extremes being 165 and 112. The heavy claws on the fore feet are well developed on all of the series, except three of the June specimens.

On the Relationship of North American Lemmings.

The number of species of American Lemmings of the genera *Lemmus* and *Dicrostonyx* and their proper nomenclature has long been an unsettled question.

In the present connection it occurred to me that an opportunity was offered to throw some light on the subject, and through the kindness of the authorities of the U. S. National Museum, the American Museum of Natural History and of Mr. Outram Bangs, I now have before me a series of 129 specimens in addition to the magnificent series of 654 skins secured by Mr. McIlhenny.

Owing to the great variation in these animals due to age and season the series is still insufficient to satisfactorily settle all the points at issue, though much is made clear.

The American specimens of *Lemmus* have been variously referred by writers to *L. lemmus*, *L. obensis* and *L. helvolus*.

The first two are respectively European and Siberian animals, and, as can be seen at a glance, are wholly different from any American Lemmings as well as from each other.

Leaving these out of the discussion, we have to consider the names proposed for the American animals. There are, I believe, only four:

Arvicola trimucronata Rich.
Parry's Second Voyage, App. (1825), p. 309.

Type locality, Point Lake, lat. 65° N.

Arvicola helvolus Rich.
Fauna Boreali-Americana (1829), p. 128.

Type locality, Alpine Swamps in lat. 56°. Evidently near the headwaters of Peace river.

Myodes nigripes True.
Proc. U. S. Nat. Mus., vol. xvii, No. 799, April 26, 1894.

Type locality, St. George's Island, Alaska.

Myodes albigularis Wagner,
Schreber's Säugeth. Suppl. (1843), vol. 3, p. 602.

Several specimens in the U. S. Nat. Mus. from the Arctic coast are practically topotypes of *L. trimucronatus*, the type locality of which is Point Lake.

These are identical with Pt. Barrow specimens of similar age, and Richardson's description, which is of an adult female animal, can be well matched by specimens in the McIlhenny series.

This being the oldest of the three names proposed, no difficulty presents itself in applying it to the *Lemmus* of the Arctic coast.

We have now to consider the status of the two other described forms. Richardson's description of *L. helvolus* is not sufficiently detailed to judge of its relationship with the more northern form. I have before me, however, a specimen from the collection of the Amer. Mus. of Nat. Hist., obtained by A. J. Stone in the Cassiar Mts., directly west of the region where Drummond collected the type of *L. helvolus*. This specimen is, unfortunately, not fully adult, and it is difficult to decide as to its relationship with the Arctic form. I find no apparent cranial differences between it and specimens of the same size from Alaska, while in color it is rather yellower than any of the Arctic series. Without more material it is impossible to say whether the two are identical or not, though it seems quite likely that the southern form will prove subspecifically different in which case it will stand as *Lemmus trimucronatus helvolus* Rich.

Lemmus nigripes True, is an island form restricted to St. George's Island. Though generally regarded as quite distinct, the large Pt. Barrow series before me contains specimens that come very close to the island form. The latter are, however, darker and have blacker feet than specimens of the same size from the mainland, and are apparently distinct, though very closely related. I have seen no specimens of *L. nigripes* which approach in size or color the old adults of *L. trimucronatus*. The great variation in *L. trimucronatus*, which presumably exists also in the other forms just mentioned, has been already described at length; and it is now quite evident that several specimens in the National Museum collection which, from their difference in size and coloration, appeared to represent distinct[4] species, are really identical. *L. albigularis*

[4] Cf. True, *Report of Fur Seal Investigations, 1896–7*, Part iii, p. 347.

Wagn., is apparently a synonym of *L. trimucronatus*, but if the Sitkan animal proves separable this name is available.

The species of *Lemmus* before me in adult pelage may be distinguished as follows:

Anterior part of back as well as whole front of head jet black; rest of upper surface, including area just above ears, tawny ochraceous. . . . . *L. lemmus.*

Head gray, body tawny ochraceous to chestnut, with a longitudinal black stripe from nose to shoulders, beneath yellowish white. *L. obensis.*

Upper surface russet passing to chestnut on rump, no median stripe, below ochraceous buff. Feet gray or white. *L. trimucronatus.*

Similar to the last but much duller and browner, with the feet black. *L. nigripes.*

Our American *Dicrostonyx* has generally been referred to the European *D. torquatus* Pallas, but while certainly quite closely related to this form, I regard it as probably distinct. Unfortunately, no skins of the Old World animal are available for comparison, and I have only been able to examine one skull from Petschara, Russia, kindly loaned by Mr. Gerrit S. Miller, Jr., from which no very satisfactory deductions can be made.

For the American animal only one name has been proposed: *hudsonius* of Pallas, while Richardson proposed *groenlandicus* for the *Dicrostonyx* of Greenland.

I am inclined to think that the characters upon which this last form was based are due to age and season, but it is quite likely that the animal may prove distinct, in which case Richardson's name will be available. The Greenland material that I have is all alcoholic, and the specimens do not seem fully adult, so that no satisfactory comparison is possible except as to cranial characters, and here I find no apparent difference.

The three specimens of *Dicrostonyx* kindly loaned by Mr. Bangs are from Labrador and consequently topotypes of *D. hudsonius.* They, as well as other Labrador specimens before me, are uniformly grayer and more finely mottled than Alaskan examples, as already explained, and in consequence I have proposed to separate the western form as *D. h. alascensis.*

Spermophilus empetra (Pall.)—Parry's Spermophile.

Forty-four skins of this animal were obtained. Four June specimens are pale and somewhat ragged, with the thick woolly under fur rather conspicuous, while two others taken late in the same month are darker, brighter and distinctly rusty beneath. These latter are evidently in the fresh summer pelage. Four July specimens are similar while two young individuals are very gray, with the back obscurely mottled, but without distinct white spots. The pelage is very thin.

The August series includes eight normal adults, three young and one large adult, which is remarkably gray below and dusky above, with scarcely any trace of rusty tints. A similar specimen was obtained in September, but the rest of the autumn series of eighteen specimens are normal (September to November 12). One albino obtained in November, 1895, by Charles Brower, is in the collection.

Sorex personatus streatori Merriam—Streator's Shrew.

Three specimens which measure as follows:

	Length.	Tail.	Hind Foot.
71. ♀, September 16, 1897, . . .	86 mm.	34	10
72. ♀, September 17, 1897, . . .	91	35	10
159. ♂, October, 1897, ...	88	34	11

Odobænus obesus (Illig).—Pacific Walrus.

Two skeletons and one skull.

Callotaria ursina (Linn.)—Fur Seal.

One female, obtained at Pt. Barrow, August 17, 1897, measuring 48 ins. in length.

Erignathus barbatus (Fabr.)—Bearded Seal.

One male specimen prepared as a skeleton was secured September 7, 1897. It measured "88 ins. in length, hind foot 20.5 ins., greatest girth 60 ins." (McIlhenny).

Phoca largha Pallas—Pallas' Seal.

Four skulls and two skeletons of this seal were secured. The cranial and dental peculiarities already pointed out by Dr. Merriam hold good throughout the series, and the species is certainly distinct from *P. vitulina*, which it represents on the Pacific coast of the continent.

Mr. McIlhenny's measurements of the length of his specimens are as follows: No. 22, 59 ins.; No. 30, 48 ins.; No. 31, 69 ins.; No. 32, 61 ins.; No. 33, 56 ins.; No. 54, 59 ins.

Phoca fœtida Fabr.—Ringed Seal.

Twenty-eight skulls and five skeletons of the Ringed Seal are in the collection, together with several skins. A comparison of the skulls with a series from the coast of Greenland fails to show any tangible differences.

Thalarctos maritimus (Phipps)—Polar Bear.

One skeleton and five skulls.

Putorius arcticus Merriam—Tundra Weasel.

Four skins of this species were obtained:

	Length.	Tail.	Hind Foot.
115. ♂, October 9, 1897, . . .	378 mm.	147	46
150. ♂, December 28, 1897, . .	406	127	44
173. ♂, February 11, 1898, . . .	399	127	46
719. ♂, June 7, 1898, ...	323	—	47

The first three are white, the last one brown, with the belly pale yellow slightly tinged ochraceous, (a mingling of the primrose and Naples yellow of Ridgway's *Nomenclature of Colors*).

The deep black tip to the tail measures 67.2 mm.

The skull of No. 115 measures as follows: Basilar length 44; mastoid breadth 22.2; breadth of postorbital processes 15; orbital breadth before postorb. proc. 11.8; orbital breadth behind do. 11; last molar to foramen magnum 29; palate 18.

Putorius rixosus eskimo subsp. nov.

Five specimens of this interesting little animal were secured and an additional skull showing the milk dentition. The measurements are as follows:

	Length.	Tail.	Hind Foot.
827. ♂, June 21, 1898, ...	204 mm.	28	20
828. ♂, June 25, 1898, ...	230	31	22
826. ♀, June 17, 1898, ...	180	24	16
829. ♀, June 14, 1898, ...	178	22	19
848. ♀, July 25, 1898, ...	184	25	23

When Mr. Outram Bangs and Dr. Merriam prepared their excellent monographs of American Weasels, there was no good series of Least Weasels from the far North, and it is therefore not surprising that the present form was not recognized. On first examination I took it to be *P. rixosus*, but a comparison with the type which was kindly loaned by Mr. Bangs showed at once that it belonged to a well-marked race, though evidently allied to that form. Mr. Bangs has since compared some of the above specimens with other examples of *P. rixosus* in his collection, and confirmed my views. He further states that it needs no comparison with *P. nivalis* of northern Europe, though lack of specimens leaves us uncertain as to what its relation to the Least Weasel of Siberia may be. As no form has yet been described from the latter country, however, no complication in nomenclature will result.

The type specimen of *P. rixosus eskimo*, No. 848, Coll. E. A. McIlhenny, ♀, July 25, 1898, Pt. Barrow, Alaska, is brown, with a tinge of reddish, being intermediate between Prout's brown and walnut brown of Ridgway's *Nomenclature of Colors*. It is much duller than *P. rixosus*, which is " burnt umber to Vandyke brown." The other specimens are still duller than the type, the extreme specimen, No. 826, being almost drab.[5] These are perhaps younger individuals. *P. rixosus eskimo* has a shorter tail than true *P. rixosus*, and rather larger feet.

The skull has the same strong sagittal ridge as *P. rixosus*, but is in every way larger. The measurements in *mm.* are appended:

	Basilar Length.	Mastoid Breadth.	Breadth of Postorbit. Processes.	Orbital Breadth before Postorbit. Processes.	Orbital Breadth behind Postorbit. Processes.	Last Molar to Foramen Magnum.	Palatal Length.
P. rixosus (type), ♀, No. 642, Bangs............	26.5	13.4	7.5	5.5	....	....	11.
P. rixosus eskimo (type), ♀, No. 848............	29.	15.4	9.3	8.	8.2	20	12.1
P. rixosus eskimo, ♂, No. 828..................	35.	17.	11.	9.	9.5	24	14.4

A specimen of this race in pure white winter pelage is in the collection of the Academy of Natural Sciences of Philadelphia, obtained at Bethel, Alaska, by J. H. Romig.

[5] Cf. Ridgway's *Nomenclature*.

Canis occidentalis Rich.—Timber Wolf.

One skeleton (female) and one skull (male) were obtained, the latter from some distance inland. The female measured as follows: No. 220. ♀, March, 1898. Length 1,550 mm.; tail 430; hind foot 298; ear 126; girth 852; height 765.

While I am not at all prepared to consider the relationships of the large Wolves of North America, I append a table of measurements of skulls in the collection of the Academy of Natural Sciences, Philadelphia, and of the two Alaskan specimens above mentioned:

	Basilar Length.	Zygomatic Breadth.	Mastoid Breadth.	Across Postorbit. Processes.	Breadth before Postorbit. Processes.	Breadth behind Postorbit. Processes.	Last Molar to Foramen Magnum.	Palate.
2,260 (A.N.S.), Missouri.....	200	134	62	61	45	39	91	109
2,262 (A.N.S.), Pennsylvania	205	130	64	53	42	37	95	118
2,261 (A.N.S.), Pennsylvania	208	122	64	57	44	42	93	117
2,256 (A.N.S,), Germany....	212	128	67	57	44	43	96	115
2,253 (A.N.S.), Sweden......	212	126	68	55	41	41	95	113
2,254 (A.N.S.), Sweden......	220	142	66	..	..	43	109	116
2,266 (A.N.S.), *L. gigas* Towns., Columbia River	236	151	72	78	54	49	108	130
220 (McI.), Point Barrow...	222	144	65	65 (?)	49	38	106	125
297 (McI.), Point Barrow...	224	138	63	65	50	41	103	...

Vulpes lagopus Linn.—Arctic Fox.

Seventeen specimens were obtained, six skins, four with skulls; two skeletons and nine separate skulls.

Five adult specimens measured as follows in mm.:

	Length.	Tail.	Hind Foot.
142. ♀, November 1, 1897, ...	993	408	126
143. ♂, November 1, 1897, ...	948	368	138
153. ♂, December, 1897, ...	1020	408	152
830. ♂, June 27, 1898, ...	926	356	175
831. ♀, June 27, 1898, ...	864	330	175

A pup, No. 832, ♂, June 21, 1898, measures about 300 mm. in length. It is of a general plumbeous color, lighter beneath with a dark dorsal area spreading out on the flanks. The face and feet have a number of scattered white hairs. The two summer adults are in very ragged pelage, the female is almost entirely covered with a thick, somewhat matted fur like coat, and here and there all over the body are scattered long white hairs left from the winter coat. The full summer hair seems to be only just appearing. The male specimen is more advanced and the dark hairs of the summer pelage are conspicuous. The general color of both specimens is the same, though the tints of the male are brighter.

The whole head above and below and a broad dorsal band are dull brown (between the seal and clove brown of Ridgway), this color also spreads over the flanks and shoulders, and down the outside of the legs to their extremities as well as on the upper surface of the tail. The sides, belly and inside of the legs are dull, buffy white, passing to vinaceous on the breast and along the edge of the dorsal band. The tips of the ears are white and a number of white hairs are scatterd over the face. The brown hairs which are appearing in the wooly pelage of the back are tipped and ringed with buff.

The winter specimens are in pure white, very long pelage; at the end of the tail the gray under fur is visible, but elsewhere it can only be seen by separating the white hairs to their very bases.

Compared with a series of Arctic foxes from Greenland, the skulls collected by Mr. McIlhenny show conclusively that they belong to a different geographic race. They are larger and heavier than the Greenland specimens, and the audital bullæ are more divergent posteriorly.

Messrs. Hamilton and Bonhote have recently (*Ann. Mag. Nat. Hist.*, April, 1898, p. 287) separated the Arctic Fox of Spitzbergen from that of the European continent as *V. l. spitzbergenensis*, and associate with it the Greenland form. From lack of material they were unable to decide upon the relationship of the American continental animal, though they suggested that it would prove identical with that of Europe.

Being without Old World material for comparison, I am equally unable to settle the point, but from size alone I should endorse their views.

The statement that both forms occur in Greenland seems very unlikely, and I should rather suggest that the large "Davis Strait" examples came from the western side of the strait. The measurements of the Alaskan skulls and a series of Greenland specimens in the Academy's collection give the following averages:

	Basilar Length.	Zygomatic Breadth.	Mastoid Breadth.	Across Postorbit. Processes.	Orbital Width before Postorbit. Processes.	Orbital Width behind Postorbit. Processes.	Last Molar to Foramen Magnum.	Palate.
Greenland, males......mm.	115	67	46	32	27	23	53	60
Alaskan, males........ "	121	72	47	36	29	25	54	63
Greenland, females..... "	100	60	43	28	24	22	46	52
Alaskan, females....... "	115	70	45	33	28	23	52	61

Lynx canadensis mollipilosus subsp. nov.—Arctic Lynx.

A single male Lynx was obtained at Wainwright Inlet, Pt. Barrow, November, 1897, which seems to be subspecifically different from the true *Lynx canadensis*, and may be described as follows:

Type No. 141. Coll. E. A. McIlhenny. Browner and less gray than true *Lynx canadensis*, with a very dense, soft, woolly pelage. Skull decidedly narrower, higher and more arched than *L. canadensis*, and much more constricted across the frontals and between the orbits, the postorbital processes are conspicuously more slender.

Measurements.—Total length 1,040 mm.; tail vertebra 130; hind foot 260 (approx.).

The skull measurements compared with those of true *L. canadensis* and an intermediate specimen from British Columbia in the collection of Mr. Outram Bangs are given in the following table :

	Basilar Length.	Occipito-nasal Length.	Zygomatic Breadth.	Mastoid Breadth.	Across Postorbit. Processes.	Orbital Breadth before Postorbit. Processes.	Orbital Breadth behind Postorbit. Processes.	Last Molar to Foramen Magnum.	Length of Palate.	Length of Mandible.
L. can. mollipilosus, No. 141 (McI.) Alaska, mm.	113.5	124.	......	56.2	......	28.	38.	70.	49.2	90.5
L. can. mollipilosus (intermediate), No. 9,059 (Bangs), Brit. Columbia	107.6	121.4	90.2	53.6	54.8	28.	38.4	67.6	47.2	86.2
L. canadensis, No. 7,259 (Bangs), Maine........	105.6	118.8	93.	55.4	60.4	30.8	38.2	68.	48.2	85.4

This is evidently a northwestern form of *L. canadensis*, and extends southward to British Columbia, as the specimen above referred to from Sumas, B. C., is much more nearly allied to it than to true *L. canadensis*. Alberta specimens in Mr. Bangs' collection, on the other hand, are nearer to *L. canadensis*, though showing a slight tendency toward *L. mollipilosus*. I am particularly indebted to Mr. Outram Bangs for his courtesy in examining and comparing the Alaskan specimen, and in placing in my hands a description and measurements of his British Columbia specimen, as well as in loaning his fine series of Lynx skulls.

A DESCRIPTION OF MICROBDELLA BIANNULATA WITH ESPECIAL REGARD TO THE CONSTITUTION OF THE LEECH SOMITE.

BY J. PERCY MOORE.

Perhaps the most noteworthy of a number of annelids collected in the mountain region of North Carolina during the summer of 1898 is the little leech about to be described. The form appears to be rare, as it was met with but once. On this occasion an even dozen were found attached in a close cluster to the axillary and pectoral regions of a large *Desmognathus nigra.* As the morphological interest attaching to these leeches was at once recognized (though unfortunately not until all had been killed), special efforts were made to add to the supply. Notwithstanding that several hundreds of the salamander host were examined, the examples first collected remain unique. The locality is a mountain stream on the Yonahlossee road, at an elevation exceeding 3,500 feet. In about one-half or more of the specimens the gastric cæca were distended with blood, apparently derived from the salamander on which they were found. During life they were sluggish, and remained huddled together in a contracted state, making but little attempt to creep about or even to extend themselves.

Falling naturally within the limits of the *Glossiphonidæ,* this is, I think, the smallest species of that family which has been discovered, the length of sexually mature individuals in a half-extended condition being only from four to five millimeters. But of much greater interest is the, up to the present time, entirely novel structure of the complete somites, none of which present more than two well-defined external rings and whose internal relations are such as to elucidate several points affecting the value and limitations of the typical leech somite. The Chinese leech *Torix mirus* Blanchard ('98) is scarcely larger than the salamander leech and approaches it very closely in the external structure of the somites, which are biannulate dorsally and triannulate ventrally. Nothing is yet known of its internal anatomy. A further study of *Torix* may render unnecessary the establishment of the following genus:

MICROBDELLA gen. nov.

The complete somites each consist externally of two annuli, a smaller posterior, and a larger anterior, which bears the metameric sensillæ on its posterior part and the nephridiopores on its anterior part. There are five pairs of testes, of which the last is enlarged. Intersegmental septa are well developed between many of the somites.

Microbdella biannulata sp. nov. Pl. VI.

Description.—The body is strongly depressed and sharp at the margins, though less so than in many parasitic species of *Glossiphonia*, etc. The suckers, and more especially the posterior one, are large even for a species of parasitic habit. Measurements are of no great value, as the proportions vary so much with the degree of extension or contraction or according to the amount of food contained in the stomach, but the specimen figured, which had the cæca only moderately filled, and was about two-thirds extended, had the following measurements:

Length 6.3 mm.
Greatest width (XV) 2 mm.
Greatest depth (XVII) .6 mm.
Diameter of acetabulum 1.4 mm.

Of course the species may reach a larger size than that attained by the type specimens, as among leeches sexual maturity is no indication of full growth, but if these specimens were found in their normal habitat this seems improbable.

The large size of the posterior sucker (Pl. VI, figs. 1, 2 and 3) is an excellent adaptation for retaining a hold on the slippery skin of a salamander, and the region of the body to which the leeches were found fixed is that which would afford them almost the best protection, and from which they would be least likely to be swept away when the host is actively swimming or when it burrows amongst shingle and pebbles, as is the habit of its kind. The anterior sucker is not expanded laterally, but its posterior margin is largely free and mobile (figs. 2 and 3).

The small mouth is situated in the anterior part of the ventral surface of the sucker, apparently in somite II (fig. 2, *m*). Almost immediately dorsal to it, and in the posterior half of somite III, is a conspicuous median spot of black (really dark brown when strongly illuminated in sections) pigment in which the two eyes are embedded close together (figs. 1 and 3, *e*). So intimately united are they that they can be resolved only in good sections. They have the typical structure. The male pore is between somites XI and XII. This opening (figs. 2 and 3, ♂) is large and conspicuous and is frequently rendered still more obvious by the partial eversion of the atrium. The much smaller female pore (figs. 2 and 3, ♀) lies in somite XII in a line with the furrow which separates the major and minor annuli, although the furrow itself is not usually continued so far onto the ventral surface. In the usual position on the dorsal surface just above the acetabulum, the rather large anus is situated; it lies behind or partly within somite XXVII (figs. 1 and 3, *a*).

Sixteen pairs of nephridial pores (figs. 2 and 5, *np*) have been definitely located on the ventral surfaces of the corresponding number of somites from VII to XXII inclusive. A seventeenth pair was sought, but not found, on somite XXIII, but owing to the proximity of this region to the acetabulum the integument is here much wrinkled, and they might readily have been overlooked in the several specimens examined. In the middle region of the body the pores are distinctly visible in surface views, and in sections the entire series can be readily traced, although the vesicles are so small that they rarely extend through more than two or three transverse, or twice that many longitudinal sections. Their position in the somite is of greater interest. The two pores of each pair are separated in the example figured by a distance which is approximately equal to one-half of the entire width of the body, but this distance necessarily varies with the shape of the body resulting from the greater or less distension of the gastric cæca. Antero-posteriorly they lie a little cephalad of the middle of the major annulus, their position being often marked by a very faint groove, which may extend nearly the width of the body.

The typical complete somites (figs. 1, 2 and 3) of this genus, as previously stated, consist of two distinct annuli, but these are generally sharply defined only on the dorsal surface and even here the furrows which separate them are much less deep than those separating successive somites. Ventrally the interannular furrows are complete on a few of the anterior somites (VI to VIII, or thereabouts) only (fig. 2). Elsewhere they are much interrupted or extend only a little way mesiad from the margin. Not infrequently in longitudinal sections of contracted specimens a slight depression indicates the presence of traces of a faint furrow suggestive of incipient subdivision of the major annulus. This may occur not on the ventral side only, as noted above, but also dorsally, and always anterior to the line of sensillæ. The complete somites are, however, always strictly biannulate above and in most cases practically uniannulate below.

The metameric sensillæ (figs. 1 and 2) are rather small, and their arrangement could be worked out only partially in surface views of alcoholic specimens; the gaps were completed after the study of sections. In figs. 1 and 3, the rows of small circles, which do not accurately indicate the relative sizes of the several sense organs, show the typical distribution as finally determined. On fig. 2 those sensillæ only are shown which were seen in a single surface view, and they are represented as too large. They were found in sections in corresponding positions of other somites, but were not plotted. The dorsal median and inner lateral series are the best developed and, in fact, the sensillæ of these rows are the only ones which certainly have the typical structure, the others very frequently lacking the clear vitreous cells. It is worthy of comment in connection with Whitman's suggestion of the homology of these vitreous cells with epidermal glands that cells of the latter character are frequently associated with these smaller sensillæ. The six dorsal sensillæ occur constantly in all of the material examined, but the marginal organs are sometimes missing from one or more of the middle somites, and constantly so from somites I, II and III, and from two or three of the preanal somites, at least they could not be detected in sections. Of the small and inconspicuous ventral sensillæ, but two series were found on each side, whose position suggests the median and outer lateral. They are not entirely constant, even on the middle body region, one or more not infrequently being absent from a somite. The twelve sensillæ of each somite form a ring, the two halves of which are widely separated by a median interspace which is somewhat wider ventrally than dorsally. This ring encircles the major annulus half-way between the nephridiopores and the posterior margin of the annulus. There are nineteen (Nos. V to XXIII inclusive) complete somites of the character just described, except, of course, that the first two and apparently the last lack nephridiopores.

Somites of a simpler character are found at both the anterior and posterior ends of the animal. At the anterior end they are related to the sucker (figs. 1 and 3). Somite V, the first of the biannulate ones, is much crowded ventrally by the posterior margin of the sucker, which is constituted of somite IV. The subdivision of the latter somite into rings is evident on the dorsal aspect only, where the shallow furrow fades and disappears a short distance from the median line, and is very faint at the margins. The line of sensillæ is placed much closer to the middle of the whole somite than is the case in the biannulate somites and the marginal pair is absent. In somite III all trace of subdivision into rings is wanting, the inner and outer lateral sensillæ lie exactly along the middle of the one simple ring, while the median pair have risen to the importance of eyes, which have moved to the posterior margin of the somite. Somite II is also a simple undivided ring, as much narrower than III as the latter is narrower than IV. Its anterior bounding furrow is so shallow as to separate it only imperfectly from the prostomium. But two pairs of distinct sensillæ remain on this somite, being those of the inner lateral and median series.

On the prostomium (figs. 1 and 2) anterior to somite II is found a pair of median dorsal sensillæ which are the only ones which can certainly be referred to the segmental series. This region has, therefore, been designated as somite I, a value which was first determined for it by Apathy ('88), and later, and on better grounds, by Whitman ('92). Other sense organs there are which appear suspiciously like still additional segmental organs placed anterior to those last described and sometimes separated from them by the faintest of transverse grooves. The possibility of an additional rudimentary somite in this region is suggested by these appearances, and is somewhat strengthened by indications that the brain contains four more lobes or capsules than are necessary to satisfy the requirements of the number of somites counted. In the absence of decisive evidence, these somewhat uncertain indications have been disregarded for the present, and in the tentative enumeration of the metameres here adopted, the system of Whitman ('92), based as it is on a careful and exhaustive analysis of the nervous system of *Glossiphonia*, has been followed. If the material were available for a similarly exhaustive study of *Microbdella*, the number of preocular somites might be augmented. The question of the constitution of this region must, I think, be regarded as still open. Although recent work has been tending toward the establishment of a typical number of segments for all leeches a great many genera still remain to be examined with requisite attention to the details. It is quite possible that leeches may vary, as all other segmented animals vary. New somites may have been added within the history of the group, just as new annul are added when the needs of greater mobility require. On the other hand, it is even more probable that the process of reduction of the number of somites below that found in primitive annelids may have continued after the establishment of the Hirudinean type, and have progressed further in some forms than in others.

The first departure from the biannulate type of somite at the posterior end occurs at somite XXIV, in which two rings can be detected only at the margins (figs. 1 and 3). The dorsal sensillæ are all present. Somite XXV is commonly a simple ring, but in the example figured (fig. 1) presented an excellent example of the spiral variation of segmentation. On the left margin a small partial annulus appears anterior to the larger one, while on the right side the latter is alone present. A very interesting circumstance concerns the position of the sensillæ on this somite. On the left side they are placed nearer to the anterior than to the posterior margin of the larger annulus, while on the normal somites, in which the relative position of the two rings is reversed, the sensillæ lie toward the posterior margin of the annulus. The next two somites are represented by simple rings, of which the first, constituting somite XXVI, is united ventrally to XXV, while XXVII is similarly coalesced with the postanal somites. Somite XXVII bounds the anus in front and may be more or less cut into by it. The anus is succeeded by two rings which are separated from each other and from somite XXVII only dorsally. As both bear metameric sensillæ they must represent somites XXVIII and XXIX. A portion of this last-mentioned somite combined with five entire somites constitute the posterior sucker. These somites are not distinguished externally, but their number was determined by the number of ganglia in the posterior mass. Leaving out of account the possible rudimentary anterior somite the whole number counted is 34, a number which was first determined accurately by Whitman ('92), and is now generally attributed to all leeches.

Structural features of interest are not confined to the exterior, but some important characters are presented by the internal anatomy. In the first place, the intersegmental septa, which, as a result of the reduction of the cœlome, are so much modified and shifted in most leeches, are clearly represented by strong transverse sheets of vertical muscle fibres corresponding, except toward the ends of the worm, exactly with the external segmentation. Some of the septa are shown diagrammatically in figs. 4 and 5, *s*, where they are seen to begin on the ventral side exactly at the intersegmental furrows, though dorsally they tend to shift their attachments with the muscular and integumentary layers slightly forward to the smaller annulus of the preceding somite. Except where they are interrupted by the passage of organs continuing from somite to somite, the alimentary canal, principal blood vessels, longitudinal sinuses, genital ducts and nephridia, these septa are complete. The cœlome has been reduced as usual and the various organs are packed around with the usual parenchymatous tissues, glands, etc., but there are very few dorso-ventral muscle fibres except in relation to the posterior sucker. The dorso-ventral musculature of the middle region of the body is almost entirely represented by these septa, which have retained a simple structure and a primitive arrangement almost as definite and regular as in the *Oligochæta*.

Unfortunately no fresh material was available for a complete study of the nervous system by the more refined neurological methods. But by dissection, after maceration, of the preserved material, I succeeded in isolating in two examples almost the entire central nervous system, with the exception of a part of the posterior ganglionic aggregation. From these preparations and from sections the general features were determined and are represented on a small scale in fig. 5. The similarity to what is known of the nervous systems of other leeches is sufficiently evident. The anterior complex is composed of at least six and not improbably of seven neuromeres. In this region but six neuromeres were found by Whitman ('92) in *Glossiphonia* and other leeches, and by

Bristol ('98) in *Herpobdella.* The determination of the exact number in *Microbdella* is uncertain, but is based upon a count of the number of neuromeric lobes or capsules after Whitman's method. In each of the two dissections a few of these were displaced or broken, but by comparing them with each other and with sections the whole number appeared to be four greater than in either of the genera mentioned above. The distribution of the nerves of this region could not be worked out. However, I hope to be able later to state the exact number of metameres in *Microbdella.*

The seventh neuromere (still following Whitman's system of enumeration) lies very close to the subœsophageal ganglionic mass. Then follow in the ventral chain sixteen more widely separated ganglia arranged along a partially double nerve cord in the usual manner. Each of these ganglia lies principally in the major, but also partly in the minor annulus of its somite. Those from XXIV posteriorly become more and more closely crowded, the neuromeres XXVII to XXIX being especially intimately associated and practically part of the posterior complex, which is made up of very closely packed neuromeres ending as in other leeches with No. XXXIV, (fig. 5.)

Typical neuromeres of two complete somites (XII and XIII) are represented in figure 8. The six groups of nerve cells, each contained in a delicate nucleated capsule, so characteristic of the leech neuromere, are present. Four of these are arranged in pairs on the sides of the cord and the remaining two placed tandem on its ventral surface. Two nerve roots arise on each side from between the paired capsules and rather toward its ventral surface. They are bound closely together in a common sheath, so that they appear as a single nerve, on the surface of which lies a large (Leydig's ?) cell. After traversing the ventral sinus, and on entering the body walls, the two nerves completely unite, a second large cell being present at this point. From the place of union three nerve trunks arise, of which the anterior and larger (fig. 8, *v 1*) supplies the ventral portion of the larger annulus. It divides into an anterior and a posterior branch and I see no evidence whatever that these extend beyond the limits of the annulus in which they originate, but they were not traced to their end organs. A second branch (fig. 8, *v 2*) supplies the ventral part of the smaller annulus. The third (fig. 8, *d*) arises from the dorsal surface of the enlargement formed by the union of the two roots. It passes dorsad through the parenchyma, and without doubt corresponds with the dorsal branch of the third nerve of *Glossiphonia.* In dissections it was frequently broken off short, but in some cases was sufficiently well preserved to show that it splits into a number of branches after proceeding a considerable distance as a single trunk. In sections this main nerve could be traced upward as far as the dorsal longitudinal muscles among which it was lost.

In some respects the arrangement of the nerves of *Microbdella* resembles that of *Herpobdella* (Bristol, '98) more closely than *Glossiphonia.* The attempt to point out homologies without having traced these nerves to their final distribution is no doubt open to criticism, but a comparison of the nerve trunks in the two cases is almost as convincing as though this had been done. There is little reason for doubting that the two nerve roots of *Microbdella* correspond to the two trunks of *Herpobdella.* The anterior nerve of the former corresponds with the anterior nerve of the latter, the one which supplies the ventral surface of the first ring of its own somite together with the fourth and fifth rings of the preceding somite. But Bristol has shown that this nerve is the homologue of the first and second nerves of the neuromere of *Glossophonia,* which agrees with the subdivision of the anterior nerve of *Microbdella* into two branches. The posterior nerve of *Herpobdella* is essentially like that of *Glossiphonia;* it gives off branches to the ventral surface of the second ring of the somite in *Glossiphonia,* or to its homologue, the second and third rings of *Herpobdella.* In both genera this nerve also gives off a dorsal branch which is equivalent to the dorsal nerve of *Microbdella.* Every important element of the neuromere of *Glossiphonia* and *Herpobdella* is, therefore, represented in *Microbdella.*

The male reproductive organs (figs. 4 and 5) consist of five pairs of testes (*t 1–5*), of which the fifth is much larger than the others, and lies partly in somite XX, but chiefly in XIX. The remaining four are situated beneath as many gastric cæca in somites XV to XVIII. The majority of species of *Glossiphonidæ* have six pairs of testes, which are commonly described as being situated in somites XIII to XVIII, and although there is some discrepancy in position it may be suggested that the number prevalent in the family may have arisen by the subdivision of the fifth pair in *Microbdella*, or by a similar process affecting the anterior pair of an ancestral form. The primitive condition may be represented by the elongated saccular testes of *Archæobdella* (Kowalevsky, '96[a]), of which there is a single pair, by the subsequent subdivision of which the five or six pairs of the *Glossiphonidæ* may have been derived.[1] Still further subdivision would lead to the nine or ten pairs of *Hirudo*, the ten to twelve pairs of *Hæmopis* and finally to the numerous small testes of the *Herpobdellidæ*, which are so beautifully arranged to meet the structural conditions to which they must accommodate themselves. Increase in the number of testes is an accompaniment of progressive development in at least one series of leeches and is associated with increasing length of body and many correlated changes in the sperm ducts.

Another feature of the testes of *Microbdella* is the unusually large size, though this is not unique, of the sperm funnels (figs. 6 and 7). They are connected with the anterior, dorsal, mesial part of the wall of each testis and consist of cells of relatively large size. In vertical section they appear to be more or less columnar, but when cut tangentially are seen to be really flattened, somewhat plate-like cells set on edge and arranged concentrically around the mouth of the funnel. The marginal cells of the funnel pass somewhat abruptly into continuity with the excessively flattened epithelium of the testes which exhibits ciliated elevations at points corresponding to the positions of the nuclei. Toward the centre of the funnel the cells become higher, first cubical and then elevated and compressed, then again cubical as they pass through the mouth into the neck and finally change into the flattened epithelium of the vas efferens (fig. 6, *ve*). The free surfaces of all of the funnel cells are ciliated. On the more prominent parts of the funnel this ciliated area is continuous, but in the narrow neck becomes first interrupted by naked spaces and then reduced to small isolated patches of larger cilia. This latter condition becomes more emphasized within the vas efferens, where a small bunch of cilia arises on each cell opposite its nucleus. The vasa

[1] The posterior part of the testes has already become lobed and partly subdivided, so that the actual primitive condition has to this extent been lost. In this and some other features of its organization *Archæobdella* approaches the *Herpobdellidæ*.

efferentia (fig. 5, *ve*) pass vertically dorsad close to the basal part of the anterior surfaces of the gastric cæca, and in close contact with the posterior faces of the septa which limit their respective somites anteriorly. They unite above in a common vas deferens for each side. Unlike the vasa efferentia, the common sperm ducts (vasa differentia) are lined by a simple flattened non-ciliate epithelium. Their course is a perfectly straight one, without tortuosity or modification of any kind, just along the inner surface of the longitudinal muscular layer and exactly over the line of sperm funnels, as far forward as somite XII.

The vasa differentia finally terminate in the conspicuous sperm sacs (figs. 4 and 5, *ss*), which are modified enlargements of the sperm ducts, their walls being characterized by a strongly developed muscular layer and a thin lining epithelium. They have the form of a dilated tube folded into S-shape, and occupy somites XI and XII on each side of the œsophagus. The sperm sacs are not succeeded by narrow tubes (ducti ejaculatorii) of considerable length as in *Glossiphonia*, but open immediately through narrow constrictions into glandular sacs (figs. 4 and 5, *pg*). The latter rise vertically upward from the ventral ends of the sperm sacs, and after bending somewhat sharply caudad, become constricted and open into the glandular horns of the atrium (figs. 4 and 5, *at*). These horns are the terminations of the paired sperm ducts, and have a structure very similar to the section of the ducts which immediately precedes them. Each has a very narrow lumen and thick glandular walls. They may be considered as together constituting the prostates. The median atrium (*at*) which receives the openings of the sperm ducts, is a thin-walled muscular globoid sac, capable of being everted through the male pore—its external opening. The sperm sacs are packed full of mature spermatozoa in all of the specimens examined.

There is nothing especially noteworthy about the ovaries, which, within their sacs, are closely approximated and form together a massive organ lying between the nerve cord, alimentary canal and series of testes. They extend from somite XII to somite XVIII, and at the anterior end diverge from each other and form a ring through which passes the nerve cord, ventral to which they unite at the common ovarian pore (figs. 4 and 5, *ov*).

The alimentary canal is nearly like that of other small Glossiphonids. The protrusible pharynx (figs. 4 and 5, *ph*) extends to IX, extensible œsophagus (*œ*) to XIII, and the stomach thence to XIX, where it joins the intestine (*i*). A pair of nearly solid elongated glands are appended to the œsophagus in X (figs. 4 and 5, *g*). There are seven pairs of gastric cæca, of which the first six are small and simple and the seventh much larger and sacculated. They arise from the stomach within the major annuli of the seven somites from XIII to XIX. The first (*c 1*) bends cephalad somewhat sharply into somite XII, the next five are confined by the septa within the limits of the somites in which they arise, but they bend caudad more or less into the minor annuli and usually terminate in a bulbous enlargement (*c 4*). The seventh and last pair are continued through five somites, developing sacculations in each (*c 7*); corresponding enlargements also appear on the intestine.

Besides the position of the nephridiopores, which is described above, the only point concerning the nephridia which is worthy of comment relates to the funnels. These are very simple in structure, being composed of a single large cell. The vesicles into which they empty are formed of a small number of rather large cells. The funnels lie opposite to the outer ends of the cæca, toward their posterior dorsal surfaces, where they open into a sinus which corresponds to the complex which Oka ('94) has described in this region of *Glossiphonia* dorsal and mesiad to the lateral longitudinal sinus. They lie wholly within the minor annuli (fig. 5, *f*).

Microbdella appears to be one of those leeches in which fertilization is accomplished by the hypodermic injection of spermatozoa, a process which has been so nearly demonstrated by Whitman ('92[b]) for *Placobdella plana*. The evidence for this is found in the presence of spermatozoa in the sinuses and internal tissues of the body. The nephridial funnels and funnel vesicles are almost always gorged with spermatozoa which have been taken through the nephrostomata from the surrounding sinus. In several cases spermatozoa were found within the ovarian sacs, either aggregated in large masses or scattered among the ova. The presence of compact masses of spermatozoa in the ovaries suggests that fertilization may also be accomplished by the entrance of spermatophores directly through the ovipores. The species is protandric.

There is nothing striking or distinctive about the color of this species. The body is translucent and speckled with scattered green and brown pigment cells, the general effect of which is to give the animal a pale olive green color.

The Leech Somite.—The facts contained in the foregoing description seem to me to point conclusively to a necessity for some modification of current views regarding the constitution of the typical leech somite. Most text-books of zoölogy agree in stating of leeches that external and internal metamerism do not correspond. Except in so far as this means that the somites are externally divided into rings which have no internal counterparts (a condition which is also met with in many *Oligochæta* and *Polychæta*, in which there is said to be agreement between internal and external segmentation), this is not true of *Microbdella*, for in this leech the metamerism of the exterior does correspond most exactly with the arrangement of the internal organs in typical somites.

Let us reëxamine a typical somite. Externally its boundaries are indicated by deep furrows which extend all around the body. Between these intersegmental furrows the body wall is divided into two distinct rings, which are only faintly, and in most cases partially, indicated on the ventral surface. The first ring is the larger and bears the metameric sensillæ posteriorly and the nephridiopores anteriorly. Internally well-developed dissepiments correspond with the bounding furrows exactly on the ventral side and nearly so on the dorsal. Each somite contains a ganglion of the ventral chain from which arise nerves distributed solely within the limits of that somite. There is complete agreement between the neuromeres and external segmentation. In some of the segments the ducts of the testes are in contact with the anterior septa, cæca of the alimentary canal occupy just the distance between the two septa and nephridial funnels open within the limits of one somite to pass into tubules which perforate the following septum and open on the anterior part of the succeeding somite. The external segmentation does, therefore, agree with all of the principal internal systems in which metamerism is expressed.

If, adopting the current definition of a leech somite, we similarly examine the organization of any leech which has been fully described—*Glossiphonia*, for example, as being one of the most simple and best known—the chief discrepancy is found to exist between the arrangement of the nervous system and the groups of rings which indicate the somites externally. The two anterior rings of each somite are innervated by its own neuromere, and its third by the immediately succeeding neuromere, or, as Whitman ('92) has stated it, the peripheral nerves of typical somites "innervate three successive rings, the first and second of their own segment and the third of the preceding segment. The distribution is thus triannulate and dimeric." The body walls have, so to speak, slipped one ring backward on the nervous system or the nervous system one ring forward on the body walls.

Can it be possible that there is such a fundamental difference between two genera of leeches of the same family as would exist if both of the above interpretations are correct, and if not, which of the two interpretations must be accepted? An attempt to reply to these questions necessitates a close comparison between typical somites of the two genera. The most striking external difference is that the somite of *Glossiphonia* is triannulate, while that of *Microbdella* is only biannulate. As each has one ring bearing metameric sensillæ, the difference appears to be that *Microbdella* has one less ring lacking segmental sense organs than has *Glossiphonia.* There are no known external marks which constantly belong to the latter rings throughout the different genera, but the comparison of the nerve supply already given shows that the second annulus of *Microbdella* finds its counterpart in the ring of *Glossiphonia* which succeeds the sensilliferous one, for in the former genus there is no ring which receives its nerve supply from the succeeding neuromere, while the nerves which supply the second annulus in the two genera have been shown to be homologous.

The sensillæ-bearing annuli of the two genera under comparison resemble each other, in addition to the presence of the sense organs, in containing the nerve ganglion and nephridiopores,[2] and according to the accepted interpretation in being the most anterior of their somites. Without further examination it might therefore be concluded that these rings are homologous, that the biannulate

[2] The description of *Clepsine hollensis* Whitman is mainly being followed. In some other allied species the nephridiopores are on the boundary between this and the preceding annulus.

somite is equivalent to the first and second rings of the triannulate type, that the posterior ring of the latter is unrepresented in the former, and that the want of a nerve supply from the succeeding ganglion is correlated with its absence. But the sensillæ-bearing annulus of *Microbdella* is not in all respects like that of *Glossiphonia*. In the first place it is much larger than its fellow-annulus in the somite, while in *Glossiphonia* the annuli are of equal size or the sensillæ-bearing one somewhat smaller than its mates. It has been repeatedly shown by Whitman and Apathy and by many others in a great variety of leeches that all the annuli of a given species of leech are not equivalent, that a single annulus toward the end of the body may represent two or more annuli of a somite in the middle region. Such annuli almost invariably indicate their greater value by a larger size as compared with those adjacent. This fact alone should make it evident that the sensillæ-bearing annulus of *Microbdella* comprehends more than that of *Glossiphonia*. This additional part cannot be the middle annulus of *Glossiphonia*, for this has already been shown to have its exact counterpart, both in position and nerve supply, in the minor annulus of *Microbdella*. Just as certainly does the posterior position of the sensillæ indicate a greater value for the part of the ring in front than behind them and lead us to look for the missing member in a more anterior position, and consequently within the preceding somite of *Glossiphonia*. Comparison of the nerve supply locates it in the third annulus, for it will be remembered that the anterior part of the larger annulus of *Microbdella* is supplied by a nerve homologous with the one which in *Glossiphonia* reaches into the preceding annulus. The major annulus of *Microbdella* is equivalent, therefore, to the sensillæ-bearing annulus plus the one which precedes it in *Glossiphonia*; the first is represented approximately by that portion of the major annulus which bears the sensillæ and lies caudad of the nephridiopores and the second by the cephalic portion. Occasionally a very faint groove partially marks the boundary line.

If the limits of the somites of leeches have been hitherto correctly defined then *Microbdella* is a leech in which every somite throughout almost its entire length has obviously given up its posterior third to the following somite and absorbed the corresponding third of the preceding somite, a suggestion which is so improbable that it might almost be repudiated without examination. But the fact that the entire bodily organization, and especially the distribution of the nerves, point to the external metamerism of *Microbdella* as fundamental is sufficient to dispel any lingering suspicion with which we might be led to regard an animal which is very small and parasitic, and therefore a likely subject for degeneration. On the other hand, the lack of alignment between the neuromeres and external segments as hitherto determined argues forcibly against the current view. The interpretation of the structure of *Microbdella* shows, therefore, that the sensillæ-bearing annulus is the middle and not the first of the triannulate and quinqueannulate somites, and that we must look for agreement between the distribution of the nerves and the external segmentation in all leeches.[3] That the neuromeres cannot be an absolute criterion of the limits of all of the somites has, of course, been shown by Whitman for *Glossiphonia* ('92), in which the peripheral nerves of the anterior neuromeres shift and unite in such a manner as to obscure their segmental value. But this fact does not lessen their utility for determining the typical somites.

Since the above conclusions were reached about eighteen months ago, I have examined many genera and species in order to apply this new interpretation to their external segmentation, and in search of corroborative evidence. The latter has been ample; but the details are too voluminous for statement here and now. That the new standard of enumeration accords better with the facts and explains away some of the difficulties now found in all families of leeches is evident from the following general statements. The increasing simplicity of the somites from the middle toward the ends of the body becomes more gradual and regular; adjacent somites differ from one another by seldom more than one ring, whereas under the current system there are sudden jumps from five to three to one, etc. Moreover the individual somites almost invariably repeat the condition of the entire extremity in which they are located; their distal ends present (especially when the whole number of annuli is less than the typical number for the species) a less devel-

[3] After this paper had been written and presented for publication, Castle (Abstract of papers read at the New Haven meeting of the Morphological Society, *Science*, February 2, 1900, p. 175) announced his arrival at precisely the same conclusion. It is a real pleasure to be able to furnish such complete confirmation of results as carefully worked out as were Castle's.

oped condition than their proximal. The necessity for splitting rings—dividing the halves between two contiguous somites—practically disappears, for union of the rings of neighboring somites consisting of more than a single annulus each, is exceedingly rare, if indeed it ever occurs; division into somites is far more fundamental than division into rings, which have no primary metameric significance, and is never, or very rarely, obscured by the latter. The shifting of the sensillæ back and forth on the ring which bears them, as the balance of growth is thrown, with the splitting off of new rings, first on one side, then on the other, takes place exactly as it should if the present view is true, while it is inexplicable upon that hitherto accepted, in fact, contradictory of it. The same is true of many of the cases of spiral annulation and partial annulation which have been studied; and none have been found to favor the current view, while opposing the one here upheld. Very curiously the left side of somite XXV of fig. 1, representing the only important variation met with among the twelve examples of this species, illustrates the last two statements. If the sensillæ-bearing annulus be really the first of all leeches, why does the partial ring appear anterior to it, and why do the sensillæ of that side move forward? If the sensillæ belong primarily to the middle of the somite, the insertion of an anterior ring is perfectly natural and the change in position of the sensillæ the result of a readjustment of the ring to the new balance of growth. The differences in the location of the nephridiopores in different genera and families is a difficulty which others have recognized and tried to explain as a result of shifting or the disappearance of annuli. Upon the view here held the nephridiopores always fall within the same region of the somite and have shifted back and forth only within limits which might have been expected. The change in the position of the septa during ontogeny appears to be confirmatory, but this evidence is still rather obscure and unsatisfactory. A better explanation of the position of the intermuscular nerve rings described by Bristol in *Herpobdella* seems to be afforded.

But one[4] serious objection to the application of this neuromeric

[4] It has not been thought necessary to regard Blanchard's ('98) determination of the large double annulus of *Torix* as the posterior one, as an objection. This conclusion was arrived at without any knowledge of the

standard has been met with. In certain genera of leeches both sex-pores would fall within the limits of somite XII, whereas under the current system the male pore is in XI and the female in XII. This condition occurs very rarely outside of the family *Herpobdellidæ,* in which the sex pores are peculiarly liable to variation both between species and among individuals of the same species. Six out of seven North American species have them separated by two rings. In European species they are from two to five rings apart. In the genus *Orobdella* of Japan, Oka ('95) has described a variable number of rings as intervening, but the distance amounts to more than a full somite. Still more remarkable are the individual variations, among which it is not uncommon to find the two sperm-ducts, instead of opening together, with distinct apertures separated by one or even two full rings. These facts and others indicate that the pores are shifting their positions and it is along this line that a solution of the difficulty is being sought.

It is a matter of some morphological importance to find a standard by which the leech somite may be correctly delimited, and the present writer's chief interest is connected with the possibility which now exists for the first time, of making a detailed comparison between the Hirudinean and Oligochæte somites, a comparison which, it is believed, will do much to bring the two groups closer together and to weaken the position which is still adhered to by some eminent authorities that the *Hirudinea* were Platyhelminthine in origin. How the general theory of metamerism will be affected has not yet been considered.

The adoption of this standard will also necessitate the modification of the generic formulæ which were proposed in my paper on "Leeches of the National Museum" ('98). The theoretical formula may remain the same for leeches with three annuli and over, but the discovery of a more primitive biannulate form destroys some of its significance, and the annuli which undergo most elaboration must now be designated as *a 1* and *a 3* instead of *a 2* and

position of the nephridiopores or sensillæ or other intrinsic data for the determination of the limits of the somite. It is an assumption from the accepted theory and practice. When *Torix* is studied by means of sections it seems very probable that the nephridiopores will be found in the anterior half and the sensillæ on the posterior half of the double annulus. Should this surmise prove to be incorrect, *Torix* will probably present a serious obstacle to the acceptance of the conclusions suggested by the structure of *Microbdella.*

a 3, while *a 2*, which becomes the symbol for the middle sensillæ-bearing annulus, remains relatively stable.

The number of annuli into which typical somites are divided, together with the number and degree of departures from this type in a given form of leech have been much used in classification. Whitman and Apathy especially have considered these characters as of great phylogenetic significance. But the fundamental conceptions of these two zoölogists regarding the meaning of the facts belonging to the first-mentioned class are diametrically opposed. Up to now leeches have been known whose complete somites contained from three (two dorsally in *Torix*) to fourteen (twelve according to Apathy's count) annuli. Apathy ('88) believes that the latter is the primitive number and that all other types have been derived from this by a process of absorption and suppression of those rings which have lost their functional importance in the evolution of genera from a purely parasitic form to forms which have become adapted to a variety of environments. Whitman (90[a] and elsewhere) considers the triannulate type as the primitive one from which the multiannulate somites of the *Gnathobdellida* are derived by a process of progressive fission and multiplication of rings. The latter view seems to be most in accord with the facts of embryology and comparative anatomy and has been supported by several zoölogists, including the present writer.

It is well known that typical complete somites are absent from the end regions of nearly all leeches, where they are represented by somites which contain a smaller number of rings. Whitman, Apathy, and I believe all other modern writers on the *Hirudinea* are agreed that such somites, when of less than three rings, are the result of a process of reduction, that uniannulate or biannulate somites occurring in a typically triannulate leech have been derived from the latter type of somite by a process which is essentially one of phylogenetic concrescence—a shrinking in size of the affected rings, together with a smoothing out of the furrows which genetically separate them. The favorable argument seems to be derived largely from analogy to other groups of segmented animals and it must be admitted has seemed to explain the facts known up to the present time. Whitman, who is the author of this hypothesis, has formulated it as follows:

"All somites with less than three rings are abbreviated, and all with more than three have been increased by the division of one or two of the three primary rings. I have collected considerable evidence, which cannot be given here, to show that in the evolution of *Hirudo,* it was the second and third rings that underwent division, while the first remained undivided" ('92, p. 392). Probably the authors of the opinions that the triannulate or multiannulate somites represent the primitive types would admit the probability of the occurrence of a uniannulate ancestor somewhere in the remote history of the *Hirudinea,* but evidently no such form was looked for within the limits of the group. Blanchard ('98), to whose activity in systematic studies we owe the discovery of so many important generic types of leeches, describes the typical somite of *Torix* as biannulate with one ring subdivided into two on the ventral surface. This type of somite he regards as more primitive than that of *Glossiphonia,* and prophesies the discovery of a uniannulate leech, a prophecy which *Microbdella* so nearly fulfils. The discovery of a truly biannulate leech sheds new light on the subject, and it seems very doubtful if Prof. Whitman himself would explain this condition as a process of abbreviation affecting all of the somites of the body, and most of them in a perfectly similar manner and to an equal degree. The variation shown in the somite XXV of fig. 1 affords, however, one little bit of evidence for such a contention, for it is indeed very curious that the only distinct attempt toward the separation of annulus *a 1* should occur in a somite which is in other respects of simpler structure than the type. I have no explanation or excuse to offer for this bit of wilfulness upon the part of my material.[5] The crucial question is really which is the most primitive in structure, *Glossiphonia* or *Microbdella.* If the former shows evidence in its general organization of standing nearer to the ancestral Hirudinean stock, then the biannulate somite has probably been derived by abbreviation of the triannulate. If *Microbdella* proves to be the more generalized, the converse is probably true. In the general description reason has been given for believing that the latter is true. The evidence is found chiefly in the exact agreement between the metameres as expressed internally and externally

[5] There is evidence that this and some similar variations may be the result of a conflict between immediate mechanical factors and hereditary influences.

by the different systems of organs, and in the structure and arrangement of the dissepiments, testes and nephridia. The few specialized characters are unimportant and easily explained. It is therefore concluded that *Microbdella* approaches nearer to and throws light upon the characters of a primitive ancestral leech which phylogenetically preceded the *Glossiphonidæ,* etc. The triannulate somite of the latter has, therefore, been derived from a biannulate somite. The derivation of the multiannulate from the triannulate type is but the continuation of the general process of elaboration begun earlier, and which affords a means of maintaining the flexibility of the body as it increases in length.

The structure of *Acanthobdella* (Kowalevsky, '96[b]), which is a true annectant type between *Hirudinea* and *Oligochæta,* seems to present a difficulty, as this leech appears to have quinqueannulate somites, but the discussion of this remarkable form can profitably be postponed until the publication of Kowalevsky's final paper, which has not, I believe, yet appeared.

Microbdella also furnishes some data which seem to make it sufficiently clear that in the development of the triannulate from the uniannulate somite (if such a type actually existed), the latter first became enlarged posterior to the segmental sense organs, a posterior ring was then split off which became the third (*a 3*). The anterior part of the then biannulate somite grew and a furrow was formed approximately in the plane of the nephridiopores, thus producing the first ring (*a 1*) and leaving the sensillæ on the second (*a 2*). Some direct evidence of an embryological nature, and a considerable amount of collateral evidence derived from comparative anatomy and relating chiefly to the relative positions of the internal organs in a number of genera has been collected in support of this view, but cannot be given here.

The conclusion arrived at that the triannulate has been reached through the biannulate somite leads to one further consideration. Are the uni- and biannulate somites which are so generally found toward the ends of the body in nearly, if not quite, all leeches the product of abbreviation as now universally admitted? The answer is in large part a corollary from the above conclusion, but the very fact of the occurrence of one or several biannulate somites[6]

[6] Such somites are not usually apparent by the current manner of counting, as the larger rings have very often been interpreted as indicating fusions of contiguous parts of neighboring somites.

having all of the essential characteristics of the typical somite of *Microbdella* in both the anterior and posterior ends of nearly all leeches is in itself very significant. The argument then is the same as that adopted by Whitman ('92) to show that the triannulate somites of the *Hirudinidæ* are "type somites" and not "abbreviated somites." It is therefore believed that the smaller number of rings embraced by the somites toward the ends of a leech's body is not due to their having been reduced from the condition of complete somites, but that most of them represent phylogenetic stages of development arrested or still in progress toward the complete type. We may therefore read one part, and this no doubt much garbled, of the story of a leech's ancestry in the records of its somites from the extremities toward the middle of its body. There are, of course, other versions of this story which are recorded elsewhere. It is not meant to be implied that the retrograde process of abbreviation has never occurred in the differentiation of the genera of leeches, as some almost certain cases of this are known, but it is believed that they are infrequent and that the process has not played anything like the important part which has been attributed to it. Nor must it be supposed that a leech which presents a large number of incomplete somites is regarded as necessarily primitive, for it is recognized that specialization of somites may take place, and has taken place, in other ways than by an increase in the number of rings, for example, by a great development of segmental sense organs, as in the *Hirudinidæ*.

The difference (in respect to the number of component rings) between somites of the middle and terminal regions of a leech's body is believed to have arisen phylogenetically by a process which is more accurately described as one of centrifugal expansion and elaboration rather than "centripetal abbreviation." The somites of the middle region probably first increased in size and multiplied their annuli and in this region the process has advanced the farthest. From this centre the change has extended toward the ends, but with gradually diminishing effect. The terminal somites, already specialized in other directions, might be positively lowered in efficiency by any increase in length.

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EXPLANATION OF PLATE VI.

Microbdella biannulata.

Figs. 1, 2 and 3. Dorsal, ventral and lateral views, respectively, of a full grown, partly extended specimen, showing the chief external characters. × (about) 15. I to XXVII, the twenty-seven preanal somites; *m*, mouth; *a*, anus; *e*, the ocular pigment spot; ♂, male pore; ♀, female pore; small circles indicate the segmental sensillæ and dots (in fig. 2) the nephridiopores.

Fig. 4. A semi-diagrammatic representation of some of the more important features of the alimentary canal, organs of reproduction and dissepiments as seen from the dorsum. The entire digestive tract is outlined and the reproductive organs are seen as though it were transparent. The sperm sacs are displaced laterally in order to expose the atrium. The parenchyma and other filling tissues are

left out of account. × 15. *m*, mouth; *ph*, pharynx; *œ*, œsophagus; *g*, œsophageal glands; *c 1–7*, the seven pairs of gastric cæca; *i*, intestine; *a*, anus; ♂, male pore; *a*, median atrium; *pg*, prostate sac and gland; *ss*, sperm reservoir; *vd*, vas deferens; *t 1–5*, the five pairs of testes; ♀, female genital pore; *ov*, ovaries and their ducts (the arrangement of the loops of the egg-strings is purely diagrammatic); *s*, the muscular dissepiments corresponding to the anterior limits of somites XI to XX.

Fig. 5. A lateral view similar to fig. 4, and showing in addition the entire length of the central nervous system, the positions of the nephridiopores and of two of the nephridial funnels. The sperm sac has been displaced slightly caudad. The lettering is the same as in fig. 4, with the following additions: *n I–VI*, *XV*, *XXVI* and *XXVII–XXXIV*, neuromeres as numbered; *np 1–16*, nephridiopores 1 to 16; *f*, funnels of nephridia; *ve 1–5*, the five vasa efferentia.

Fig. 6. A vertical longitudinal section through a sperm funnel of the last pair, showing the continuity of its cells with the testicular epithelium on the one hand, and with its vas efferens on the other, and the contact of the latter with the muscular septum. The testes, of course, faces to the right instead of the left as in fig. 5. × 300. *d*, dorsal wall of testes, with *e*, its lining epithelium, and *ct*, its connective tissue tunic; *a*, anterior wall of testes; *m*, muscle fibres, and *cs*, connective tissue of septum; *ve*, ciliated epithelium of vas efferens.

Fig. 7. A tangential section across a sperm funnel, showing the concentric arrangement of the cells around the contracted mouth. × 300.

Fig. 8. Two typical neuromeres, XII and XIII, showing the principal nerve trunks and their relation to the annuli, etc. × 35. *ma*, major, and *mi*, minor annulus; *s*, position of the row of metameric sensillæ; *np*, position of nephridiopore; *v 1*, anterior, *v 2*, posterior, and *d*, dorsal nerve trunks; *l*, Leydig's (?) cells.

NEW AND UNFIGURED UNIONIDÆ.[1]

BY CHARLES T. SIMPSON.

In preparing a synopsis of the *Naiades*, quite a number of new species of *Unionidæ* have come to light. These I have held until the work should be practically finished, and they are here published for the first time.

Messrs. S. H. and B. H. Wright having generously donated the types of most of their species to the National Museum, it was thought best to give figures of those which were described in *The Nautilus*, and which are unfigured.

Only brief descriptions are here given of the new genera and of a few used in a new sense. These will be fully described in the *Synopsis*.

Genus LAMPSILIS Rafinesque.[2]

Lampsilis fallaciosus (Smith) Simpson. Pl. II, fig. 5.

Lampsilis fallaciosus Smith, Bull. U. S. Fish Com., 1899, p. 291, Pl. 79. Figured and name given, but not described nor authority given.

Shell elongate elliptical, subsolid, inflated, rounded in front, and ending in a rather sharp point behind, at two-thirds of the height of the shell, with a moderate, rounded posterior ridge; beaks not prominent, their sculpture consisting of a few delicate parallel ridges, somewhat doubly looped, the hinder loops generally open behind; epidermis very smooth and shining, ashy straw color, often brownish on the back of the shell, generally feebly rayed with green; female shell decidedly swollen in the postbasal region, so that the base line is often incurved in front of the swelling; teeth rather delicate, there being one compressed pseudo-cardinal and one lateral in the right valve, and two pseudo-cardinals and two laterals in the left; beak cavities not deep; nacre brilliant, silvery.

Length 90, height 40, diam. 32 mm.

[1] Published by permission of the Secretary of the Smithsonian Institution.

[2] See Simpson in Baker, *Mollusks of the Chicago Area*, 1898, p. 93.

Upper Mississippi drainage; scuth to the Cumberland and Arkansas rivers; Red river of the North.

This species has generally been confounded with its near ally, *Lampsilis anodontoides* Lea. It is a smaller, more inflated, and in every way a more delicate form than the latter, it is not so high, the epidermis is brighter and more glossy, and generally rayed. The postbasal inflation of the female is usually more pronounced, and the posterior point is higher than in *anodontoides*. The latter is usually more yellow or tawny than *fallaciosus*, and is, on the whole, a heavier shell.

In *L. fallaciosus* there is a horny, brown, raised streak on the inside of the mantle behind, that I do not find in *anodontoides*, and the palpi of the former are shorter.

Lampsilis australis Simpson. Pl. II, fig. 2.

Shell long elliptical, subsolid, moderately inflated, bluntly pointed behind above the middle; beak sculpture not seen on account of erosion, posterior ridge low, rounded; epidermis smooth, shining, greenish yellow, rayed with green, with a large burnt brown patch on the central and upper part of the shell; female shell slightly inflated in the postbasal part; hinge teeth delicate, somewhat compressed; beak cavities moderate; nacre bright bluish white, iridescent behind, dark lurid in the cavity of the shell.

Length 52, height 28, diam. 15 mm.

Little Patsaliga creek, southeastern Alabama.

Both the type, a young shell, and an older, larger specimen are badly eroded at the beaks, so that the hinges are slightly injured. I am not positive as to the relations of this species, but it seems to belong in the *anodontoides* group, next to *L. rectus* Lam.

Lampsilis mearnsi Simpson. Pl. I, fig. 4.

Shell small, rather solid and inflated, elliptical, pointed at the middle of the posterior end, with a rather pronounced, rounded post ridge; beaks moderate, the sculpture consisting of several ridges looped in a single loop, which are strongly curved upward behind; epidermis tawny with a greenish tint, rather smooth and shining, though sometimes a little silky, often with a large, dark green blotch at the posterior base, which sometimes covers the entire posterior half of the shell, or it may break into rays at its front edge; female shell decidedly swollen at the postbase; hinge teeth rather delicate; laterals curved; pseudo-cardinals smooth below and slightly reflexed upward; muscle scars distinct; beak cavities shallow; nacre brilliant, soft silvery, yellowish or salmon.

Length 53, height 30, diam. 22 mm.

Near Fort Clark, southwest Texas.

A large number of valves and several perfect specimens were contributed to the Museum by Dr. Edgar A. Mearns, of the U. S. Army. It is closely allied to *L. texasensis* Lea, but it has a higher posterior ridge, is much smoother, and the remarkable color pattern is totally different.

Lampsilis brittsi Simpson. Pl. V, figs. 1, 2.

Shell elliptical, subsolid, moderately inflated; beak sculpture not seen; epidermis smooth, shining, greenish yellow to tawny, with delicate wavy, often broken green rays; hinge line curved; pseudo-cardinals small, rather high but stumpy; laterals somewhat remote; muscle scars distinct; nacre whitish to salmon colored.

Animal: Marsupium occupying the hinder part of the outer gills, with 13–15 large ovisacs having dark bases; inner gills united to abdominal sac throughout; mantle with a thick border, incurved in the female behind the postbase, and having several strong, lengthened, fingerlike papillæ; palpi small; branchial and anal openings but slightly fringed.

Length 72, height 43, diam. 23 mm.

The female shell is decidedly emarginate behind the postbasal swelling.

Differs from *L. breviculus* in several respects. The female shell is more emarginate behind; the painting is in more regular, wide rays. The male shell of *breviculus* is obovate, rounded or slightly biangulate behind; that of *L. brittsi* is more elliptical and pointed posteriorly.

Lampsilis kirklandianus S. H. Wright. Pl. I, fig. 7.

Unio kirklandianus S. H. Wright, Naut., X, 1897, p. 136.

A wonderfully beautiful shell, of which I have only seen the type, apparently a male. It is very different from the ordinary manifestation of *Lampsilis*, but seems to be nearly related to the *Unio subangulatus* of Lea, which is nearer the typical form of the genus, and in which the difference between the male and female shells is clearly shown. The marsupium is of the *Lampsilis* type.

Lampsilis villosus B. H. Wright. Pl. I, fig. 1.

Unio villosus B. H. Wright, Naut., XII, 1898, p. 32.

A species close to the *Unio amygdalum* of Lea, but which also seems to be related to his *U. exiguus*.

Genus **MEDIONIDUS** Simpson.

Shell elongated, elliptic rhomboid, subsolid, with a more or less definite posterior ridge; beak sculpture fine, subparallel, broken, doubly looped ridges; epidermis smooth, rather bright, variegated with broken green rays or clouds; pseudo-cardinals small, stumpy; laterals curved; female shell generally slightly swollen at and behind the central base; marsupium occupying the centre and postcentre of the outer gills, in a few large, irregular, distinct ovisacs. Type *Unio conradicus* Lea.

Medionidus walkeri B. H. Wright. Pl. I, fig. 5.

Unio walkeri B. H. Wright, Naut., XI, 1898, p. 91.

A singular shell, but most probably related to *Unio rubellinus* of Conrad, which is a member of this genus.

Genus **NEPHRONAIAS** Crosse and Fischer.

Shell rather solid, elliptical, more or less biangulate behind, that of the male often becoming arcuate when old, that of the female generally swollen on the postbase; surface sulcate; beaks sculptured with faint, broken ridges; two pseudo-cardinals in each valve; laterals perfect; beak cavities rather deep.

Type *Unio plicatulus* Charpentier.

Nephronaias reticulatus Simpson. Pl. II, fig. 3.

Shell evenly elliptical, subinflated, rather solid, slightly biangulate behind; surface decidedly sulcate and sculptured throughout with radiating ridges or slight furrows, which cut the sulcations into loops, and give the shell a reticulated appearance; epidermis tawny; pseudo-cardinals stumpy; laterals rather heavy and granular; muscle scars distinct; nacre lurid, thicker in front.

Length 50, height 33, diam. 20 mm.

Patook river, Honduras.

A single shell, which is probably not fully adult, is in the National Museum collection. The sculpture reminds one of that of *Glabaris reticulatus* Sowb., of South America, or *Plagiola encarpa* Lea, of Lake Nicaragua.

Genus **OBOVARIA** Rafinesque.

Shell solid, inflated, short, rounded before and often behind, that of the female swollen at postbase; beaks high, their sculpture delicate and faint, slightly doubly looped; epidermis silky, but feebly rayed; pseudo-cardinals and laterals strong; animal having the marsupium in the hinder part of the outer gills with well-marked ovisacs.

Type *Unio retusa* Lamarck.

Obovaria rotulata B. H. Wright. Pl. IV, fig. 2.

Unio rotulatus B. H. Wright, Naut., XIII, 1899, p. 22.

A very solid shell, nearly circular in outline, and having a black epidermis. It seems to be closely related to the *Unio circulus* of Lea, but I have only seen a single specimen, the type.

Obovaria tinkeri B. H. Wright. Pl. IV, fig. 3.

Unio tinkeri B. H. Wright, Naut., XIII, 1899, p. 7.

A species near to the *Unio unicolor* of Lea, but probably distinct.

Genus **TRITOGONIA** Agassiz.

Shell elongate rhomboid, solid, that of the male somewhat swollen and truncate behind, that of the female longer, more compressed, and having a rounded posterior wing or flap; posterior ridge high and well defined; beak sculpture consisting of strong, irregular corrugations; surface covered with tubercles; epidermis dark and rough; hinge strong, curved; a decided lunule showing in front of the beaks, which extends underneath and behind them, and is filled with epidermal matter; pseudo-cardinals strong, ragged, radial; laterals somewhat remote, two in each valve; muscle scars distinct, those of the anterior deep and rough; beak cavities deep, compressed; dorsal scars on the under side of the hinge shelf.

Animal: Inner gills much the larger, mostly free from the abdominal sac; palpi enormous, elongated; mantle of male truncate behind, that of the female produced into a wide, rounded, thickened flap filling the wing of the shell behind; marsupium not observed.

Type *Unio tuberculatus* Barnes.

? Tritogonia conjugans B. H. Wright. Pl. IV, fig. 1.

Unio conjugans B. H. Wright, Naut., XIII, 1899, p. 89.

A most remarkable shell, of which only the type, probably a male, is known. I am not certain as to the relationship of this species. It does not have the biangulation at the postbase generally found in male shells of *T. tuberculata* Barnes, but has an almost straight truncation from the postbase to the dorsal region. However, *T. tuberculata* often shows such a truncation when young, and we have shells of this an inch and a half in length which are much like *T. conjugans* would be at the same size.

Genus **PTYCHOBRANCHUS** Simpson.

Shell somewhat subtriangular or elliptical, solid, that of the male and female alike; epidermis having hairlike or broken rays; beak sculpture faint, broken, and somewhat doubly looped ridges; hinge strong; pseudo-cardinals stumpy; laterals club-shaped, remote; the muscle scars deep; shell cavity with one or more oblique furrows. Marsupium occupying the entire outer branchiæ in a series of beautiful, wide folds, the ovisacs well marked and rounded below.

Type *Unio phaseolus* Hildreth.

Ptychobranchus clintonensis Simpson. Pl. V, fig. 3.

Shell elongate, elliptical, sometimes slightly obovate, feebly biangulate behind, quite solid; beak sculpture not seen; epidermis somewhat clothlike, dirty olive, the hinder two-thirds of the shell ornamented with delicate, wavy, capillary rays; pseudo-cardinals low, laterals very heavy, remote; muscle scars large and well defined; nacre lurid, with greenish brown blotches.

Length 73, height 40, diam. 22 mm.

Archie's Fork of Little Red river, near Clinton, Ark. Probably extends into Kansas.

This form I at first mistook for a variety of *Unio gibbosus* Bar., but an examination of the animal in a gravid state later on showed me that it is a *Ptychobranchus*. The soft parts of the specimens examined were a dark leaden color, almost blue.

Genus **UNIO** Retzius.

Unio iheringi B. H. Wright. Pl. IV, fig. 5.

Unio iheringi B. H. Wright, Naut., XII, 1898, p. 93.

This shell is rather close to *Unio mitchelli* Simpson, but differs from it in the character of the beak sculpture, in the rays, the texture of the epidermis, and in the form.

Unio dispalans B. H. Wright. Pl. I, fig. 9.

Unio dispalans B. H. Wright, Naut., XIII, 1899, p. 50.

A member of the *complanatus* group, probably, though it has relations with that of *buckleyi* and *fisherianus*. It is one of those puzzling forms which is a good deal like several things, but not near enough to anything to be referred to it.

Unio lehmani S. H. Wright. Pl. IV, fig. 9.

Unio lehmani S. H. Wright, Naut., X, 1897, p. 138.

A member of the *buckleyi* group.

Unio burtchianus S. H. Wright. Pl. IV, fig. 8.

Unio burtchianus B. H. Wright, Naut., X, 1897, p. 137.

Another member of the *buckleyi* group.

Unio pinei B. H. Wright. Pl. III, fig. 1.

Unio pinei B. H. Wright, Naut., XI, 1897, p. 40.

Near to forms of *U. buckleyi*, but probably distinct.

Unio buxtoni B. H. Wright. Pl. I, fig. 6.

Unio buxtoni B. H. Wright, Naut., XI, 1897, p. 55.

A peculiarly formed member of the *buckleyi* group.

Unio brimleyi S. H. Wright. Pl. IV, fig. 6.

Unio brimleyi S. H. Wright, Naut., X, 1897, p. 138.

A species related to *U. subplanus* Conrad.

Genus **PLEUROBEMA** (Rafinesque) Agassiz.

Shell solid, oval, triangular or rhomboid, usually inflated, inequilateral, with high beaks, their sculpture coarse and broken; epidermis generally tawny, but sometimes brownish or black, often having broken rays and square spots; rest lines strong; hinge heavy, with pseudo-cardinals and laterals; beak cavities shallow, nacre white. Embryos contained in the outer gills alone.

Type *Unio clava* Lamarck.

Pleurobema brevis subelliptica Simpson.

Shell elliptic rhomboid, solid, inflated, slightly biangulate behind; beaks rather high, but compressed, sculptured with strong, irregular corrugations that curve up behind; epidermis tawny, with a few faint posterior rays; rest marks moderate; nacre silvery, iridescent behind; muscle scars well marked; beak cavities moderate; teeth strong, two laterals in each valve.

Length 55, height 40, diam. 28 mm.

Hardy, Arkansas. Tennessee drainage, probably.

Something like *P. brevis* Lea, but much more inflated, and slightly rayed instead of square blotched, and less rhomboid. Probably a distinct species.

Pleurobema avellana Simpson. Pl. II, figs. 6, 7.

Shell small, solid, inflated, rhomboid elliptical, with a well-developed, rounded posterior ridge; beaks full, badly eroded in the only specimens seen; surface lightly concentrically striate, greenish brown, scarcely rayed, but slighly clouded; two diverging pseudo-cardinals in the left valve and one in the right; two laterals in each valve; muscle scars deep; nacre bluish, iridescent behind.

Length 30, height 20, diam. 15 mm.

Catawba river, Alabama. Collections of Bryant Walker and Lorraine Frierson.

Seems to be near *P. rubellus* Con.

Pleurobema strodeana B. H. Wright. Pl. I, fig. 3.

Unio strodeanus B. H. Wright, Naut., XII, 1898, p. 5.

This species is nearly related to *P. patsaligensis* and *P. simulans.*

Pleurobema harperi B. H. Wright. Pl. I, fig. 10.

Unio harperi B. H. Wright, Naut., XIII, 1899, p. 6.

I am somewhat doubtful whether this is more than a variety of *Unio bulbosus* Lea.

Pleurobema pinkstoni S. H. Wright. Pl. I, fig. 8.

Unio pinkstoni S. H. Wright, Naut., X, 1897, p. 136.

Related to *P. hanleyana* Lea and *P.*

Pleurobema swordiana S. H. Wright. Pl. IV, fig. 4.

Unio swordianus S. H. Wright, Naut., XI, 1897, p. 4.

A puzzling form which may be related to *Unio appressus* of Lea and *U. abacus* of Haldeman. Its shallow beak cavities distinguish it at once from *Unio bursa-pastoris* of B. H. Wright, which it resembles, but which has deep cavities.

Pleurobema patsaligensis Simpson. Pl. II, fig. 1.

Shell rather small, nearly elliptical, subsolid and somewhat inflated, with a well-developed, posterior ridge, sometimes slightly biangulate behind; posterior slope with two or three faint ridges; epidermis a little silky, but shining when rubbed, greenish yellow, with scarcely perceptible rays, and often clouded with bluish green; beaks eroded and the sculpture not seen; hinge curved; pseudo-cardinals radiate, rather stumpy; two laterals in the left valve and one and a vestige of a second in the right; beak cavities moderate, but compressed; nacre whitish, often blotched with brown, iridescent behind.

Length 43, height 28, diam. 18 mm.

Little Patsaliga creek, southeast Alabama.

This groups with *P. strodeana* B. H. Wright and *P. simulans* Lea, but is perfectly distinct.

Pleurobema reolusa B. H. Wright. Pl. I, fig. 2.

Unio reclusus B. H. Wright, Naut., XI, 1898, p. 111.

Closely related to *P. harperi* and *bulbosa*.

Pleurobema argentea pannosa Simpson.

Shell rather solid, irregularly and rudely concentrically striate; epidermis where fresh somewhat clothlike, tawny or brownish.

White river and Hot Springs, Ark.

Possibly a variety of *P. argentea*, but it may prove to be a distinct species.

Genus **QUADRULA** (Rafinesque) Agassiz.

Quadrula rudis Simpson. Pl. III, fig. 2.

Shell large, long quadrate, inflated, solid, with high beaks, curved inward and forward, having apparently delicate corrugated sculpture, a decided, sharp, curved posterior ridge ending in a blunt point at the posterior base, in front of which the basal line is incurved, anterior end rounded, posterior end an even curve from the ligament to the postbase; epidermis brownish, rough, rayless; surface sulcate and, excepting the later growth, covered with sharply elevated small pustules which are sometimes united; hinge curved; a single very large pseudo-cardinal in the right valve which fits in a cavity of the left, around which there is a high ridge which develops into a high tooth behind the cavity; under the beaks is a sort of lunule which is extended inward across the hinge plate, which is partly filled with epidermis; laterals curved, rather delicate; anterior scars deep, those of the adductor very rough in the centre; posterior scars shallow, beak cavities very deep, slightly compressed; front part of the shell greatly thickened; nacre soft, creamy white.

Length 103, height 65, diam. 45 mm.

Rio Taxtunilha, Guatemala.

A single shell, the type, is in the Lea collection, presented to Dr. Lea by C. M. Wheatley, and labelled by the latter *Unio psoriacus* Morelet. It is evidently not that species, and is, I think, new. The type is nearly decorticated.

Quadrula guatemalensis Simpson. Pl. II, fig. 4.

Shell rather small, subrhomboid, solid, scarcely inflated, with a low posterior ridge, above which it is faintly biangulate; beaks moderate, their sculpture not seen; surface sulcate, covered throughout, with rather obsolete pustules and corrugations; epidermis dark brown, rough, rayless; there are two partially united pseudocardinals in the left valve, with a pit between them, into which the large tooth of the right valve fits; under and behind the beaks on the hinge plate is a deposit of epidermal matter; beak cavities moderately deep; nacre coppery purple.

Length 45, height 27, diam. 14 mm.

Rio Usumasintæ, Guatemala.

The only shell seen, the type, is probably young. It does not agree with anything I can find described, though it seems to come nearest to *Q. ostreata*.

Quadrula triumphans B. H. Wright. Pl. III, fig. 3.

Unio triumphans B. H. Wright, Naut., XI, 1898, p. 101.

A fine shell which has characters like those of *Q. boykiniana* and *multiplicata*, but which, I think, is neither.

Quadrula flexuosa Simpson. Pl. II, fig. 8.

Shell subtriangular, solid, inflated, with a faintly double posterior ridge, rounded in front and slightly incurved at the posterior base; beaks high, eroded in the only specimen seen; a low, wide, radiating depression leads from them down to the base; epidermis roughly concentrically striate, tawny to brownish, showing the rest marks; hinge plate wide and flat; pseudo-cardinals low, diverging, ragged; laterals straight, short, two in each valve; anterior adductor scars deep, rough; posterior scars distinct; nacre lurid whitish, dull.

Length 65, height 55, diam. 33 mm.

Holston river, Tennessee. Collection of L. S. Frierson.

Apparently nearest to *Q. plena*, but not so high or inflated.

Genus **NODULARIA** Conrad.

Shell elliptical to elongated, inflated; beaks not prominent, sculptured with some form of zigzag, radiating sculpture, which often extends over part or all of the shell; epidermis generally greenish, often bright; hinge provided with pseudo-cardinals and laterals which are usually somewhat compressed; beak cavities shallow; nacre whitish. Marsupium occupying the inner gills only.

Nodularia cylindracea Simpson.

Unio grayanus Schrenck (non Lea), Reis. und Forsch. im Amur-Lande, 1867, p. 694, Pl. XXVII, figs. 1–3.

Shell greatly elongated, inflated, rather solid and slightly arcuate, very inequilateral, rounded in front, with a low, rounded posterior ridge which runs to the postbase, where the shell ends in a somewhat rounded point, above which it is obliquely subtruncated; ligament large, long; surface apparently without sculpture save for slight concentric ridges; epidermis thick, brown, and in the shell figured cracking and peeling off; dorsal line wavy at the hinder end where the point of the shell turns a little to the right; pseudocardinals apparently broken up into several slightly curved denticles; anterior muscle scars deep and large.

Length 155, height 45, diameter 38 mm.

China.

Schrenck supposes this to be Lea's *Unio grayanus*, which is a smaller shell, is always more or less nodulous and corrugated, and has a pinched up posterior ridge and different pseudo-cardinals. He has three shells from a London dealer said to come from China. The specimen figured is very badly eroded on the dorsal region, and is apparently damaged at the postbase, while the heavy epidermis has peeled off in a number of places. I do not think it should group with *N. grayana*.

Genus **PSEUDODON** Gould.

Pseudodon loomisi Simpson. Pl. IV, fig. 7.

Shell elongated elliptical and slightly obovate, somewhat inflated, rather thin; beaks not high, the sculpture not seen; posterior ridge low, rounded; posterior slope having a few corrugations running in a nearly horizontal direction, the rest of the shell nearly smooth; epidermis black, rayless; there is a single rather elevated tooth in each valve, there being a vestige of a second in the right valve; laterals represented by a low, rounded ridge; beak cavities shallow; muscle scars well marked; nacre pale bluish, becoming a lurid salmon in the cavities.

Length 73, height 37, diam. 23 mm.

Asaka, Japan. Loomis.

This seems to be a rather peculiar *Pseudodon*.

EXPLANATION OF PLATES

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FEBRUARY 6.

MR. CHARLES MORRIS in the Chair.

Thirteen persons present.

Papers under the following titles were presented for publication:

"Additions to the Insular Land-shell Fauna of the Pacific Coast, especially of the Galapagos and Cocos Islands," by William Healey Dall.

"Notes on the Anatomy of the Helicid Genus Ashmunella," by Henry A. Pilsbry.

"Mollusca of the Great Smoky Mountains," by Henry A. Pilsbry.

FEBRUARY 13.

CHARLES SCHAEFFER, M.D., in the Chair.

Twenty-three persons present.

A paper entitled "Descriptions of New Bees Collected by Mr. H. H. Smith in Brazil. I," by T. D. A. Cockerell, was presented for publication.

The death of James B. England, a member, was announced.

FEBRUARY 20.

MR. CHARLES MORRIS in the Chair.

Sixteen persons present.

FEBRUARY 27.

The President, SAMUEL G. DIXON, M.D., in the Chair.

Sixteen persons present.

The death of Ernest B. Sangree, M.D , a member, was announced.

Harry G. Parker was elected a member.

Henri Lacaze-Duthiers, of Paris, and Frederick W. True, of Washington, were elected correspondents.

The following were ordered to be published:

ADDITIONS TO THE INSULAR LAND-SHELL FAUNAS OF THE PACIFIC COAST, ESPECIALLY OF THE GALAPAGOS AND COCOS ISLANDS.

BY WILLIAM HEALEY DALL.

Several expeditions, during the last five years, have made collections on islands lying off the Pacific coast of America, south of the United States. Material from most of them came into my hands for examination, or as the property of the National Museum.

In 1896, Mr. A. W. Anthony, of San Diego, Cal., undertook a collecting tour along the west coast of Lower California, touching at Rosalia Bay and Guadelupe, Cerros, San Martin, San Benito and Natividad Islands. The collection of land shells included several novelties and was acquired by the National Museum. A subsequent visit to Clarion Island was less lucky: the few land shells obtained were put into formalin solution, which destroyed them utterly before they could be identified.

Guadelupe has been visited by Mr. C. H. Townsend, of the U. S. Fish Commission, and the Coronado Islands and Tiburon by parties from San Diego, from whom small lots of material have been obtained.

In 1898–99 a party from Stanford University visited Guadelupe, Cocos and the Galapagos Islands, particularly exploring the less-known islets of the latter group.

The party consisted of Mr. R. E. Snodgrass and Mr. Edmund Heller, who, through the generosity of Mr. Timothy Hopkins, of Menlo Park, Cal., were able to take passage on a sealing schooner from San Francisco, commanded by Captain W. P. Noyes. The time from December, 1898, to July, 1899, was spent in the work. The attempt was made to spend as much time as possible on the less-known islands. A week was given to Chatham, ten days to Charles, but Tagus Cove, Elizabeth Bay and Iguana Cove, all on Albemarle Island, were given three months. Narborough had never been visited by collectors and Abingdon but rarely. On Bindloe, Mr. Snodgrass made careful search, but could find no traces of the species reported from it.

Through the kindness of President Jordan and Mr. R. E. Snodgrass, I have been able to examine and report upon the land shells of this expedition. All this material being of a congruent nature, the results obtained from a study of it may properly be assembled in a single paper.

The present publication may be regarded as a supplement to that published in the *Proceedings of the Academy of Natural Sciences* for 1896, pages 395–479, which was largely based on the collections made at the Galapagos by the late Prof. G. Baur.

Species from the Galapagos Islands.

The Stanford expedition collected land shells at Chatham, Hood, Charles, Barrington, Duncan, Albemarle, Narborough, James and Abingdon, islands of the group. From Narborough and Abingdon no collections had previously been made, but curiously enough no new species turned up on either. Narborough is probably the youngest island of the group, being actively volcanic in historic times; so perhaps its land shells are comparatively new immigrants from Albemarle, its nearest neighbor. But Abingdon, so small, distant and isolated, would have been expected to furnish some new material.

It was something of a surprise to find two new species from Albemarle out of ten collected, and three from Hood, all that were collected.

The additions to previously published lists of known species are three each to Albemarle and Narborough, six to Abingdon and one to Barrington.

The references are to my paper above cited of 1896, where the synonymy is given in full, and the species are here given in the same order, with the intercalation of those supposed to be new.

Bulimulus nux Broderip.

Bulimulus nux Dall, 1896, p. 429, Pl. XVI, fig. 6, Pl. XVII, fig. 10.

Charles and Chatham Islands, Snodgrass and Heller.

The collection of *B. nux* was not very large, but contained the banded variety (*B. unifasciatus* Reibisch non Sowerby) and the pale form, approaching *rugulosus,* which Reibisch named *invalidus.*

Bulimulus duncanus Dall.

Bulimulus duncanus Dall, 1896, p. 438, Pl. XVI, fig. 7.

Duncan Island, Snodgrass and Heller.

As in previous cases, all the specimens were dead, and those collected were not quite mature as the parietal denticle had appeared in none of them. The species is probably extinct.

Bulimulus eschariferus Sowerby.

Bulimulus eschariferus Dall, 1896, p. 434.

Chatham and Barrington Islands, Snodgrass and Heller.

This species had not been found at Barrington previously.

Bulimulus Snodgrassi n. sp. Plate VIII, fig. 2.

Bulimulus having the general form of *B. perspectivus* Pfr., with a distinct suture and eight polished moderately convex whorls; apex attenuated, nucleus livid, with an apical dimple and fine regular ribbing which becomes obsolete on later whorls; there is also on the first four whorls more or less spiral sculpture of microscopically fine lines, which also disappear on later whorls; subsequent whorls smooth or with fine incremental lines; upper whorls dark purplish brown, later ones a little paler, with a narrow paler band just behind the suture, which on the last whorl becomes strongly marked, with a dark reddish narrower band on each side of it, and traces of another at the suture; in some specimens the dark coloration covers the whole surface on each side of the peripheral pale band, but inside the aperture the bands can always be distinguished; base rounded about a well-marked umbilicus; aperture small, ovate, marginally thickened and slightly expanded, but not reflected; a narrow band of callus over the body connects the posterior ends of the lips; pillar broad, slightly swollen, external coloration visible in the throat. Alt. of shell 17, of aperture 5.2, diam. of shell 6, of aperture 4 mm.

Hood Island, Snodgrass and Heller; numerous.

This species is smaller than *B. perspectivus* and differently colored, but belongs to the same group.

Bulimulus approximatus n. sp. Plate VIII, fig. 4.

Shell belonging to the type of *B. nux* and *B. rugulosus* with seven pretty evenly tapered whorls, with a distinct suture; nucleus as in the last species, livid, but the early whorls bear no traces of revolving lines; whorls moderately convex, base evenly rounded; sculpture, on the later whorls, only of faint incremental lines; umbilicus small and narrow, aperture rather elongate. Alt. of shell 17.5, diam. 8 mm.

Hood Island, Snodgrass and Heller.

A single specimen of this shell was obtained which differs from all the others of the *nux* group in the absence of spiral sculpture and the smooth and polished surface. The peristome is not quite matured, so it cannot be determined whether it is reflected or not, but the probabilities are in favor of its being simple and unreflected.

Bulimulus hoodensis n. sp. Plate VIII, fig. 1.

Shell allied to *B. unifasciatus* Sby., but smaller, with about six convex, rapidly tapering whorls; nucleus sculptured as usual in the group, livid purple; later whorls smooth, polished, with no sculpture but faint incremental lines; color light yellowish brown, with two broad reddish purple spiral bands nearly peripheral, and a narrower one in front of the suture; base evenly rounded, with a narrow but deep umbilicus; aperture ovate-oblong, the peristome white, thickened and distinctly reflected; pillar broad, white, not swollen, a thin wash of callus over the body, the external coloration distinct within the aperture. Alt. of shell 18, of aperture 8.5, diam. of shell 8.5, of aperture 6 mm.

Hood Island, Snodgrass and Heller.

This well-marked form more nearly resembles some of the continental species than the typical Næsioti. The distinctly reflected lip and rapid enlargement of the whorls distinguish it from any other Galapagos species.

Bulimulus jacobi Sowerby.

Bulimulus jacobi Dall, 1896, p. 436.

This seems to be the commonest and, among the islands, the most generally distributed species of the Galapagos. It was obtained by Messrs. Snodgrass and Heller at James and Albemarle, where it was previously known, and also from Narborough and Abingdon, where it had not previously been reported. There is not a great deal of variation in the specimens, which were found at elevations of from 1,700 to 2,000 feet. The form named *cinereus* by Reibisch was obtained at Iguana Cove, Albemarle Island, and the variety *acutus* Reibisch, at a height of 3,000 feet, near Tagus Cove, Albemarle Island. The species is usually found under flat pieces of rock, and a large proportion of the specimens are dead.

Bulimulus curtus Reibisch.

Bulimulus (amastroides var.?) *curtus* Dall, 1896, p. 442, Pl. XV, fig. 13, Pl. XVII, fig. 8.

Chatham Island, Snodgrass and Heller; also Baur, Wolf and the U. S. Fish Commission.

Bulimulus rugiferus Sowerby.

Bulimulus rugiferus Dall, 1896, p. 443.

James Island, Cuming.

A single specimen of a very young shell probably belonging to this species was obtained by Messrs. Snodgrass and Heller.

Bulimulus Tanneri Dall.

Bulimulus tanneri Dall, 1896, p. 438, Pl. XVI, fig. 3.

Tagus Cove, Albemarle Island, Snodgrass and Heller.

This species was previously known only from Indefatigable Island, where it was collected by the U. S. Fish Commission. The present specimens are not fully grown and do not show the broadly reflected lip.

Bulimulus indefatigabilis Dall, nom. nov.

Bulimulus n. sp. Dall, 1896, p. 444, Pl. XV, fig. 15.

One specimen found on James and two on Indefatigable Island, according to Reibisch.

In 1896, to complete my monograph of the Galapagos shells, I figured and described this shell but left it unnamed, thinking Herr Reibisch himself intended to name it. But the years have passed by and I have been unable to renew communication with that gentleman, who is, I am informed, absorbed in other pursuits, so I take this opportunity of applying a name to this shell.

Guppya Bauri Dall.

? *Trochomorpha Bauri* Dall, 1896, p. 447, Pl. XV, figs. 8, 9.

Abingdon Island, at an elevation of 1,700 feet, Snodgrass and Heller; Albemarle Island, Baur.

The specimens of this species obtained by Mr. Snodgrass were dead and discolored, but the identification is complete. This is a new locality for the species.

Conulus galapaganus Dall.

Conulus galapaganus Dall, 1896, p. 448, Pl. XV, fig. 11.

Chatham Island, at 1,600 feet, Baur; Abingdon Island, at 1,700 feet, Snodgrass and Heller; numerous.

Quite a number of these were obtained but mostly in poor condition. It was previously known only from Chatham Island.

Vitrea chathamensis Dall.

Vitrea chathamensis Dall, 1896, p. 448, Pl. XV, figs. 3, 10.

Chatham Island, 1,600 feet, Baur; Abingdon Island, 1,700 feet, Snodgrass and Heller.

Good specimens of this species were obtained by Mr. Snodgrass.

It was previously known only from Chatham Island, by a single specimen.

Vitrea actinophora n. sp. Pl. VIII, figs. 11, 16, 17.

Shell small with four brilliantly polished, subtranslucent, olivaceous whorls; spire depressed but slightly rounded, with a distinct suture; nuclear whorl and a half smooth, succeeding whorls near the suture with well-defined close-set incised lines in harmony with the lines of growth but short, rarely extending to the periphery; last whorl evenly rounded, base smooth, convex, with a narrow deep umbilicus; aperture oblique, hardly expanded, the peristome sharp, thin, the pillar and outer lips not approximated. Major diam. 4, minor diam. 3.2, alt. 2 mm.

Top of mountain near Tagus Cove, Albemarle Island, Snodgrass and Heller.

This belongs to the group of *V. radiatula* Alder, but is sufficiently distinguished by its sculpture and umbilicus; the last whorl is also proportionally smaller.

Endodonta Helleri n. sp. Pl. VIII, figs. 7, 8, 9.

Shell small, solid, pale olivaceous gray, with about five sharply sculptured, acutely keeled whorls; nucleus smooth, the succeeding whorls with close, oblique, evenly spaced, elevated lamellæ in harmony with the lines of growth, and covering both the upper and lower surface of the shell; spire elevated, domelike, the surface of the whorls somewhat flattened with the periphery narrowly compressed forming a sharp marginated keel; base rounded with a rather wide and deep umbilicus; aperture oblique, the peristome widely reflected and thickened except at the upper angle which is appressed against the keel of the prior whorl; interior of the aperture with a narrow low rounded parietal lamella running far into the throat; on the basal side, a fourth of a whorl behind the aperture, two narrow white patches are seen through the shell, indicating the presence of two short basal lamellæ. Major diam. 3, minor diam. 2.6, alt. 1.75 mm.

Near Iguana Cove, Albemarle Island, at an elevation of 2,000 feet, Snodgrass and Heller.

This very characteristic and elegant little shell adds a representative of a genus and family new to the Galapagos fauna.

Pupa Wolfii Miller.

Pupa (Leucochila?) wolfii Dall, 1896, p. 446, Pl. XVII, fig. 14.

Guayaquil, Ecuador, Wolf; Albemarle Island, near the sea level, Wolf and Baur; near Tagus Cove, Albemarle, on leaves of *Croton;* near Iguana Cove, Albemarle, at 2,000 feet elevation; Narborough Island, Snodgrass and Heller; abundant.

This species was usually found, when alive, on leaves of plants. It seems to be common and many of the specimens approximate in the characters of the armature of the mouth to *P. clausa.* Their distinctness cannot yet be said to be demonstrated.

Pupa clausa Reibisch.

Pupa clausa Dall, 1896, p. 447.

On bushes near the sea, Indefatigable Island, Wolf; Abingdon and Narborough Islands, near the sea level, Snodgrass and Heller.

These localities are additional to that of Wolf, which was the only one previously known for this rather doubtful species.

Succinea Bettii Smith.

Succinea bettii Dall, 1896, p. 448, Pl. XV, fig. 6.

Previously known from Charles, James and Chatham Islands; Iguana Cove, Albemarle and James Island, Snodgrass and Heller; variety *Wolfii* Reibisch, at 1,700 feet elevation, Abingdon Island, 2,000 feet elevation near Iguana Cove, Albemarle Island, Snodgrass and Heller.

This species appears to be common and is doubtless widely diffused among the islands.

Succinea brevior (Smith).

Succinea brevior Dall, 1896, p. 449, Pl. XV, fig. 4, Pl. XVI, fig. 8, Pl. XVII, fig. 9.

At 1,000 feet elevation, on shrubbery, near Black Beach, Charles Island, Baur; Charles Island, Snodgrass and Heller.

Succinea producta (Reibisch).

Succinea producta Dall, 1896, p. 449, Pl. XV, fig. 7, Pl. XVI, fig. 10, Pl. XVII, fig. 5.

Chatham Island, on lichen-covered rocks at 900 to 2,000 feet elevation, Wolf and Baur; Chatham and Narborough Islands, Snodgrass and Heller.

The last locality is a new one for the species.

Succinea corbis Dall.

Succinea corbis Dall, 1896, p. 450, Pl. XV, fig. 5.

South Albemarle Island, on dry bones of turtles, Dr. Baur; Iguana Cove, Albemarle Island, and also on James Island, Snodgrass and Heller.

The specimens obtained by Messrs. Snodgrass and Heller were less strongly reticulate than the original type, but on examination in a good light and strong magnification the characteristic sculpture was detected.

Tornatellina chathamensis Dall.

Leptinaria chathamensis Dall, 1896, p. 451, Pl. XVI, fig. 9, Pl. XVII, fig. 16.

Chatham Island, on ferns at 1,600–2,000 feet above the sea, also South Albemarle Island, Baur; Iguana Cove, Albemarle Island, Snodgrass and Heller.

In his revision of certain *Stenogyridæ*, Dr. Pilsbry has shown that the small forms, often called *Leptinaria*, which are allied to and perhaps were the original root stock of the *Achatinellidæ*, must take the name *Tornatellina*, while the very similar shells with a Stenogyroid radula will be called *Leptinaria*. Hence the shell described by me as *Leptinaria chathamensis* will now take its place as a *Tornatellina*.

The close resemblance between many of the non-arboreal minuter Achatinellas and *Tornatellina* is sufficiently obvious. The anatomy confirms the relationship intimated by the shell characters. Add to this that the only fossil (possibly Pliocene) Achatinellas yet observed belong to this dwarfish dull-colored group, and the hypothesis that *Achatinella* originally sprang from a Tertiary *Tornatellina*-like immigrant, borne, perhaps, on the wings of the wind, from other islands of the Pacific, does not seem to be very far-fetched.

Helicina nesiotica Dall.

Helicina (Idesa) nesiotica Dall, 1896, p. 451, Pl. XV, figs. 1, 2, Pl. XVII, fig. 12.

Chatham Island, on leaves at 1,600 feet, Baur; top of mountain, near Tagus Cove, Albemarle, also near Iguana Cove, Albemarle, Snodgrass and Heller.

It is quite likely that this inconspicuous species may exist on all the islands, and the new material obtained during this the latest expedition may serve to confirm the opinion that the islands are still not sufficiently explored to warrant final conclusions on interisland distribution.

Cocos Island Species.

Cocos Island is a remote volcanic islet, about half-way between the Galapagos Islands and the Panamic Isthmus in a north-north-easterly direction. The only reference to its land shells I have found is a short paper by von Martens[1] on a small collection of small land shells obtained by Herr Pittier in June, 1898. These comprised four species of which one was an undetermined species of *Conulus*.

Messrs. Snodgrass and Heller obtained also four species, one of which appears to be identical with one of von Martens', the other three to be undescribed.

I have had the valuable advice of Dr. H. A. Pilsbry in the determination of these shells, and it appears that the revision of the group containing *Subulina*, etc., leaves in the genus *Leptinaria* the Achatinoid forms which have, like these from Cocos Island, the dentition of *Stenogyra*, while to *Tornatellina* will fall those having a radula recalling *Achatinella*, such as the species described by me under the name of *Leptinaria chathamensis*.

The list of Cocos Island species, so far known, will be as follows:

Conulus sp.
Guppya Hopkinsii Dall. On leaves.
Leptinaria (*Neosubulina*) *Pittieri* (von Martens).
Leptinaria (*Neosubulina*) *Martensi* Dall. Under stones.
Opeas juncea (Gould).

[1] *Sitzungsberichte der Gesellschaft Naturforschender Freunde zu Berlin*, pp. 156–160, 1898.

Vertigo cocosensis Dall. On leaves.

Succinea globispira von Martens. On leaves.

Siphonaria gigas Sowerby and *Melampus panamensis* C. B. Adams were obtained by the U. S. Fish Commission from the beaches of Cocos Island in 1888.

Guppya Hopkinsii n. sp. Pl. VIII, figs. 5, 6.

Shell small, with 5½ whorls, of a reddish horn-color when fresh, polished below; above, the surface is dulled by fine close even striation in harmony with the lines of growth crossed by a microscopic, partly obsolete spiral striation; spire moderately elevated, nepionic whorls polished, the sutures very distinct, the whorls rounded between them; base evenly rounded, the periphery of the last whorl situated in the path of the suture as it advances and not in the middle of the whorl; umbilical region impressed, imperforate; aperture lunate, wider than high, the margins acute, the parietal surface without callus and polished. Alt. 4.2, lat. 6 mm.

Cocos Island, on leaves, Heller and Snodgrass, 1899.

This is a very neat little shell in which the reddish color of the living form seems to fade to a pale yellowish after the animal has been some time removed. It seems to have been not uncommon. It is named in honor of Mr. Timothy Hopkins, patron of the expedition. An examination of the animal by Dr. Pilsbry has settled the genus.

Leptinaria (Neosubulina) Martensi n. sp. Pl. VIII, fig. 10.

Shell small, of a yellowish-green color, polished, with 5½ whorls, a rather blunt apex and distinct suture ; under magnification the upper whorls are seen to be minutely axially wrinkled, most distinctly so in front of the suture, but, in the later whorls, this sculpture becomes obsolete. There is also a fine obscure spiral striation and in certain spots, under magnification, the two series of lines form a faint reticulation. The shell has much the general form of *Cochlicopa lubrica*, the aperture is small, semilunate, the pillar obliquely truncated, somewhat thickened at the twisted edge; on the body is a very prominent projecting lamina which extends inside the shell for about one whorl, projects at the mouth half-way to the outer lip and is united to the pillar and outer lip by a thin callus; the outer lip is not reflected, but is not sharp-edged in the adult; directly opposite the parietal lamella is a single thickened spiral ridge, but little elevated, and extending inward about one-third of the last whorl. Alt. of shell 10, of aperture 4.25; lat. of shell 4, of aperture 2 mm.

Cocos Island, under stones, Heller and Snodgrass.

An immature dextral specimen among the seven sinistral *L. Pittieri* v. Marts. may have belonged to this species. It differs from that species by being dextral, by having the mouth larger in proportion to the spire, and in having one less whorl in a somewhat greater length. The specimens were strongly contracted in alcohol but presented the general appearance of *Stenogyra*, with which the short and broad, very small, radula fully agrees. The partitions of the upper whorls are not absorbed. The foot is entire and quite small. I could detect no jaw nor eyes, but the tentacles were inverted. It seems, according to Dr. Pilsbry, that *Leptinaria* is the proper name for these stenogyroid forms with dentition of *Achatina*, while *Tornatellina* includes those with achatinelloid teeth. Consequently *Neosubulina*, which was founded chiefly on these distinctions, is, at most, hardly of more than sectional value. The resemblance to *Stolidoma* Desh. is quite marked, but they may be discriminated by the apical characters of the shell.

Vertigo cocosensis n. sp. Pl. VIII, fig. 13.

Shell small, reddish brown, rather pointed, with nearly five rounded whorls; apex paler, polished, rather blunt; last whorl much the largest; base rounded with a well-marked umbilical pit; aperture wider behind, the posterior part of the outer lip and the pillar lip broadly reflected, the anterior outer and basal margin narrow; the pillar and outer lip united by a thin callus; lamellæ according to Sterki's formula .ABDE, comprising one columellar and two parietal folds, and, on the outer wall well within the peristome, two narrow little-elevated ridges, of which the anterior is shorter. Axial length of shell 2.2, of aperture .8, width of last whorl 1.5, of aperture .8 mm.

Cocos Island, on leaves, Heller and Snodgrass.

The chief peculiarity of this species is that the surface, which looks silky under an ordinary hand lens, when more magnified is seen to be punctate all over, recalling *V. variolosa* Gould, of Florida, which, however, differs in form, size and dental armature.

Succinea globispira von Martens.

S. globispira v. Mts., Sitzb. Ges. Naturf. Freunde zu Berlin, p. 158, 1898.

Cocos Isand, on leaves, Heller and Snodgrass.

This is a rather rude, short-spired form of a yellowish-white color, and which covers itself in life with pellets of its own excreta. It does not seem to be abundant.

Species from the Californian Islands.

Epiphragmophora Veatchii (Newcomb).

Arionta Veatchii Newcomb (MS.) Tryon, Am. Journ. Conch., II, p. 316, Pl. 22 (5), fig. 19; Pl. 23 (6), fig. 6, Oct., 1866; III, p. 162, 1867.

Cerros Island, off Lower California, in about N. Lat. 28°, Veatch (1859), Anthony (1896).

This splendid shell is well suited to its arid environment, since Stearns had a specimen collected by Veatch which only issued from behind its epiphragm in 1865, having been kept six years in a dry box without food or moisture.

Epiphragmophora leucanthea n. sp. Pl. VIII, figs. 18, 20.

Shell with five and a half rather convex whorls; pale lavender, nearly white below, with an obsolete white peripheral band, above which the whorl is more or less tinged with pale bluish gray; a translucent band above the peripheral one through which the dark brown with which the interior of the whorls is lined may show through more or less distinctly; nuclear whorls with wavy radial striæ, visible under a lens, for a whorl and a half, translucent; succeeding whorls opaque, except as stated, polished, with rather distinct incremental lines and obsolete vermiculations or malleations; base rounded, perforate, with the umbilicus nearly closed by the columellar reflection; aperture rounded, the outer lip slightly reflected, white, with the throat brown internally; body without callus, pillar short, arcuate, with no thickening or denticle upon it. Major diam. 28, minor 23.5, alt. of shell 20, of aperture 15 mm.

Eastern side of Cerros Island, Anthony, 1896.

This is evidently a derivative from *E. Veatchii*, from which it differs in the absence of the numerous interrupted brown bands, in the usually blunter and lower spire and more distinct and deeper sutures.

Epiphragmophora areolata (Sowerby).

Helix areolata Sowerby (MSS.), Pfeiffer, Zeitschr. für Mal., II, p. 154, 1845.
Polymita areolata Tryon, Am. Journ. Conch., II, p. 319, Pl. 23 (6), fig. 5, 1866.

Margarita Bay, L. Cal., Newcomb; Natividad Island, ten miles south of Cerros Island, Anthony, 1896.

This species was mistakenly referred to Oregon by Tryon. Binney, in *Land and Fresh-water Shells of North America*, figures for it a specimen of *E. Veatchii* (p. 177, fig. 311, two middle figures) and one of *E. levis* Pfr. (*ibid.*, two outer figures). Though doubtless similar in origin and in coloration, *areolata* is smaller than *Veatchii* and has a more depressed spire, and on the whole is easily separable from the latter if a good series is compared.

Epiphragmophora levis (Pfeiffer).

Helix levis Pfr., Zeitschr. für Mal., II, p. 152, 1845; Binney, Land and Fresh-water Sh. N. Am., I, p. 180, fig. 316, 1869.

Rosalia Bay, mainland of Lower California, in N. Lat. 28° 30′, Anthony, 1896.

Erroneously referred to the Columbia river by Pfeiffer.

Epiphragmophora crassula n. sp. Pl. VIII, fig. 3.

Shell small, solid and heavy, smooth, with five whorls; spire rather pointed, suture distinct, not deep, last whorl evenly rounded at the periphery; color opaque white with more or less numerous very pale-brown subtranslucent spiral bands, all or part of which may be absent; usually there is a peripheral white band and between it and the suture one or two translucent bands of which the anterior is most constant; from two to four narrower translucent bands may exist in front of the periphery; the base is rounded, at first minutely perforate, later imperforate and sealed by a reflection of the pillar lip; aperture rounded, slightly oblique, with a solid white, slightly reflected peristome, but no callus on the body; pillar broad, short with a conspicuous callosity. Alt. of shell 15, of aperture 6, lat. of shell 15.5, of aperture 7.5 mm.

Natividad Island, ten miles south of Cerros Island, Anthony, 1896.

This species is an offshoot of *E. levis* Pfr., from which it differs by its smaller and much heavier shell, fewer whorls, conspicuous peristome and narrower, fewer and less interrupted banding of a paler tint.

Epiphragmophora pandoræ (Forbes).

Helix pandoræ Fbs., P. Z. S., 1850, p. 55, Pl. IX, figs. 3a, 3b.
Helix damacenus Gould, Proc. Bost. Soc. N. Hist., VI, p. 11, 1856.

San Benito Island, east of Cerros, in N. Lat. 28° 16′, Anthony, 1896; Santa Barbara, on Margarita Bay, L. Cal., Forbes.

This is a well-marked species which varies from white to dark gray above, and, below, may be white or banded with ashy gray. The nucleus is, however, invariably of a livid purplish color and the surface is dull and conspicuously striate. A typical specimen, received by Dr. Lea from Forbes, is now in the National Museum.

It differs from the San Benito shells chiefly in having the spire less elevated and the whorls slightly flatter above.

Epiphragmophora Stearnsiana (Gabb).

Helix Stearnsiana Gabb., Am. Journ. Conch., III, p. 235, Pl. XVI, fig. 1, 1867.

Lower California, from San Diego, Cal., south to San Tomas river, Binney; San Martin Island, in N. Lat. 30° 30′, Anthony, 1896.

These specimens do not seem to differ from those taken on the mainland.

Epiphragmophora (Micrarionta) guadelupiana n. sp. Plate VIII, figs. 14, 15.

Shell small, thin, depressed, of a dark-brownish color with a narrow reddish band, bordered on each side by a pale streak, just above the periphery; spire little elevated, suture distinct; epidermis strong, in well-developed specimens slightly microscopically hirsute; sculpture of well-marked incremental lines, stronger on the spire, with occasional microscopic punctations; base more or less flattened, the last whorl with the periphery somewhat above the middle of the whorl, umbilicus narrow and deep; aperture subcircular, very oblique with a strong whitish reflection of the peristome, the ends of the lip on the body approximated, throat with the bands showing through. Alt. of shell 6, diam. 10.5, aperture diam. 4.5 mm.

Guadelupe Island, off Lower California, in N. Lat. about 29°, Anthony, 1896; Snodgrass and Heller, 1899.

This very well-marked little species is nearest to *E. catalinæ*, but is more depressed, with a larger umbilicus and differently shaped aperture. It seems to be tolerably abundant, though most of the specimens received were defective.

Epiphragmophora sp. indet.

Among the shells collected by Anthony from Guadelupe Island, was a single specimen of a species of *Epiphragmophora* considerably larger than the preceding, but which I am unable to identify since it is not mature. There is a pale band and an almost obsolete reddish band at the periphery. It represents a species quite unlike *E. guadelupiana*.

Binneyia notabilis Cooper.

Binneya notabilis Cooper, Proc. Cal. Acad. Sci., III, p. 62, 1863, with figures.

Santa Barbara Island, Cooper, 1863; Guadelupe Island, Anthony, 1896.

This species appears to be abundant on Gaudelupe Island, but owing to want of care in collecting few of the delicate shells were intact when received.

Succinea (rusticana Gld. var.?) **guadelupensis** Dall. Pl. VIII, fig. 12.

Shell small, acutely pointed, strongly marked with incremental lines; whorls very convex, with deep sutures; last whorl the largest; aperture small for the genus, oblique, with a well-marked callus over the body. Lon. of shell 8.5, of aperture 5, of last whorl 7, diam. of shell 5, of aperture 3.2 mm.

Guadelupe Island, Anthony, 1896.

This variety differs from *S. rusticana* in its much smaller size with the same number of whorls, also by the incurving outer lip where it joins the body. The surface is rather coarsely striated with incremental lines. The specimen obtained was dead, and the color when fresh was doubtful, but the appearances indicate that was pale yellow. It resembles a good deal *Succinea corbis* Dall from the Galapagos, but is a broader shell and does not possess the fine reticulate surface sculpture. It may very likely prove eventually to be of specific rank, but in the present state of our knowledge of the American species I prefer to introduce this as a variety.

Epiphragmophora catalinæ Dall.

"*Helix tenuistriata*" W. G. Binney (as mutation of *H. Gabbi*), Land and Fresh-water Sh. N. Am., part I, p. 175, fig. 305, 1869; not of A. Binney, 1842.

Arionta Gabbi W. G. Binney, Bull. U. S. Nat. Mus., No. 28, p. 148, fig. 130, 1885.

This form was collected on Catalina Island by H. Hemphill, and, while obviously a member of the *Gabbi-facta* group, seems perfectly distinguishable from the other members of that group. There is a very large series of *Gabbi* and *facta* in the collection of the National Museum, and notwithstanding their variability I do not find any specimens which are not readily referred to one or the other, and none intermediate between these and *catalinæ*. The name *tenuistriata* had previously been used specifically by A. Binney, and was repudiated for this shell by his son. As the original *tenuistriata* A. Binney has never been identified, and in the case of the present species the name would have to rest anonymous, it seems better to apply a local name to it which is free from any uncertainty. It has a small deep umbilicus partly shaded by the reflected pillar lip and a broadly reflected peristome, the ends of which upon the body are not approximated. It measures as follows: Alt. of shell 7, diam. 12, diam. aperture 4.5 mm. There are five and a half rounded whorls and the entire shell is finely spirally striate. It is also found fossil on Santa Barbara Island, but the fossil specimens are often considerably larger than the largest living specimens now known; one measures 15 mm. in major diameter and nearly 10 mm. in height.

Epiphragmophora Kellettii Forbes.

Helix Kellettii Forbes, P. Z. S., 1850, p. 55, Pl. IX, fig 2, a, b.

Epiphragmophora (*Micrarionta*) *Kellettii* Pilsbry, Cat. Land Shells of Am. North of Mex., p. 6, 1897.

The measurements of the type are major diam. 22, minor diam. 19, alt. 19 mm. No locality is mentioned. A shell occurs on San Clemente Island of the Santa Barbara group, which has been referred to *Kellettii* as a dwarf variety. I suspect it to be distinct, but, at all events, it is sufficiently different to deserve a name:

Epiphragmophora (var. ?) **clementina** Dall.

Shell small, thin, pale translucent brownish in color with obscure, revolving series of very minute yellow or whitish flecks; whorls four, the nucleus wrinkled transversely, reddish, slightly flattened, the succeeding whorls rather convex with a distinct suture; a very narrow dark reddish-brown band, with a hardly visible pale border in front of it, revolves above the periphery; sculpture of rather well-marked incremental rugæ, cut on the upper part of the last whorl by microscopic spiral striation, to which is added a partly obsolete oblique striation which is visible, under magnification, chiefly in patches; the effect of the whole is to give the surface a very fine shagrination; the last whorl near the aperture descends strongly and the plane of the aperture forms an angle of about 45° with the axis of the shell; base full and rounded, the umbilicus completely covered by a reflection of the pillar lip; aperture rounded, the peristome narrow, whitish, slightly thickened and reflected. Major diam. 15, minor diam. 12, alt. 11 mm.; other specimens are slightly larger.

Habitat: San Clemente Island, Cal., U. S. Fish Com.

The typical *E. Kellettii* is that found in the vicinity of San Diego. It has six whorls and they are well rounded. It differs from the Catalina Island form in its less flattened and more inflated whorls, more dome-like spire, smaller size and browner aspect, the contrast between the upper and lower sides of the last whorl being much less marked. Specimens from the Coronado Islands are like those from San Diego. The National Museum has this species only from the above-mentioned three localities authentically. "Santa Barbara," frequently mentioned as a locality, should read "Santa Barbara Islands," as it is improbable that the shell occurs at the town of Santa Barbara on the mainland. A lot in the National Museum are labelled "Oregon City, Shumard," which is, of course, an error. *E. clementina* differs in size, in number of whorls and in the more emphasised surface sculpture. It is more like the San Diego shells than like those from Catalina.

Epiphragmophora Orcutti n. sp. Pl. VIII, fig. 19.

Shell globose, moderately elevated, polished, with nearly six moderately convex whorls forming a dome-like spire; color purplish brown, lighter toward the umbilicus; a narrow pale band on the last whorl bordered behind by a darker brown, poorly defined, similar band, both being above the periphery and the suture in the earlier whorls being laid on the anterior edge of the darker line; nucleus finely flexuously radiately wrinkled, pale colored; subsequent whorls with fine incremental wrinkles the ridges of which are cut by revolving, partly obsolete incised lines; as a rule these lines are not deep or continuous, cutting merely the tops of the wrinkles and not the furrows between them; suture distinct, last whorl rounded, plump, toward the aperture descending below the pale band; base plumply rounded, the umbilicus covered by a reflection of the pillar-lip with a minute chink behind it; aperture very oblique, thickened, whitish, reflected, especially near the pillar; throat livid brownish with the bands well indicated. Major diam. of large and small specimens, respectively, 24 and 22.5, minor diam. 20 and 18.5, alt. 19 and 16 mm.

Habitat: Rosario mesas, in northern Lower California, in May, 1886, by C. R. Orcutt.

This form much resembles in shape the typical *E. Kellettii*, from which it differs in the absence of the yellow flecking and the different surface sculpture. *E. Kellettii* is also a more globose shell. The same stock, doubtless, was the origin of both species, as well as several others.

Addendum—Note on the Anatomy of Guppya Hopkinsi Dall.

By Henry A. Pilsbry.

The sole is distinctly tripartite; tail with a subtriangular mucous pore surmounted by a blunt short fleshy process. The mantle lining the lung cavity is pearl-gray with some opaque white spots and irregular, broken, black, transverse lines. Genital system of the simple "haplogon" type, the vas deferens and retractor terminal on the penis. Kidney long-triangular, nearly double the length of the pericardium. Jaw arcuate with a slight median projection below, entirely smooth. Radula with the centrals tricuspid, the ectocones diverging; laterals bicuspid; marginal teeth at first with the long cusp bifid (entocone + mesocone), then trifid (entocone + mesocone + ectocone), the outermost marginals shortened and simplified as usual. The whole anatomy agrees with *Guppya*, so far as that genus is known.

Jaw and teeth of *G. hopkinsi.*

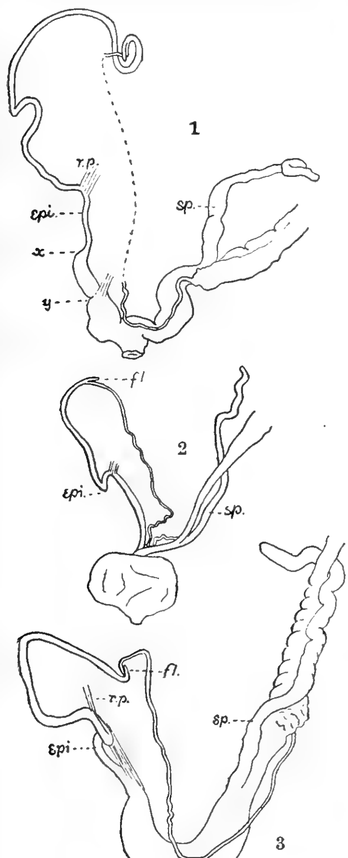
EXPLANATION OF PLATE VIII.

Fig. 1. *Bulimulus hoodensis* Dall; alt. 18 mm., p. 91.
Fig. 2. *Bulimulus Snodgrassi* Dall; alt. 16.5 mm., p. 90.
Fig. 3. *Epiphragmophora crassula* Dall; alt. 15 mm., p. 100.
Fig. 4. *Bulimulus approximatus* Dall; alt. 17 mm., p. 90.
Fig. 5. *Guppya Hopkinsi* Dall; viewed from above, major diam. 6 mm., p. 97.
Fig. 6. The same, in profile.
Fig. 7. *Endodonta Helleri* Dall; profile; diam. 3 mm., p. 93.
Fig. 8. The same, viewed from above.
Fig. 9. The same, basal view, the basal lamellæ indicated by the lighter spots.
Fig. 10. *Leptinaria Martensi* Dall; alt. 10 mm., p. 97.
Fig. 11. *Vitrea actinophora* Dall; viewed from above, major diam. 4 mm., p. 93.
Fig. 12. *Succinea guadelupensis* Dall; alt. 8.5 mm., p. 102.
Fig. 13. *Vertigo cocosensis* Dall; alt. 2.2 mm., p. 98.
Fig. 14. *Epiphragmophora guadelupiana* Dall; major diam. 11 mm., p. 101.
Fig. 15. The same, in profile.
Fig. 16. *Vitrea actinophora* Dall; in profile, p. 93.
Fig. 17. The same, from below.
Fig. 18. *Epiphragmophora leucanthea* Dall; alt. 20 mm., p. 99.
Fig. 19. *Epiphragmophora Orcutti* Dall; alt. 16 mm., p. 104.
Fig. 20. *Epiphragmophora leucanthea* Dall; from below, major diam. 28 mm., p. 99.

NOTE ON THE ANATOMY OF THE HELICOID GENUS ASHMUNELLA.

BY HENRY A. PILSBRY.

This genus was established[1] by Prof. Cockerell and myself for a series of *Polygyra*-like Helices from New Mexico and Arizona, only one of which, *A. miorhyssa*, was then known anatomically. That we did not exceed the legitimate bounds of inference from mere shell characters, in grouping eight anatomically unknown forms around *A. miorhyssa*, I am now in a position to show.



Living specimens of the following species of the genus have been secured by Prof. Cockerell and transmitted to me for study: *A. thomsoniana porteræ*, Beulah, Upper Sapello Cañon, New Mexico; *A. thomsoniana* (Anc.), one living specimen found by T. D. A. Cockerell and Wilmatte Porter under a rock at Monument Rock, in Santa Fé Cañon, 8,000 feet elevation, in the region of quaking aspens and scrub oaks, December 30, 1899; *A. rhyssa hyporhyssa* (Ckll.), Cloudcroft, Sacramento Mts., N. M., 8,750 feet elevation, collected by Prof. E. O. Wooton.

The examination of these forms fully confirms the anatomical characters ascribed to the genus in the above-mentioned paper.

[1] These *Proceedings* for 1899, p. 188.

A. thomsoniana (Anc.). Fig. 2.

This species diverges from the others in having three aperture-teeth as in *Triodopsis*. The single specimen secured extruded its penis in drowning, and I found it impossible to retract it. It is notable that only the lower and wider portion is everted, not the tapering upper part, which is probably epiphallic.

The general proportions of the genitalia are as in var. *porteræ*, the spermatheca being long, decidedly over half the length of the penis + epiphallus, in both forms. The lower insertion of the penis retractor muscle in var. *porteræ* seems to be wanting in *thomsoniana*.

The jaw is strongly arcuate with seven moderately strong, separated, distinct ribs.

Radula with 27. 1. 27 teeth, similar to those of *A. hyporhyssa*, the tenth to the thirteenth transitional, outer 10 marginals with the inner cusps bifid.

A. thomsoniana porteræ Pils. and Ckll. Fig. 3.

Genital system similar to that of *A. thomsoniana*, except that it is larger, with a double insertion of the penis retractor muscle.

A. miorhyssa (Dall).

These *Proceedings*, 1899, p. 189, figs. 1 (genitalia), 2 (jaw), 3 (teeth).

The spermatheca is half the length of the penis + epiphallus, being shorter than in *A. thomsoniana* and *porteræ*. The penis retractor muscle has a double insertion, as in the preceding and following forms.

A. rhyssa hyporhyssa (Ckll.). Fig. 1.

The epiphallus is very long, the penis + epiphallus being $2\frac{1}{2}$ times the length of the spermatheca. The lower insertion of the penis retractor muscle is situated decidedly further down than in *A. miorhyssa*, and the spermatheca is shorter.

The jaw is horse-shoe shaped with eight or nine weak unequal ribs.

Radula with 28. 1. 28 teeth, the central and laterals with small ectocones developed, 12 marginals with the inner cusp bifid, outer cusp simple. The fourteenth to sixteenth teeth are transitional.

It will be noticed that all the species have similar kinks in the epiphallus, showing it to be doubled in the body-cavity in much the same manner in all of them. The tridentate forms *thomsoniana* and *porteræ* differ from the others in the greater proportionate length of the spermatheca. The length of the flagellum varies somewhat between the species, but it is so small in all of them that very exact measurements of its length are not readily obtained. Moreover, a vestigial organ so near its extinction as this is not likely to be constant in any species. I would not be surprised to find that it had entirely disappeared in some cases.

Measurements of genitalia, in millimeters.

SPECIES.	Miorhyssa.	Hyporhyssa.	Thomsoniana.	Porteræ.
Total length of penis, epiphallus and flagellum	41	40	ca. 28	34
From atrium to upper insertion of penis retractor	15	11	?	11
Length of flagellum	$1\frac{1}{2}$	1	nearly 1	$\frac{1}{2}$—$\frac{3}{4}$
Length of spermathecal duct	$20\frac{1}{2}$[2]	16	$16\frac{1}{2}$	22
Museum No. of shell supplying preparation	73,557	77,869	77,870	76,789

The absolute measurements will, of course, vary with individual variation in the size of the individual; but the comparative lengths of spermatheca and penis + epiphallus, and probably the details of the penis retractor muscle, will evidently afford valuable specific characters.

The study of the anatomy of three more species and subspecies shows *Ashmunella* to be a remarkably distinct genus anatomically. There can be no question of its radical difference from *Polygyra*, but light may be thrown on the nature of its relationship to *Epiphragmophora* by the investigation of the species now referred to that genus which inhabit the same region. Judging from a single half-grown and sexually immature specimen of *E. hachitana* which I was able through the courtesy of Prof. Cockerell to examine, a series strikingly divergent in genitalia from the Californian forms may be found here. I shall be most grateful for living or drowned alcoholic specimens of any *Epiphragmophora* from New Mexico or Arizona. Also for *E. gabbi, facta, rowelli,* or *ruficincta.*

[2] The length of the spermatheca was given as 27 mm. in our former paper, p. 190. This was a typographical error for 21 mm. In the table here given I have not given the length of the penis, as it is doubtful whether it should be measured to the point marked x in fig. 1 or to that marked y. I incline now to the latter view, as the portion extruded in a specimen of *A. thomsoniana* only extends to y.

MOLLUSCA OF THE GREAT SMOKY MOUNTAINS.

BY HENRY A. PILSBRY.

The material recorded and described in this paper was gathered by a party of five naturalists, Messrs. J. H. Ferriss, Bryant Walker, George H. Clapp, H. E. Sargent and myself, who visited the mountains in July and August of 1899.[1] Some account of the wanderings and adventures of this band has been given elsewhere,[2] and it will suffice here to give their itinerary as briefly as may be.

From Knoxville, Tenn, the rendezvous, travel was by wagon through Chilhowee Gap to Cade's Cove,[3] in Blount county, Tenn., a valley adjacent to the main range of the Great Smokies. Thence with guides, pack mules and camping outfit we ascended Thunderhead, camping at "Spencer's Cabin," and collecting both near the summit and at various lower levels. Ferriss made a day's journey to Block House Mountain, a peak running up to some 5,500 feet, nameless on the Geological Survey topographic

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[1] All of those mentioned have contributed valuable notes and specimens toward this paper, so that it really represents our joint and several observations, which I have correllated and systematized. To this end, most of the smaller or more critical specimens have been generously entrusted to me for examination, to the number of some six or eight thousand shells including those collected by myself.

It should be mentioned that Mr. Ferriss had previously made several vacation journeys to the Great Smokies, and Mr. Clapp was there in 1898. The richness of the region in molluscan life was first made known by Mrs. George Andrews, of Knoxville, although Rugel, many years ago, evidently ventured within the mountain fastnesses, and Miss Law visited the outlying ridges.

[2] *Nautilus*, 1900.

[3] A mountain valley becomes a "cove" on the tongue of the mountaineer. Some of the "coves" are of considerable extent and nearly level; the soil is fertile and the farms productive and beautiful. Cade's Cove is also the name of a post-office in the valley. The localities "Sugar Cove," "Rose Cove," Brannon's, Rowan's. "Laurel Creek" are all in Cade's Cove or subsidiary valleys thereto. During our stay in Cade's Cove we were indebted to Mr. Blair for numerous courtesies, which are here gratefully acknowledged.

map, but shown on the Knoxville sheet, due south of Thunderhead, with which the 4,700 foot contour connects it. From Thunderhead the trail follows the ridge along the Tennessee-North Carolina boundary, over Briar Knob (an outrageous climb) and Proctor's Knob to the south end of Miry Ridge. Thence over Siler's Bald to Clingman Dome (6,600 feet altitude), still upon the interstate boundary. The main collecting ground on Clingman was a few hundred feet below the summit along the north side. This was the last camp of Messrs. Clapp, Walker and myself; but Mr. Ferriss and Mr. Sargent explored beyond, first visiting Andrews Bald, an outlier of the Clingman mass, and then returning to Siler's Bald they followed the crest of the great ridge ramifying southwest, to Welch Bald, which reaches 5,000 feet elevation. From this peak they descended the Welch Bald Branch to Chamber's creek, and down to the Little Tennessee river. Crossing the river into Graham county, N. C., they ascended Tuskeegee creek, collecting *en route* and on "Tuskeegee Mountain" (not named on the Nantahala topographic sheet), a spur of the Cheoah Mountains which projects northward between the headwaters of Tuskeegee creek and Yellow creek. Most of the shells here came from a valley called "Ramp Cove," on the Yellow creek side. Along Yellow creek they followed the road to the Cheoah river. From here they entered the Unaka Mountains,[4] ascending the twin peaks Hangover and Mt. Hayo (5,200 feet) and Stratton Bald, (5,400 feet)—this peak named for Robert Stratton, being locally known as "Bob's Bald." Some collecting was then done in "Glen Cove," nameless on the Geological Survey map, but readily located as one of the heads of Slick Rock creek, in Tennessee. They then turned northward in Monroe county, Tenn., stopping at Tallassee ford of the Little Tennessee river, at Caringer, Tenn., where they collected on the south side of the river, finally returning across country to Cade's Cove.[5] Mr. Sargent made a journey by rail to Hayesville, Clay county, N. C.,

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[4] This Unaka range must not be confused with another so-called on some maps, lying to the west of Roan Mountain.

[5] No ordinary atlas gives an adequate idea of the extent or complexity of this mountain region. Recourse must be had to the excellent topographic maps published by the U. S. Geological Survey. The localities mentioned on the route described above will be found on the Knoxville, Mt. Guyot, Nantahala, Murphy and Loudon sheets.

the malacological results of which have been incorporated in this list.[6]

In the region where collecting was done the country rock is mainly sandstone and a coarse gray conglomerate. The coves are said to have a floor of limestone, but it is evidently buried deeply, as I noticed no exposures. There is a good exposure of the "Hazel Slate" on the dizzy, knifelike ridge connecting Siler's Bald and Clingman Dome. The strata along the boundary ridge dip deeply to the south and southeast, and the débris of the broken edges falling down the northern and northwestern declivities makes more abundant shelter for rock-loving snails on this than on any other slope. Springs can be found almost anywhere, up nearly to the mountain tops, and frequent rains or cloud-mist hanging about the summits keep the ground moist, and the deep moss holds water like a sponge.

Relationships of the Great Smoky Mountain Fauna.

The Appalachian mountain system is divided in the south by the broad valley of eastern Tennessee into two divisions unlike in their physical features and geological structure. The level strata of the Western Division, or Cumberland Plateau, though more or less dissected by stream-erosion, never become so rugged as the steeply tilted strata forming the noble mountains of the Eastern Division.

Faunally the two divisions have hitherto been considered to constitute a zoögeographic unit, under the title of the "Cumberland Subregion."[7] The inclusion of both the Eastern and Western Divisions under one zoögeographic term would lead one to suppose a numerically important part of the characteristic species composing the fauna to be common to the whole tract; but the collector on the ground finds this to be far from the truth. A certain number of land snails extend over the whole mountain region and far east and west of it; but of those restricted to the Appalachian system we find that the Cumberland Plateau has its own set of species, and the eastern mountains another. The characteristic

[6] It may be mentioned here that the shells Ferriss collected in 1898 and labeled "Unaka Mts." were taken on Citico Creek, in Monroe county, Tenn.

[7] See W. G. Binney, *Manual American Land Shells*, p. 33.

species, those which give the mountain regions individuality as contrasted with the lowlands, are very largely different on the two sides of the great valley.

I would submit, then, that the "Cumberland Subregion" as understood hitherto is not a faunal unit, but contains two faunulæ as diverse from one another as either is from the lowland fauna to the west or the east of the mountains.

Characteristic forms illustrating this diversity are as follows:

EASTERN DIVISION.

(Roan Mt. to the Great Smokies.)

Polygyra chilhoweensis,
" *subpalliata,*
" *ferrissii,*
" *clarkii,*
" *andrewsæ,*
" *wheatleyi,*
" *christyi,*
" *lawæ,*
" *depilata,*
" *barbigera,*
" *hirsuta altispira,*
" " *pilula,*
" *maxillata.*

Omphalina rugeli,
" *subplana,*
" *andrewsæ.*

Vitrinizonites.

Zonitoides patuloides.

Gastrodonta lasmodon,
" *cœlaxis,*
" *andrewsæ,*
" *clappi,*
" *walkeri.*

Pyramidula alternata costata,
" *bryanti.*

WESTERN DIVISION.

(Cumberland Plateau.)

Polygyra plicata,
" *dorfeuilliana,*
" *fatigiata,*
" *troostiana,*
" *tridentata complanata,*
" *wetherbyi,*
" *obstricta,*
" *sargentiana,*
" *downieana,*
" *spinosa,*
" *labrosa,*
" *edgariana,*
" *edvardsi,*
" *stenotrema exodon.*

Omphalina inornata.

Zonitoides lateumbilicatus.

Gastrodonta collisella.

Pyramidula alternata carinata,
" *cumberlandiana.*

The list could be increased, but these main genera sufficiently illustrate the distinctness of the faunas. It seems that the depression of the East Tennessee valley practically prevents intermingling of the mountain species, and has doubtless been a barrier far back into Tertiary time. Further north, in the Virginias and Pennsylvania, the distinction is almost obliterated; partly owing to the absence of an intervening tract so markedly differentiated physically, and partly because, if the northward extensions of the eastern and western divisions of the mountain system ever had special faunas, they were obliterated by the severe conditions of the Ice Age far beyond the southern border of the actual ice sheet, and there has not been time for the differentiation of new faunas in the North.

The Eastern Division, with which we have particularly to do, extending in a great ridge from northeast to southwest, between Tennessee and North Carolina, is cut transversely into several sections by rivers breaking through the highest ranges—the upper Nolichucky, the French Broad and Little Pigeon, and the Little Tennessee. The mollusk fauna of the section above the Nolichucky is fairly well known by the researches of many naturalists on Roan Mountain and in its vicinity, Mrs. George Andrews and Mr. A. G. Wetherby having contributed most largely to our knowledge.

The Great Smokies proper, as far east as Clingman, and the mountains along the southern side of the Little Tennessee, are now fairly known by the work of Mrs. Andrews and our party of five, and especially by Ferriss' explorations, though no doubt the lists of species will be largely augmented in future.

The mountain region between the Nolichucky and Clingman's Dome, a distance of about seventy-five miles as the crow flies, *is wholly unknown malacologically,* so far as I know. We may reasonably expect the forms common to Roan and the Great Smokies to occur in this intermediate tract; but in view of the extreme local differentiation, specific and varietal, in the known areas, how many splendid snails, never yet seen by man, still lurk in their rocky shelters along these mountain tops!

Comparing the fauna of Roan Mt.[8] and its environs with that of

[8] For the fauna of Roan I take Wetherby's papers: "Some Notes on American Land Shells," *Journ. Cincinnati Soc. N. H.*, IV, 1881; and "Natural History Notes from North Carolina," in the same *Journal*, XVI, 1893, p. 87, and XVII, 1894, pp. 69 and 209. These articles, containing the observations of an experienced naturalist, give as good an idea of the fauna as could be obtained without actually working over the ground.

the Great Smokies below Clingman shows the following forms common to the two tracts, exclusive of those occurring also in the Cumberland Mts. or elsewhere:

Polygyra andrewsæ,	*Vitrea sculptilis,*
" *wheatleyi,*	*Zonitoides elliotti.*
Vitrinizonites latissimus,	*Philomycus wetherbyi.*
Omphalina subplana,	

Special to the Roan Mountain neighborhood are:

Polygyra subpalliata,	*Gastrodonta andrewsæ,*
" *hirsuta altispira,*	" *cœlaxis,*
Omphalina rugeli,	*Pyramidula bryanti.*

And the following forms have hitherto been found only in the Great Smokies and adjacent ranges along the Little Tennessee river:

Polygyra chilhoweensis,	*Zonitoides patuloides,*
" *ferrissii,*	*Pyramidula alternata costata,*
" *depilata,*	*Punctum blandianum,*
" *edwardsi magnifumosa,*	*Gastrodonta lamellidens,*
" *hirsuta pilula,*	" *walkeri,*
Omphalina andrewsæ,	" *clappi.*

And also some varietal forms of various other species.

Vertical Distribution of Species.

Our data on *Polygyra andrewsæ* show that mere altitude has little, if any, influence within the limits afforded by the region investigated. Thus, on the flanks of Thunderhead Mt., the shells up to fully 4,000 feet do not differ in size or other characters from those of Cade's Cove, at half that elevation. At Proctor's Knob (5,000 feet) and Miry Ridge (4,500–5,000 feet) the average size and solidity of the shells is undoubtedly somewhat greater than at the lower stations, though the conditions do not differ much, and the country rock is not greatly different. What favorable local cause works this change is not clear. It is only near and at the exposed mountain tops themselves that the shells suddenly diminish in size and solidity, as among the scrubby beeches at the storm-swept summit of Thunderhead, or along the lofty ridge of Clingman, from 5,500 to 6,500 feet elevation.

Polygyra wheatleyi, also a species of wide distribution, is similar to *P. andrewsæ* in its variations. The toothed form with wide lip occurs throughout the region, except along the ridge of Clingman, where a more delicate and toothless form replaces the ordinary one. For the rest it varies greatly in size, and without reference, so far as I can see, to altitude or exposure, the other factors of soil and vegetation being probably more potent. Extremely small specimens occurred in the Tuskeegee Mountains (between Yellow creek and Tuskeegee creek), at a small elevation, and very large ones on Stratton Bald, over 5,000 feet above the sea. The only locality in which anything like racial characters are appearing, however, is on Clingman, as mentioned above, the only locality, so far as I know, where the forest is coniferous.

Polygyra ferrissii has been found so far only at elevations above 4,000 feet, on the Clingman conglomerate which crowns Miry Ridge and Clingman's Dome, though probably some of the lower stations are on the Thunderhead conglomerate, lithologically the same. An equilateral triangle with sides about seven miles long, the angles at Miry Ridge, Andrews Bald and Welch Bald, includes all known localities, though it certainly does not occur over much of the small area thus enclosed. The researches of our party along the high ridge west from Miry Ridge, and Ferriss' and Sargent's search to the south, make it probable that the species has no great extension in these directions. It remains to be seen whether it extends along the interstate boundary ridge toward Mt. Guyot and the Big Pigeon river gap, but such extension is likely.

Polygyra depilata has occurred so far only along the interstate boundary ridge from Thunderhead to Clingman's Dome, reappearing south of the Little Tennessee river on Stratton Bald.

Pyramidula alternata costata has been found only along the south side of Cade's Cove. The small Gastrodonts are probably more widely distributed than existing data indicate.

List of Species.

HELICINIDÆ.

Helicina occulta (Say).

Rowan creek, Cade's Cove. A single, rather thick-lipped small specimen, diam. $5\frac{1}{2}$ mm., was taken by Ferriss, and two more by Sargent. This is further south than any previous record.

HELICIDÆ.

Polygyra tridentata (Say).

Practically typical specimens of this species occur in the upper Tennessee Valley in eastern Tennessee. In the Great Smokies, however, a divergence occurs which I have not seen from any other locality. The basal tooth is split into two denticles; either distinctly or obsoletely; or without being bifid, the tooth has a callous slope or buttress against its outer side. This tendency to double the basal tooth evidently characterizes a mountain race, but I doubt whether the race be yet firmly enough established to require recognition in nomenclature. The localities are: "Roe's Flat," in Cade's Cove (Ferriss and Clapp, 1898), diam. 16 to 18 mm. Brannon's, Sugar Cove, off Cade's Cove, one specimen; basal tooth very heavy. Hannah Mt. (Ferriss, 1898). Welch Bald, on the Forney Ridge, diam. ranging from slightly over 13 to nearly 18 mm.; basal tooth nearly as simple in a few specimens as in *tridentata*, distinctly double or buttressed in others. Ten specimens collected by Ferriss. A single *P. fraudulenta* with typical aperture was taken with them. *P. tridentata* also was taken on Welch Bald branch of Chamber's creek, and on Chamber's creek down to the Little Tennessee.

South of the Little Tennessee, in Graham county, Ferriss took specimens on Yellow creek and Bob's Bald; in both localities the basal tooth was double or calloused.

"Other characters of the mountain form of *P. tridentata* are the tubercular upper tooth and the flattening of the basal lip. Another variety of *tridentata* from Oakdale, Morgan county (Clapp, 1899), and Concord, Knox county (in the James H. Lewis collection), has the aperture of var. *complanata*, with very small and widely spaced teeth, but is striated like typical *tridentata*. Largest from Concord, diam. 23 mm., alt. 10½ mm; smallest, diam. 19½, alt. 9 mm. Largest from Oakdale, diam. 20¼, alt. 9½ mm.; smallest, diam. 19, alt. 10 mm."—*G. H. C.*

Polygyra fraudulenta Pilsbry.

Welch Bald, Swain county, N.C. One specimen, diam. 13 mm.

Polygyra rugeli (Shuttl.).

An abundant species. Tuckaleechee Cove, at about 1,200 feet elevation, two rather small shells, 11 mm. diam. Cade's Cove, very abundant, usually about 14 mm. diam., the ordinary variation 12 to 15. One umbilicated specimen taken, and one slightly less than 9 mm. diam., the smallest *rugeli* on record. Ferriss took a specimen in 1898 which is distinctly carinated at the periphery, this being from "Roe's Cove."

Of ten specimens collected at Brannon's, Sugar Cove, off Cade's Cove, by Ferriss, five measure 9 to 10 mm., one 10½, and four 13½ to 14 mm. Some of these are among the smallest specimens of the species seen.

On Thunderhead, in the Eagle creek region, N. C., probably between 3,500 and 4,500 feet, the extremes in a series collected are 11 and 15 mm. diam.

"Quite common on Miry Ridge in 1898, probably about 4,000 feet, about same size as Cade's Cove specimens, average. The smallest shell of this species which I have seen is from Russellville, Ala. (Lewis collection), 8½ mm. diam. From Scott county, Va., I have two specimens of 9 and 9½ mm. diam. respectively."—*G. H. C.*

It occurred also on Andrews Bald, Welch Bald and Chamber's creek.

On the Little Tennessee river, at mouth of Chamber's creek, Mr. Ferriss collected small specimens, 11 to 12 mm. South of the Little Tennessee river specimens were taken on Cheoah creek, and in Glen Cove, in the Unakas, twenty-one specimens, varying gradually from 10½ to 14½ mm. diam.

At Tallassee ford, Little Tennessee river, in Monroe county, Tenn., a dozen specimens taken by Ferriss vary from 12 to nearly 13 mm., being thus very uniform in size.

Polygyra chilhoweensis (Lewis).

This magnificent species is characteristic of the Great Smoky Mountains, having been described from an outlying ridge, the Chilhowee Mountain, which rises some 2,000 to 2,500 feet—about the elevation of the slopes of Cade's Cove. In large series collected by the party of 1899, and in those taken by Ferriss and Clapp in 1898, no intergradation with *P. sayii* Binn. was observed. *P. chilhoweensis* is always larger, with broader lip and more obsolete teeth or none. *P. sayii* is not known to occur in the region, though Wetherby has taken it at Roan Mountain.

Of many specimens taken by our party, 1899, in "Sugar Cove," off Cade's, the largest I have seen measures 39 mm. diam., the smallest 31 mm. Mr. Ferriss gives 40 and 27½ mm. as the diameters of his largest and smallest specimens.

At Eagle creek, N. C., on Thunderhead, 35 mm. diam.

Proctor's Knob (on the Tennessee-North Carolina boundary, between the south end of Miry Ridge and Briar Knob), 33 mm. diam.

South end of Miry Ridge, 31–34 mm. Ferriss' 27½ mm. shell was from Miry Ridge.

On Clingman's Dome it is rare, occurring on the western end, probably at about 4,800 feet. We did not find it near the summit.

South of the Little Tennessee Ferriss found it on Yellow creek, Graham county, N. C., and in Glen Cove, one of the heads of Slick Rock creek, in the Unaka Mountains.[9]

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[9] Mr. Clapp furnishes the following table of measurements of specimens of *P. sayii* and *P. chilhoweensis* in his collection :

Polygyra sayii Binn.

Gr. diam.	17½	lesser	15	alt.	10½	mm.	New York.
"	19	"	17½	"	11¼	"	North Carolina.
"	20	"	17	"	13	"	New York.
"	20½	"	18	"	11	"	North Carolina.
"	20½	"	17½	"	11½	"	"
"	21½	"	19	"	13	"	New York.
"	23	"	20	"	13½	"	Ontario, Can.
"	23	"	19	"	13	"	Pennsylvania.
"	23	"	20	"	13	"	Ohio.
"	24½	"	21½	"	15	"	West Virginia.
"	25½	"	22	"	14	"	Virginia. This specimen has a double parietal tooth.
"	27½	"	24	"	16	"	Kentucky.
"	28	"	24	"	16	"	Virginia.
"	28½	"	24½	"	17	"	"

Polygyra chilhoweensis Lewis.

Gr. diam.	31½	lesser	26½	alt.	21	mm.	Miry Ridge. Tenn.
"	31½	"	27	"	20	"	"The Balsams."
"	33	"	28½	"	18½	"	Braden Mt., Campbell county.
"	33	"	28	"	21½	"	Miry.
"	35	"	30	"	21	"	Toothed. Campbell couuty.
"	35½	"	30	"	22	"	" Cade's.
"	36¼	"	31	"	20	"	" "
"	36½	"	31	"	21	"	Cade's.
"	36½	"	32	"	24½	"	Unaka Mountains.
"	37½	"	32	"	22½	"	Campbell county.
"	38	"	33	"	24½	"	Toothed. Cade's.
"	39	"	33	"	24½	"	" Miry.
"	39¼	"	33	"	24½	"	Unaka Mountains.
"	42	"	35½	"	26½	"	Bald Mountain, 6,000 feet, Blount county, Tenn.

This last giant is in the Lewis collection, and Dr. Lewis says: "Cubic dimensions 9.65 of *H. diodonta* of the size of Say's type." I think the altitude given for Bald Mountain, 6,000 feet, is a mistake.—*G. H. C.*

Polygyra albolabris (Say).

Cade's Cove, at "Roe's Flat" and "Laurel Creek" (Ferriss and Clapp), Blount county, Tenn. South of the Little Tennessee, in Graham county, N. C., Ferriss reports the species from Tuskeegee Mountain (at the head of Yellow creek), Yellow creek, and the Cheoah river.

We did not find *albolabris* on the mountains and it probably does not ascend over 2,500 feet, if so high as that, in this region, being confined to the coves.

The specimens from Cade's Cove are heavy, solid shells, 32 to 35 mm. diam., of beautiful texture, the microscopic sculpture being sharply developed. Many of them blush with a distinct rose tint above, the base pale yellow. The white peristome is strongly developed.

I have been disposed to refer these shells to the variety *major*, the typical form of which occurs in Georgia and western extra-peninsular Florida; but the dividing line between *albolabris* and *major* is at best an exceedingly indistinct one, and we may perhaps be nearer the truth if we consider the shells of this region as a transition between *albolabris* and *major*. A specimen from Johnson City, in the valley of East Tennessee, measures 38 mm. diam.

Polygyra exoleta (Binn.).

Cade's Cove, abundant; Glen Cove, Unaka Mountains, N. C.; Tallassee ford, Caringer, Tenn.; well-developed shells of the normal form. It was not found by us on the mountains, but in the coves, and apparently does not ascend much above 2,000 feet. "The Cade's Cove shells vary in color, some having a very dark spire shading to nearly white on the base, while others are either uniform dark or light."—*G. H. C.*

Polygyra ferrissii Pils.

This beautiful species can never become common, so rugged and remote are its mountain haunts. To the north and northwest of the summit of Clingman's Dome the slope is steep, frequently precipitous, and covered with a talus of great blocks of rock, deeply carpeted with sphagnum and shaded by great balsam firs.[10] Like the other mountains of this ridge, Clingman seems to be a mono-

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[10] Besides the balsam fir or "she balsam," *Abies fraseri*, the *Picea rubens* Sargent is mingled with it in the Clingman forest. I am indebted to Mr. Thomas Meehan for the identifications, based on cones and foliage.

cline, the massive conglomerate beds dipping steeply to the south or southeast. This results in a rocky talus on the north or northwest slopes, from disintegration of the faulted or eroded edges of the strata, while the other slope is less rugged. Mossy trunks lie in every direction, making progress slow and difficult.

It is on the wet and bare under surfaces of blocks resting free from the ground that Ferriss' *Mesodon* lives. Kneeling or lying at length on the wet moss, and peering or crawling into these black crevices, we found the snails on the rock roofs of the cavities, but only in small numbers. Candles were occasionally of use.

A few specimens were taken among the rank herbage covering the ground near the summit of the ridge, where they live with Clapp's variety of *Polygyra andrewsæ*.

Besides this locality near the summit of Clingman, a few specimens were taken from a similar station about one and a half miles down the west end of the mountain on the Tennessee side, probably near the 4,000 foot contour. This spot was reached by a desperate climb in the bed of a leaping brook, through a dense laurel thicket, the way led by the indomitable Ferriss. This locality is a jolly good place for hard work, but a poor one for snails.

Ferriss and Sargent found *P. ferrissii* on Andrews Bald, which is really but a spur of the Clingman mass.

Another spot at which *P. ferrissii* has been taken is on " Miry Ridge on the western slope, from a quarter to a half mile below the point where the ridge leaves the boundary range. The situation is very similar to that described above for Clingman, except that many of the fallen stones are smaller and the bulk of the collecting was done by ' quarrying.' On the southern side of the main range Ferriss found a few specimens in 1898. These two localities are so close together that they may be considered as practically the same."—*G. H. C.*

Along the great ridge ramifying southward from Siler's Bald, Ferriss and Sargent found *P. ferrissii* at Welch Bald. This peak rises to 5,000 feet, and is connected with Miry Ridge and Clingman by the 4,000 foot contour.

P. ferrissii does not show much variation so far as known. Ferriss found a single albino, a lovely light-green shell, which he gave to the Academy, and Sargent found two light-colored shells, one of which was albino, in 1899. Of the specimens taken on Clingman, the largest measures 23½, the smallest 19 mm. diam.

Polygyra palliata Say.

Taken by Ferriss at Laurel creek, Cade's Cove. It is apparently wanting in the mountains along the interstate boundary, but reappeared in the Little Tennessee region on Chamber's creek, and at its mouth, on Bob's Bald (Stratton Bald), at Glen Cove, Unakas, and Tallassee ford, Monroe county, Tenn. Mr. Clapp observes that the southern specimens are less hairy than the northern.

Polygyra appressa perigrapta Pils.

Tuckaleechee Cove; Cade's Cove; Eagle Creek, Thunderhead, about 4,000 feet; Block House, "The Balsams," west end of Clingman, about 6,000 feet; Welch Bald creek and Chamber's creek, to the Little Tennessee. Everywhere well-developed, typical specimens. South of the Little Tennessee, Ferriss took specimens on Tuskeegee creek, Cheoah creek, Bob's Bald and in Glen Cove. We found *P. appressa sculptior* Chadw. on the bluffs of the Tennessee, opposite Knoxville.

Polygyra clarkii (Lea).

Cade's Cove. Fine specimens were taken about 1,000 feet below the summit of Thunderhead, on the North Carolina side, though it is far from common. The largest and smallest shells measure: Alt. 10½, diam. 14 mm.; alt. .10, diam. 13½ mm. Clingman's Dome and Andrews Bald; Welch Bald branch of Chamber's creek; and south of the Little Tennessee on Tuskeegee and Cheoah creeks, in Glen Cove, and at Tallassee ford of the Little Tennessee.

"Ferriss and I found this species on Miry Ridge in 1898, at about 4,000 to 4,500 feet. *Decidedly scarce.* Largest alt. 12, diam. 15¾ mm. Largest from Thunderhead, just below Spencer's Cabin, alt. 10½, diam. 15½ mm. Largest from Cade's Cove, alt. 11, diam. 15 mm."—*G. H. C.*

Polygyra thyroides (Say).

We did not find this species along the Tennessee-North Carolina boundary, but Ferriss found it in North Carolina, at Welch Bald, and on the Little Tennessee at mouth of Chamber's creek, and at Tallassee Ford. I picked up a specimen at Porter's Academy, Blount county, Tennessee.

Polygyra andrewsæ (W. G. Binney).

This species was originally described from the thin, small, greenish horn-colored form occurring on the upper 2,000 feet of Roan Mountain. This form is in reality a local race of a species widely spread along the mountain ridge between Tennessee and North Carolina, and eastward, probably throughout the mountains, extending into Georgia. Just what its westward limit may be is uncertain; but apparently it does not invade the valley of eastern Tennessee watered by the Holston, Nolichucky and Tennessee rivers. In Blount county, Tenn., we did not find it below about 2,000 feet, first encountering the species on the slopes of Cade's Cove. Whether it occurs at lower levels, or in the isolated Chilhowee ridge, remains to be seen, as no exploration has been made. It is obviously not a species of the Cumberland elevation, in the proper restriction of that term.

Typical *P. andrewsæ* will, of course, be restricted to the small Roan Mountain race, first described and well represented by Mr. Binney's figures (*Man. Amer. Land Shells*, fig. 321). For the larger, more solid, yellowish-brown or slightly greenish form, with wider lip and a more or less distinct prominence (hardly a tooth) on the columella, the varietal name *normalis* may be used, the types being from Cade's Cove, Blount county, Tenn.

The typical *P. andrewsæ* is not known to occur in the Great Smoky Mountains.

P. andrewsæ normalis n. var.

This is the form occurring throughout the Great Smokies, in the coves and on the mountain sides, up in some places to 4,500 feet, as at the southern end of Miry Ridge, or even higher, at the western end of Clingman's Dome. Specimens with a parietal tooth are very rare, and have only a small or indistinct tooth. No example of var. *normalis* with a band is known. Our collecting gave the following data:

Cade's Cove. The snails live on densely wooded mountain sides in the subordinate coves on the Thunderhead side at an elevation of about 2,000–2,500 feet. We found them crawling on the ground, and especially on logs or sticks. The lip is broad; none show a parietal tooth, and none are banded or dark colored. Largest of a series of seventy-five, $34\frac{1}{2}$ mm. diam.; smallest, 29 mm.; average of the entire lot $31\frac{1}{2}$ mm. Seventy-five per cent. of the shells measure 31–33 mm. diam.

Eagle creek, on the South Carolina side of Thunderhead, from about 3,500 to 4,000 feet. Station similar to Cade's Cove, but sometimes crawling up trees four to six feet. The shells are similar to the preceding lot, but there are apparently more very pale or albino specimens among them. Largest of a series of nineteen, $33\frac{1}{2}$ mm. diam.; smallest, 29 mm.; average of the lot, 31 mm. diam. Two-thirds of the shells are 31–32 mm. diam.

Proctor's Knob, on the Tennessee-North Carolina boundary, west of Miry Ridge; alt. about 5,000 feet. The shells taken are solid and large, measuring 32, 33, 33, 34, 35 mm., diam.; average $33\frac{1}{2}$ mm.

South end of Miry Ridge, 4,500–5,000 feet altitude, on the boundary trail. Sixteen specimens, two with a very slight trace of a parietal tooth. A few show a slight channel at the upper termination of the outer lip. They occurred on logs of a former camp. Largest specimens, 33 mm. diam.; smallest, 30 mm.; average of the lot, 32 mm. diam. The shells are more solid than at Eagle creek or Cade's Cove.

"Miry Ridge, in Tennessee. In 1898 Ferriss and I followed out the ridge a few hundred yards and then down the western angle probably 2,000 feet. (According to the 'Knoxville sheet' Miry is 5,000 feet high where it leaves the boundary.) We collected *normalis* all the way down, but found it most plentiful on top. It was a very wet season and the snails were all over the ground and weeds and even on the trees several feet above the ground. My largest from Miry is $36\frac{1}{2}$ mm. diam.; smallest, $31\frac{1}{2}$ mm. diam. Many of the shells were very globose, two measuring, alt. $27\frac{1}{2}$, diam. 32 mm., and alt. 28, diam. $34\frac{1}{2}$ mm., respectively. One shell, 33 mm. diam., has a strong parietal tooth, and two others have faint teeth."—*G. H. C.*

Western end of Clingman's Dome, at about 5,600–5,800 feet. Specimens of the large variety (*normalis*) are rare here, only two being found by me, to nineteen of the small variety (see below), during a long search. These measure 32 and 33 mm., are rather solid, toothless, without a groove at the upper insertion of the lip, and quite similar to specimens from Miry Ridge. Clapp writes of the specimens from this locality: "Shells from

'The Balsams' are large and very heavy, largest $35\frac{1}{2}$ mm., smallest 30 mm. diam." As at the second Miry Ridge locality, it occurs here with the var. *altivaga*, but only sparingly.

It was taken also at Andrews Bald and on Chamber's creek by Ferriss. South of the Little Tennessee, Ferriss took specimens on Tuskeegee creek and Yellow creek, Cheoah river and in Glen Cove, one of the heads of Slick Rock creek. In the Unaka Mountains, not far from Citico creek, the shells are large and solid, toothless or with the slight trace of a parietal tooth, lip not grooved at its junction above. Diam. 33–$36\frac{1}{2}$ mm. A series would probably show them to be perceptibly larger as well as more solid than the Miry Ridge shells, which excel those of other localities mentioned above.

P. andrewsæ altivaga n. var.

This is the form of the higher mountain tops. It is characterized by the small size, globose contour, compact coiling of the whorls which scarcely exceed five in number; the striation being very fine and delicate; parietal wall unarmed or with a small acute tooth; lip flat and rather wide, the internal rib interrupted near the upper termination, leaving a slight channel at the angle of junction, more or less obvious in different specimens. Shell thinner in adults than in adults of var. *normalis;* colors typically darker and richer, but varying to pale with a dark band above the periphery. Types from near the summit of Clingman's Dome, with *P. ferrissii.*

Mr. Clapp first directed attention to this form, which he and Mr. Ferriss took at the summit of Thunderhead and at Miry Ridge in 1898. While there is no sharply defined single character separating it from the ordinary form of *P. andrewsæ normalis,* yet among some hundreds of specimens of *P. andrewsæ* I have examined I find it easy to distinguish this form, which is by all odds the handsomest of the varieties of *P. andrewsæ.* The following details relate to special localities :

Clingman Dome, near the summit, 6,500 feet elevation. On herbage and moss on the ground, shaded by balsams. The shells are often dented while alive, and mostly appear to complete their growth in two seasons, the second period of growth beginning of a lighter color and slightly coarser texture than the preceding growth. Of thirty-two specimens the largest has a diameter of

28, the smallest 24 mm., eighty per cent. being from 25 to 27 mm., the average of the lot is 26 mm. Thirty per cent. are more or less distinctly banded. Mr. Clapp writes of the specimens taken by him that " out of thirty-six shells, nineteen are dark and seventeen banded, some of the latter with only the peripheral band, others with an additional subsutural band. Largest 29 mm., smallest 24½ mm. diam. West of 'Double Springs' I got one specimen 31½ mm. diam., alt. 24 mm "

Andrews Bald, south of Clingman Dome, and connected with it by a high ridge, alt. about 5,800 feet. Forms entirely like that on Clingman were found here by Ferriss.

West end of Clingman, between 5,500 and 6,000 feet. Shells similar to those from top of Clingman, but usually paler colored. Fewer specimens are banded, one with two distinct bands; and a few specimens show a minute but sharply defined parietal tooth, quite near the upper end of the lip. The largest of nineteen examples is 28 mm., the smallest 24½ mm. diam.; average of the lot 26 mm.

Miry Ridge. " In the same locality as *ferrissii*, and either under the rocks or in the moss overhanging the edges of the rocks, on the western angle of the ridge. I think the Miry Ridge shells collected last year are more typical than those from Clingman as they are more mature and heavier. Out of fifteen Miry Ridge specimens in my collection, six have the parietal tooth strong, three have it faint and six are toothless. These shells also show the channel much better than those from Clingman on account of the lip being fully formed. Of the fifteen shells, three are dark, six are light (we did not get this color variety on Clingman), two have a peripheral band, one has a faint line between the band and the suture, and three are what Ferriss calls 'half and half'—that is, the band extends from the periphery to the suture. Largest Miry shell diam. 30, alt. 21½ mm.; smallest, diam. 26, alt. 18½ mm."—*G. H. C.*

The specimens vary from the pale greenish-yellow tint, occasionally with a band above, to a dark reddish-brown color, similar to the Clingman form. The largest of twelve specimens is 28½, the smallest 25 mm. diam.; average of the lot 27 mm. diam.

Thunderhead, at the summit, in a sparse growth of scrub beeches, under bunches of moss on the trunks. The shells are pale green or tinted with red, frequently with a reddish band, and sometimes having an indistinct band at the suture. The largest of six shells measures 25½ mm., the smallest 22½ mm.; average of the lot 24 mm. Mr. Clapp found nine shells, which measure, "Largest 26 mm., smallest 23 mm.; average of lot 24½ mm. One is dark red, four light, three with a single band, and one dark above, lighter beneath. One has a faint parietal tooth."

The shells inhabit a grove of beeches at the edge of the "bald." The trees are dwarfed by the exposed situation, and look, as one approaches the grove, like an old country orchard. The shells differ from those of Clingman in being smaller on the average and paler colored. The form is that of the Clingman *altivaga.*

Polygyra wheatleyi (Bld.).

A characteristic and widespread species in this region. It is allied to *P. ferrissii* rather than to the species with which it has hitherto been grouped. The specimens vary considerably in size, and in presence or absence of the parietal tooth, the variations being mainly local rather than indiscriminate.

Specimens from Cade's Cove (2,000 feet) and Thunderhead (up to 5,300 feet) are of good size, 13 to 16½ (rarely 18) mm diam., moderately solid, with very broad lip and a well-developed parietal tooth when mature. Similar specimens occur on Block House Mountain (south of Thunderhead), diam. 16 to 17 mm.

Ferriss found some beautiful greenish-white albino specimens in Cade's Cove.

Miry Ridge. "Quite common in 1898, and intermediate between the Thunderhead and Clingman forms, the lip being narrow and the parietal tooth small. Smallest of five, 14 mm.; largest, 15¼ mm. diam. Found down the western slope, from 4,000 to 4,500 feet."—*G. H. C.*

On Clingman Dome the shells are all small, diam. 12½ to 14 mm., thin, *without a parietal tooth*, the aperture more rounded, and the lip less flattened. This seems quite a well-marked local form. It occurred from our camp near the western end to the summit.

On Welch Bald the shells are like those from Cade's, diam. 14½–16 mm. Ferriss took it also along Chamber's creek.

South of the Little Tennessee, specimens were taken by Ferriss on Tuskeegee Mountain (north of Tuskeegee creek), where they are remarkably small, diam. 12-12½ mm., but the lip is wide and a parietal tooth developed in fully adult shells. They are not like the form from Clingman. At Bob's Bald, near Mt. Hayo, in Graham county, N. C., the shells are very large, 20–23 mm. diam., the parietal tooth present but small. On Hangover Lead, four miles east of Mt. Hayo, they are 12½–13 mm., and all dentate. Mt. Hayo, 16–17 mm., dentate. At Tallassee ford of the Little Tennessee river, the specimens are like those from Cade's Cove. It occurs also in Glen Cove.

Polygyra christyi (Bld.).

Roes Cove and Rowan's in Cade's; one specimen taken on Clingman's Dome. South of the Little Tennessee, Ferriss and Sargent found it on Tuskeegee creek and Cheoah river.

Subgenus **STENOTREMA**.

The various interrelations of the *Stenotrema* species have been discussed in more or less detail by Bland, Wetherby and Binney. Probably the primary division of the group should be based upon the epidermal sculpture, the first five species of the *Catalogue Amer. L. Shells—spinosa, labrosa, edgariana, edvardsi* and *barbigera,* to which *depilata* should be added—having no erect hairs whatever above, but short curved epidermal laminæ, running with the growth-lines; while *stenotrema, hirsuta* and the rest have either erect hairs above or are nude. Species of the first division are more or less carinated or angular at the periphery, at least in front of the aperture; those of the second division usually are rounded, though sometimes subangular.

This division of the group separates *depilata* from *P. stenotrema,* of which it has hitherto been considered a variety; and as there are several other characters of importance sundering the two, it will be better to treat *depilata* as a distinct species. The distinguishing characters of *depilata* and *stenotrema,* and the varieties of the latter, are shown in the following key:

a.—Surface with short *processes parallel with the growth-lines above, but no erect hairs anywhere;* parietal lamella slighter and straighter than in *stenotrema,* the *inner end not bending in to meet the basal lip,* outer end not passing under the basal lip, when viewed from below; *no callous ridge between* *the lamella and the peripheral termination of the outer lip;* space between lamella and lip wider than in *stenotrema;* basal lip with a shallow median notch, but no notch or tooth on the outer arc of the lip; fulcrum quite small; *spire high;* periphery angular; *surface hairless,* with faint spiral striæ and *a silken lustre* below.

P. depilata Pils.

a'.—Surface *without laminar processes above, bearing erect hairs* or none; parietal lamella very strong, crescentic, its inner end curving in and terminating at the axis close to the inner end of the basal lip; outer end also strongly incurved.

P. stenotrema (Fer.), Pfr.

b.—Surface densely though shortly hirsute or beset with the scars of hairs, both above and below.

c.—Outer lip with a deep notch for the reception of the outer end of the deeply incurved parietal lamella, a distinct tooth outside of the notch; *fulcrum long;* form depressed; pale colored. 6 × 10 mm. Woodville, Jackson county, Ala.

P. stenotrema exodon Pils.[11]

c'.—Outer lip less notched and less distinctly or not toothed; fulcrum decidedly shorter; form more globose, more elevated, and usually dark colored.

Typical *stenotrema.*

b'.—Surface without hairs or their scars; other characters of typical *stenotrema;* 6½ × 10 mm. Nashville, Bellevue and Johnson City, Tenn.

P. stenotrema nuda, n. var.

Polygyra depilata Pilsbry.

This species was first found by Mrs. Andrews. It is not closely allied to *P. stenotrema,* with which I formerly associated it, but to *P. edvardsi.* It is known from high up in "Sugar Cove," on the Thunderhead side of Cade's Cove (one specimen); near the summit of Thunderhead, where all our party took specimens, and

[11] The names *globosa* (*Nautilus* vi, p. 77) and *subglobosa* (*Catalogue,* p. 14) are to be suppressed. Both are purely *nomina nuda.* As not a word of definition has been published, and as they are quite inapplicable to the depressed variety here defined from Woodville, Ala., no good purpose would be served by their perpetuation. Both typical *stenotrema* and var. *exodon* were collected at Woodville by Mr. H. E. Sargent.

where Mrs. Andrews first found it, and Clingman Dome, near the summit. "Ferriss and I found it on Miry Ridge in 1898, same locality as *P. ferrissii.* Occasionally on trees in moss."—*G. H. C.*

It also occurs on Andrews Bald, a spur of Clingman, in Swain county, N. C., and south of the Little Tennessee river in the northeastern Unaka Mountains, on Stratton Bald (Sargent). In the specimens from this peak, collected not far from the 5,000-foot contour, the notch in the basal lip is shallower and wider from the obsolescence of the callus between it and the axis.

It lives in wet moss and on rocks; not around logs, like our northern Stenotremes.

In size it varies but little, the extremes being $9\frac{1}{3}$–$10\frac{1}{3}$ mm. diam. The conic spire is lower in some individuals, there being sometimes as much as 1 mm. variation in height in specimens of the same diameter. The silky sheen of the surface seems invariable. Some albino specimens from Thunderhead are light green.

Polygyra edvardsi magnifumosa n. var.

Shell small, dark brown and lustreless, often with some golden streaks or spots; the periphery angular in front; whorls $4\frac{3}{4}$ to $5\frac{1}{2}$; the upper surface distinctly wrinkle-striate, not hairy but when unworn showing short cuticular laminæ (like those on *P. spinosa*); lower surface smooth, showing fine, slight spiral striæ, and sometimes very short hairs or hair-scars. Aperture much as in *P. stenotrema*, the parietal lamella well developed, curving downwards at both ends, a callous ridge running from it to the peripheral insertion of the outer lip; notch of the basal lip median, of moderate size; no tooth developed on the callus within the outer lip. Alt. 4.7 to 5, diam. 7 to $7\frac{1}{2}$ mm.

Brannon's and Chestnut Flats, in Cade's Cove, Blount county, Tenn. (one specimen an albino); Welch Bald, on the Forney Ridge (one specimen), and Welch Bald branch of Chamber's creek (nineteen specimens); Chamber's creek (four), all in Swain county, N. C. Also south of the Little Tennessee river, in Graham county, N. C., on Tuskeegee creek (three specimens), and on the Cheoah river, near the confluence of Yellow creek (thirty-one specimens). "Bob's Bald" (three specimens). Clay county, N. C.; at Hayesville (forty-three specimens).

In all, 105 specimens from some eight localities, the extreme points about forty miles apart. Its vertical range is from about 4,500 feet on Welch Bald to a little below 2,000 feet at Hayesville, Chamber's creek, Cheoah river, etc.

Despite the varying localities, the specimens are remarkably uniform in character. The largest specimen was taken on Chamber's creek, measuring 5.7 mm. alt., 8.8 mm. diam.; otherwise typical. The peculiar sculpture of the upper surface, resembling that of *P. spinosa, depilata, edvardsi,* etc., and wholly unlike *P. stenotrema* or *P. hirsuta,* amply distinguish it from the latter species. Compared with *P. edvardsi,* described from West Virginia, the var. *magnifumosa* differs in the following features: the parietal lamina is higher, stronger and more sinuous, with a stronger callus between it and the upper end of the peristome; the lip notch is deeper and wider, and the periphery is less angular.

P. edvardsi was collected at Burnside, Pulaski county, Ky., by Messrs. Ferriss and Sargent, the specimens differing from the West Virginians in the well-developed lip notch.

P. barbigera (Redf.).

A single half-grown shell from Hayesville, Clay county, N. C., was taken by Mr. Sargent; and while the peristome is still sharp and simple, the shaggy cuticle, fringed at the sutures, indicates this rare species.

Polygyra stenotrema ('Fer.' Pfr.).

Practically typical specimens occur throughout the region, but in some localities, noted below, huge fellows larger than ever have been recorded were found by Mr. Ferriss. The localities are: Tuckaleechee Cove, and Cade's Cove, including the dependent "Sugar Cove;" Thunderhead, the specimens being very densely hirsute above and below, 9–11 mm. diam., and have an extremely small notch in the basal lip.

Chamber's creek, Swain county, N. C. Diam. varying from 8.7 to 10 mm. Densely hirsute, the notch very small in two, quite large in three specimens, the latter smaller. Another lot from same locality consists of eight very large, densely hirsute specimens, normal in form, varying from $7\frac{1}{2} \times 11$ to 8.2×12.3 mm., whorls $5\frac{1}{2}$ to 6. Some of these shells are the largest I have seen of the species.

Tuskeegee creek, Graham county, N. C., small specimens, diam. 9 and 10 mm., the form typical

Tallassee ford of the Little Tennessee river, Monroe county, Tenn. Several large, globose shells, 11½–12 mm. diam., and some decidedly smaller, 8½–10 mm. diam.

Yellow creek, Mt. Hayo, Stratton Bald and Glen Cove, Graham county, and Hayesville, Clay county, are other North Carolina localities where Ferriss or Sargent took specimens.

Polygyra hirsuta pilula n. var.

Smaller than typical *hirsuta*, with more elevated spire; whorls nearly 5, the last with well-rounded periphery, surface beset with rather long curved hairs. Parietal tooth sinuous, connected with the peripheral end of the outer lip by a callous ridge. Basal lip 3-toothed, the median notch much deeper than in *hirsuta*, with raised edges, the outer tooth small. Alt. 4½, diam. 6 mm.

The smallest specimens measure, alt. 4, diam. 5½ mm.

Thunderhead Mountain, from near the summit to Cade's Cove.

This form is not only smaller and more globular than *P. hirsuta*, but the armature of the basal lip is different. The median notch is much deeper, and instead of being a mere notch in a straight calloused edge, it appears as a deep sinus between two wide, irregular teeth.

This form seems to be confined to the Great Smoky Mountains. It was first found in June, 1895, by Mrs. George Andrews. Subsequently Messrs. Ferriss and Clapp collected specimens; and the party of five collected it in 1899. We found it in "Sugar Cove," "Lead Cove," "Rowan's" and Laurel creek in Cade's Cove, and on Thunderhead, near the middle summit, among the rocks where *Gastrodonta lamellidens* was found. Sargent found it on Welch Bald, and Ferriss took specimens on Tuskeegee creek, below the Little Tennessee river, in Graham county, N. C. It apparently does not descend below 2,000 feet above the sea.

This variety must not be confused with a small form of the species which occurs in the mountains of Pennsylvania, Maryland and Virginia, which is more depressed than var. *pilula*, and has not the peculiar basal lip described above. In the West, Michigan, Illinois, Iowa, etc., a form decidedly larger than that of the Middle States occurs, still retaining the normal shape of the basal lip.

In the region of Roan Mountain, ascending to about 5,000 feet, *P. hirsuta* is represented by another well-marked subspecies, *P. h. altispira* Pils. This form is large, diam. 9, alt. 7 mm., with high, conoidal spire, and broad, deep labial notch. It occurs also in the Black Mountains, N. C. (Hemphill), and in its area apparently replaces the true *P. hirsuta*, as the subspecies *pilula* does in the Great Smokies. It has the habits of *P. depilata*, according to Wetherby, living in damp moss, not under logs and sticks, like the lowland *P. hirsuta*.

Polygyra monodon cincta (Lewis).

Found very sparingly at Chamber's creek Church, on Yellow creek, Cheoah river, in Glen Cove, and at Tallassee ford of the Little Tennessee river. The specimens are nearly typical of the variety, which has more striking peculiarities of form than of color. In the James Lewis collection there are specimens from Hayesville, N. C. It was found to be a very rare shell by Ferriss.

PUPIDÆ.

Bifidaria contracta (Say).

"Sugar Cove" and Laurel creek, in Cade's Cove (Ferriss, Clapp and Walker); Thunderhead (Clapp, one specimen). It is rare in the mountains.

Vertigo bollesiana Morse.

Cade's Cove (Ferriss and Clapp); "Tuskeegee Mountains," between Yellow creek and Tuskeegee creek (Ferriss). Very rare in the mountains, and apparently quite typical.

Strobilops labyrinthicus strebeli (Pfr.).

Cade's Cove (Clapp *et al.*); Tuskeegee creek (Ferriss).

ACHATINIDÆ.

Cochlicopa lubrica (Müll.).

"Sugar Cove" in Cade's Cove, Blount county, Tenn., and "Ramp Cove," between the headwaters of Tuskeegee and Yellow creeks (Sargent). Very rare in the mountains, a single specimen found at each of the two localities.

CIRCINARIIDÆ.

Circinaria concava (Say).

Cade's Cove; Thunderhead; Clingman's Dome, to near the summit; Welch Bald; Chamber's creek. South of the Little

Tennessee it was taken by Ferriss on Tuskeegee and Yellow creeks, Cheoah river, in Glen Cove, and at Tallassee ford.

After his visit to the mountains in 1898, Mr. Clapp called my attention to the fact that there are two forms of this species in the Smokies, a larger and a smaller. This, however, seems to be a case of wide range of individual variation in size. Thus, of five adult specimens taken in the lily patch near the summit of Clingman, the largest is $15\frac{1}{2}$ mm. diam., with $5\frac{1}{3}$ whorls, the smallest $12\frac{1}{2}$ mm. diam., with $4\frac{1}{2}$ whorls. Two others are $13\frac{3}{4}$ and $14\frac{1}{2}$ mm. in diam.

A larger series taken on Thunderhead, in the Eagle Creek region, N. C., between 3,500 and 4,500 feet, contains larger shells, the measurements of four being $18\frac{1}{2}$, $16\frac{1}{2}$, 15 and slightly under 14 mm. There seems but little variation in the specimens from Cade's Cove, adults measuring about 16 mm. diam. Of course only specimens with the peristome completely developed are considered. Mr. Clapp's note follows:

"Largest from Cade's $18\frac{1}{3}$, smallest $13\frac{1}{2}$ mm. diam. Largest from Thunderhead, $20\frac{1}{2}$ mm., with 5 whorls; smallest, 14 mm., with $4\frac{1}{2}$ whorls. The small shells have a proportionately wider umbilicus. It may be merely an optical illusion, but the last whorl of the small shells appears to be subangular around the umbilicus. A specimen from Philadelphia, Loudon county, Tenn., in the Lewis collection, measures $22\frac{1}{3}$ mm. diam."

ZONITIDÆ.

Omphalina fuliginosa polita Pils.

Fine specimens up to 28 mm. diam. occur in Cade's Cove. Those from Thunderhead, near the summit, are not so large, diam. 25–26 mm. Mr. Ferriss took it also at Chamber's Church, at the mouth of Chamber's creek, Swain county, N. C. In 1898 Clapp collected specimens along the bluffs of Little river, in Tuckaleechee Cove. They are much smaller than the Great Smoky shells, the largest being only 20 mm. in diam.

Omphalina lævigata ('Raf.' Beck).

Mesomphix lævigata Raf., Beck, Index Molluscorum, p. 7, 1837.

Helix lævigata Fér., Pfr., et auct., not *Helix lævigata* Pennant, 1777.

The name of this species has been long preoccupied as a *Helix*, but I propose to avoid the obloquy of changing it by dating it from Beck, who really first defined the species by a reference to Férussac's figures, and whose publication was anterior to that of Pfeiffer, who has generally been cited as authority for the name. The synonomy has been ably discussed by Mr. W. G. Binney, who, however, does not credit Beck with the name. The type locality is "Kentucky."

Not uncommon in Cade's Cove, attaining 20 mm. diam. Those from high on Thunderhead are rather smaller; the color being decidedly green. Mr. Clapp took one specimen on the west end of Clingman. Mr. Ferriss took duskier specimens on the Cheoah river, Graham county, N. C.

Two notable varieties occur near the Little Tennessee river.

O. lævigata perlævis n. v.

Whorls more convex beneath than in typical *lævigata*, the *last whorl much smoother above*, not rib-striate, its width at the aperture (measured above) less than one-third the diameter of the shell. Aperture rounded-lunate, almost as high as wide. Alt. 9½, diam. 17 mm. This is from Tallassee ford of the Little Tennessee river, Monroe county, Tenn.

Omphalina lævigata latior n. v.

Broad and depressed, more broadly excavated around the umbilicus than the typical form, *the last whorl wider*, its width at aperture (measured above) one-third the diameter of the shell, and far smoother than in *lævigata*, being wrinkled irregularly, but without the close, deeply cut and subregular rib-striæ of the typical form of that species. Aperture oval-lunate, far wider than high. Color yellowish green. Alt. 13½, diam. 24 mm., or as large as 14 × 27 mm.

Tallassee ford, Little Tennessee river, Monroe county, Tenn.; also Chamber's creek Church, at junction of Chamber's creek with the Little Tennessee river.

A large, flattened and very green form, in which the rib-striæ are obsolete on the last whorl, and the aperture decidedly oval. In *O. l. perlævis* the base is more convex around the umbilicus, the mouth much more nearly round, and the last whorl narrower. *O. l. latior* has an elegant microscopic sculpture, which gives the upper surface a somewhat silky lustre.

Omphalina subplana (Binney).

In this species the apex and inner whorls are striated, as in *O. lævigata*, not smooth as in *inornata*. Splendidly developed specimens occur in the Smokies; the largest taken by myself in Cade's Cove measuring 21½ mm. diam. On the flanks of Thunderhead equally large specimens occur nearly to the summit, one in Clapp's collection measuring 23⅓ mm. diam. A clear green albino is among those collected there. As on Roan Mountain, it lives with *Vitrinizonites*, but is not rare. The shells are hard to clean, scarcely ever "pulling" well.

It occurs, but rarely, on Clingman's Dome. Ferriss took specimens on Block House Mountain and Welch Bald, and south of the Little Tennessee river on Tuskeegee creek, Cheoah river, Mt. Hayo and in Glen Cove.

Omphalina andrewsæ Pilsbry.

A very characteristic shell of the Great Smokies in Blount county, replacing here the *O. inornata* of the Cumberland Plateau. The largest taken by myself in Cade's Cove is 16 mm. diam., but Clapp took one 17½ mm. diam. On Thunderhead, near the summit (about 5,400 feet), they are smaller, diam 12 mm., and rather thinner. Specimens with a dark band above the periphery occasionally occur. It is one of the most beautiful shells of the region. Specimens were taken by Clapp on Miry Ridge, in 1898, diam. of the largest 17 mm. Also collected by Ferriss on Block House, Clingman's, Welch Bald, Welch Bald branch, Chamber's creek, and south of the Little Tennessee river on Tuskeegee creek, Cheoah river, Mt. Hayo, in Glen Cove, and at Tallassee ford. It therefore seems generally distributed in the Great Smokies and northeastern Unakas.

O. andrewsæ montivaga Pils.

This form seems to show no intergradation with *andrewsæ*, and is chiefly notable for the prolonged form of the aperture. The largest taken in Cade's Cove measures 19 mm. diam., and it is usually over 17. They are smaller, 15 to 17 mm., near the summit of Thunderhead. Mr. Ferriss took specimens on Welch Bald and Chamber's creek, and south of the Little Tennessee on Cheoah river. Clapp took it in 1898 on Miry Ridge, diam. 18⅔ mm.

Vitrinizonites latissimus (Lewis).

Slopes on south side of Cade's Cove, about 2,000–2,500 feet elevation; near summit of Thunderhead, lurking in deep moss covering the damp rocks; Block House Mountain, just south of Thunderhead; Clingman's Dome, not far from the summit, in moss, on the *Polygyra ferrissii* and *P. andrewsæ altivaga* ground; Welch Bald; and below the Little Tennessee, Ferriss took one specimen on Stratton Bald, in the northeastern part of the Unaka range.

The species is ubiquitous in the Great Smokies everywhere above 2,000 feet, though not found in great numbers, and restricted to moist places where moss carpets the rocks or logs. These conditions are met on the lower levels where the mountain slopes are densely shaded, but on the cloud-touched heights not much shade is necessary.

The shell of *V. latissimus* is often deficient in calcareous stiffening in the region near the axis behind the columella, and it is more or less shrunken or dented there. This is a significant feature, showing that *Vitrinizonites* is varying toward the condition of shell we find in *Cryptostrakon*, *Peltella*, *Gæotis* and some forms of *Girasia*,[12] in all of which decalcification has affected the same region of the shell. The following form, however, shows more impartial decalcification, or, to be more exact, want of calcification.

Vitrinizonites latissimus uvidermis, n. var.

Near the summit of Thunderhead and Clingman's Dome, in the wet moss covering the rocks, there lives a form of *Vitrinizonites* of about the size of *latissimus*, but almost wholly lacking any calcareous layer of the shell. The cuticular test is more or less dented and distorted in the living snails; and when "cleaned" the shell collapses like wet paper, unless stuffed with cotton. The surface is usually less brilliant than in *V. latissimus*, and the last half-turn of the suture deviates somewhat more tangentially. The color varies from as light as the ordinary *V. latissimus* of the region to a very dusky, even blackish, shade. These "grape-skin *Vitrinizonites*," as we called them, live with the normal form, but are apparently always easily distinguished as above indicated. A cleaned shell quite resembles the empty skin of the ordinary free-

[12] See *Manual of Conchology*, XII, second series, p. 211.

skinned Concord grape. The form was first found by Ferriss and Clapp in 1898. It is not improbable that a study of the soft parts, which I hope to find time for before long, will show it to differ specifically from *V. latissimus.*

Vitrea petrophila pentadelphia n. var.

Shell about the size of *V. indentata;* glossy, pink-brown, openly umbilicated, convex above, composed of 4½ whorls, those of the spire slowly widening, the last much wider; surface sculptured with many unevenly spaced radiating grooves similar in character to those of *V. indentata*, but more numerous; and there are some striæ intermingled, the spire being more closely striate. No mentionable spiral striæ seen with an enlargement of fifty diameters. The grooves continue upon the base, but are weaker there. Aperture broadly lunate. Alt. 2½, greatest diam. 5 mm.

Cade's Cove, Blount county, Tenn., in many places—"Roe's" and "Sugar" Coves, "Rowan's" and Laurel creeks—from about 1,800 to 2,200 feet elevation. Apparently wanting in the higher region, at least not found by us along the crests and peaks; but taken by Ferriss and Sargent on Stratton Bald, in the Unaka Mountains, Graham county, N. C., at what altitude not known, and at or below the level of Cade's Cove on the Cheoah river, near the junction of Yellow creek, and in Monroe county, Tenn., at Tallassee ford of the Little Tennessee river, near Caringer.

This *Vitrea* may be briefly characterized as similar to *V. petrophila*, but with only 4½ instead of 5–5½ whorls in shells of the same size, slightly wider umbilicus, less embracing and therefore less deeply lunate aperture and usually pinkish instead of whitish-corneous color. *V. rhoadsi* is a smaller shell with decidedly narrower umbilicus.

V. petrophila is not known to occur in the Great Smoky Mountains.[13] Judging from specimens taken by Mr. Clapp and myself at Knoxville, Tenn., and part of the original lot received from Bland, as well as other specimens collected by Ferriss and Sargent at Burnside, Ky., that species is very constant in characters. *V. p. pentadelphia* seems equally constant in the considerable number I have now seen, collected by Mrs. Andrews and the members of

[13] The form reported thence in the *Catalogue of American Land Shells*, p. 27, No. 263, was var. *pentadelphia.*

our party of 1899. It is the memory of this journey of five conchologists which the name seeks to perpetuate.

Vitrea carolinensis (Ckll.).

This species has been discriminated from *V. sculptilis* in the published accounts, but it is very much more closely allied to *V. indentata.* Indeed, it becomes an extremely difficult matter to separate the smaller form of *carolinensis,* such as prevails in the Great Smoky Mountains, from *V. indentata.* There is, however, one usually decisive criterion: *V. carolinensis* when examined with a *very strong* hand-lens, or, better, a compound microscope with an enlargement of 25 or 50 diameters, shows a minute sculpture of *very even, close, clear-cut spiral engraved lines.* In *V. indentata* the same magnification only brings out an extremely weak striation or none; only rarely does it approach the condition of *V. carolinensis.*

This micro-sculpture is so minute that an ordinary pocket lens, even a very good one, rarely reveals it. But I have seen very few specimens which could not be definitely referred either to *carolinensis* or *indentata* when examined with a compound microscope. The sculpture is visible only in the "high-light" or point of reflection.

Common throughout the Great Smoky ranges wherever explored. In Cade's Cove and the dependent valleys it has been taken in many places: Rowan creek, diam. 6 mm.; "Brannon's"; "Chestnut Flats," diam. 6 mm.; Laurel creek, diam. 5½ to 7½ mm.; "Sugar Cove," diam. 6 mm.; most of these having been collected by Ferriss; the localities lying between 1,800 and 2,200 feet.

On Thunderhead, near the summit, at 5,300–5,400 feet, on Block House Mountain, and on the western end of Clingman Dome, 6,000 feet, they measure 5 to 6 mm. diam.; Welch Bald, diam. 6½ mm.; and on Chamber's creek, adults 5 to 6 mm. diam.

South of the Little Tennessee river specimens were taken by Ferriss and Sargent on Tuskeegee creek and Cheoah river, diam. 7 mm.; Hayesville, diam. 5½ mm.; Stratton Bald, in the northeastern Unakas, alt. about 5,000 feet. In Monroe county, Tenn., it occurred at Tallassee ford, diam. 6½ mm.

It was taken on Miry Ridge in 1898 by Clapp, whose largest specimen measures 8½ mm. diam.

Besides these mountain localities, Mr. Clapp collected *V. carolinensis* at Oakdale, Morgan county, Tenn., and Mr. Ferriss obtained at at New Pittsburg, Tenn. ($6\frac{1}{2}$ mm. diam.), and at Burnside, Ky., diam 6 to 7 mm. I found a specimen among shells Clapp and I collected on the south side of the Tennessee at Knoxville.

Vitrea sculptilis (Bld.).

This strikingly distinct species was taken in Cade's Cove and on Thunderhead Mountain, up to the spot near the summit where *Gastrodonta lamellidens* was found. The largest from this locality is 7 mm. diam. Ferriss and Sargent add the localities Block House, Andrew's Bald, Chamber's creek, in Swain county, and Cheoah river and Stratton Bald in Graham county, N. C. Also Tallassee ford and Welch Bald. It was described from somewhat below these localities, in the Anantahely Mountains, N. C.

Under a strong lens the surface of this species is seen to be granulose in spiral series, and the edges of the radial grooves seem somewhat raised. This is usually more prominent on the spire than on the last whorl.

Vitrea capsella (Gld.).

Probably most of the examples from the Great Smokies are referable to the variety *placentula*, which is larger than typical *capsella*, with an additional whorl; but one lot of seven shells from "Sugar Cove," off Cade's Cove, is typical *capsella*. The largest shell measures 5 mm. diam., and has $6\frac{1}{3}$ whorls. Sargent took it in "Ramp Cove," on Tuskeegee Mountain, between the headwaters of Tuskeegee and Yellow creeks, in Graham county, N. C.

V. capsella placentula (Shuttl.).

Cade's Cove; Thunderhead near summit, a little smaller. It occurs also on Chamber's creek, Swain county, N. C. It is very difficult to draw a line between *capsella* and *placentula*.

Conulus chersinus (Say).

Cade's Cove (Ferriss and Clapp).

Zonitoides arboreus (Say).

Cade's Cove, at many points (Laurel and Rowan's creeks, Roe's, Brannon's, etc.), but not common; Thunderhead, at Spencer's Cabin, under dried cow-dung, and near Eagle Creek; Block

House Mountain, south of Thunderhead; west end of Clingman, at about 5,800 feet, on logs. Chamber's creek and Welch Bald, Swain county, and south of the Little Tennessee on Tuskeegee creek, Graham county (Ferriss and Sargent), and at Hayesville, Clay county (Sargent). Also Tallassee ford. It is common at Knoxville. Seems to occur throughout the mountains, though far more sparingly than on lower country, and apparently varies from the Northern shells in being somewhat smaller and frequently more widely umbilicated.

Zonitoides patuloides (Pilsbry).

I found one specimen under chips in Cade's Cove, on the Thunderhead trail. Ferriss and Clapp took one or two specimens each in various parts of Cade's Cove in 1898, and Sargent in 1899. It is one of the rarest snails.

Zonitoides elliotti (Redfield).

Cade's Cove; Thunderhead near the summit; Welch Bald and Welch Bald branch; Chamber's creek, down to the Little Tennessee, south of which Ferriss and Sargent took specimens on Tuskeegee creek, Cheoah river and Mt. Hayo. Also Stratton Bald and Hayesville, N. C. (Sargent).

Z. elliotti is evidently allied to the preceding species, not to the Gastrodontas, where I formerly placed it. It has the foot-grooves and caudal pore of the *Zonitidæ*, as Binney has stated, and the resemblance of the shell to *Circinaria* is therefore meaningless.

Messrs. Ferriss and Sargent took specimens of *Zonitoides lateumbilicatus* Pils. at Burnside, Pulaski county, Ky. This species has not hitherto been reported from elsewhere than the type locality in Jackson county, Ala., where it was discovered by Mr. H. E. Sargent.

GASTRODONTA.

The genus *Gastrodonta* is a most interesting one to the evolutionist, presenting a considerable number of local forms. These are of all grades between the slightest deviation from the historic types of the species and strongly marked subspecies, or forms which apparently could be called specific. Taking the group (exclusive of *Taxeodonta*) as enumerated in the Catalogue recently published by the *Nautilus*, it divides naturally into three parts: the *group of G. ligera*, containing *intertexta*, *acerra*, *demissa*, *cerinoidea* and *ligera;* the *group of G. gularis*, containing *collisella, gularis, suppressa, cœlaxis, lawæ* and *lasmodon;* and finally the *group of G. interna*, comprising that species alone.

"*G. elliotti*" evidently does not belong here, but to *Zonitoides*, next to *Z. patuloides;* and *G. macilenta* (Shuttl., not W. G. Binn.) is a synonym of *G. lasmodon.* It is often an excessively difficult matter to separate young *G. gularis* from *G. suppressa*, yet they cannot reasonably be united specifically.

Gastrodonta intertexta (Binn.).

Cade's Cove, Blount county, Tenn. Also taken by Ferriss on Welch Bald branch, Chamber's creek and Tuskeegee creek, and by Sargent at Hayesville, N. C. Clapp found one specimen, an albino, on the west end of Clingman.

Gastrodonta acerra (Lewis).

Commonly distributed in the Smokies. Cade's Cove (variable in size and form, measuring from alt. 10, diam. 16, to alt. 11, diam. 14 mm.; the high bee-hive shaped form prevailing); Thunderhead (5,400 feet) and Clingman Dome (6,500 feet), somewhat thinner and smaller, diam. 12–13½ mm.; and in North Carolina at Welch Bald, Chamber's creek, in Swain county, and south of the Little Tennessee river on Cheoah river, Mt. Hayo, and in Glen Cove, Graham county, and Hayesville, Clay county, N. C.; also at Tallassee ford, Monroe county, Tenn. (Ferriss and Sargent).

The form of *acerra* prevalent in the mountains is generally smaller and more elevated than Dr. James Lewis' specimens from Monroe county, Tenn., and the last whorl seen from above is not so wide. Occasional specimens, however, may be found almost exactly like the Monroe county shells, though the average or norm of the mountain shells is perceptibly different.

Mr. Walker got a sinistral specimen in Cade's Cove.

Gastrodonta demissa (Binn.).

Rowan creek, Cade's Cove, with *G. gularis* (Ferriss). Also taken at Chattanooga, Tenn., by Mr. Ferriss, and at Stratton Bald, Graham county, N. C., and Harriman, Tenn, by Mr. Sargent.

Gastrodonta gularis (Say).

The very large series examined shows considerable variation in height of the spire, but is constant in the barely perforated umbilicus. The teeth vary as usual, often curving strongly toward each other, but sometimes nearly straight. The same sort of shell prevails throughout most of the localities thus far explored in the Great Smokies, about 400 shells from that region having been individually examined.

The localities are as follows: Monroe county, Tenn., Tallassee ford, and on Citico creek; Blount county, Cade's Cove, in many places. Along the Tennessee-North Carolina boundary at Thunderhead and Clingman's Dome. Swain county, N. C., at Welch Bald and on Chamber's creek; Graham county, N. C., on Tuskeegee creek and Cheoah river, and on Stratton Bald (5,000 feet). At Hayesville, Clay county, N. C. (slightly below 2,000 feet), a series of over 100 specimens collected by Sargent shows somewhat more variation than occurs in the other localities enumerated above. The umbilicus varies from a very minute perforation in nearly all examples to one about .8 mm. wide in a very few; and of two specimens with a diam. of 8 mm., one is 5½ mm. high with fully 8 whorls, another 4⅓ mm. with 7 whorls. All intermediate contours occur. The high examples do not have the full basal whorl of *G. collisella*, and are true *gularis* in the mouth parts.

Gastrodonta interna (Say).

Apparently does not occur abundantly in the mountains along the Tennessee-North Carolina boundary. Ferriss found it on Welch Bald, Chamber's creek Church, and south of the Little Tennessee on Tuskeegee creek, Cheoah river and Bob's Bald.[14]

Section TAXEODONTA.

This little group comprises the thin little Gastrodonts allied to *G. multidentata*. Comparison of the shells and soft anatomy should be made with the toothed *Conulus* and with certain toothed individuals of the *V. capsella* group. Aside from these, the group stands well apart from others. *G. significans* and *G. andrewsæ* are comparatively large and robust forms, the former widely distributed and with teeth in pairs, the latter belonging to the Roan Mountain region, and with numerous teeth. Then we have in the Great Smokies several peculiar species:

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[14] Ferriss lists *G. interna* from "Brandon's Cove," probably Brannon's Cove, subsidiary to Cade's Cove.

Gastrodonta clappi Pilsbry.

Described from Miry Ridge, where it was taken by Ferriss and Clapp in 1898, but most of the few shells taken that year were found at the *lamellidens* locality on Thunderhead. In 1899 we found it at the western end of Clingman, at about 5800 feet alt., on wet stones some distance below the surface. Mr. Ferriss found a single half-grown but unmistakable specimen on Block House Mountain, a peak nameless on the Geological Survey topographic map, lying south of Thunderhead; and Sargent took specimens on Thunderhead, in the *G. lamellidens* locality.

No specimens yet seen, either old or young, have internal teeth or barriers. It is very distinct from the following forms by its much larger size and conspicuously coarser sculpture, wider whorls, etc. The type measures, alt. 3, diam. 5.5, width of umbilicus .23 mm., whorls 6½. The spire is slightly raised. The Thunderhead examples agree with the type in having a very small umbilicus, the spire being slightly convex. A specimen taken by Clapp on Clingman measures, alt. 3, diam. 6.2, width of umbilicus .54 mm., whorls 6½, the spire nearly plane. Below "The Balsams" on the western end of Clingman, a few hundred feet down the Tennessee side, I found two half-grown specimens of about 3.8 mm. diameter, also having the umbilicus somewhat wider than in the Miry Ridge type, though less wide than Clapp's specimen, and the spire nearly flat. It is unsafe to draw conclusions from the three specimens thus far known from Clingman, but perhaps that peak has a race with more depressed spire and wider umbilicus.

Four localities are now known for this species, the Thunderhead, Miry Ridge and Clingman shells coming from a little north of the interstate boundary, in Tennessee, the Block House shell from south of the boundary, in North Carolina. None of the localities are far from the 5,000-foot contour, and the extremes lie about thirteen miles apart. The shells are extremely fragile, like most forms living on the Clingman and Thunderhead conglomerates.

The most assiduous search by our party of five in 1899 resulted in finding fourteen specimens, most of them immature. About as many were found by Messrs. Ferriss and Clapp in 1898.

G. lamellidens Pilsbry.

A very glossy and brilliant, dark reddish-brown shell, with the closely coiled whorls and size of *G. multidentata*, but differing from that species in never having radial rows of teeth, but having obliquely radial laminæ, three in young, rarely more than one or two in adult shells. This armature is constant in a large number of specimens that I have examined, collected by Ferriss, Clapp and myself.

Mr. Clapp has a similarly armed shell, very light colored but otherwise typical, from Deering, N. H., collected by Mr. E. W. Roper, and there is one (No. 57,106) in the collection of the Academy from Greenwich, N. Y. The question arises, are these not mere occasional variations of *G. multidentata*, which appear sporadically, rather than a distinct species? In this case *lamellidens* is to be regarded as a race in which this rare variation has become a fixed and, so far as can be proved by about 150 shells examined, probably a constant character. And in this connection the possible relationship to these forms of *Conulus dentatus* Sterki, which has similar armature, needs investigation.

In *G. lamellidens* the surface shows no spiral striation under an enlargement of 50 or 75 diameters; it is rather deeply, closely and regularly costulate-striate; and the width of the umbilicus is contained about ten times in the diameter of the shell.

The type locality[15] is a steep slope close to the middle summit of Thunderhead, deeply covered with a talus of angular stones small and large, in the interstices of which there is considerable mould which supports a herbaceous growth. *Vitrinizonites*, *Gastrodonta acerra* and a few *Polygyra depilata* are the chief dwellers among the moss of the superficial stones, but, as Ferriss wrote last year, a "quarry" must be opened to find *G. lamellidens*. Each one of the wet stones must be closely examined on all sides before it is thrown out, and once in a long while one or two of the snails may be found, if one is in luck. They occur from a few inches to a foot or more below the surface of the talus.

Specimens have also been found by Mr. Ferriss at Block House Mountain (near and south of Thunderhead), Swain county, and at

[15] By an error of my own, the locality "Clingman's Dome" was given in the *Classified Catalogue*, p. 29. No specimens are yet known from Clingman, though it will probably be found there.

Stratton Bald and on the Cheoah river, Graham county, N. C.; Sargent also took it at Stratton Bald.

Gastrodonta walkeri n. sp.

Size of *G. lamellidens,* and general contour about the same; whorls $5\frac{3}{4}$; umbilicus much wider and more open, its diameter contained about $5\frac{1}{2}$ times in that of the shell; *surface rather dull to the naked eye,* under strong magnification seen to be extremely finely and irregularly plicatulate-striate, *the striæ cut into minute beads by close decussating, impressed, encircling lines.* No internal aminæ or teeth in adults, or with two transverse, curved barriers, as in *G. lamellidens.* Alt. 1.45, diam. 2.9, width of umbilicus .5 mm.

Cheoah river, near junction of Yellow creek, Graham county, N. C., three specimens taken by Ferriss. "Ramp Cove," on Tuskeegee Mountain, between the heads of Tuskeegee and Yellow creeks, several taken by Sargent.

This form differs from *G. clappi* in the sculpture and in size. It resembles *G. lamellidens* and *multidentata,* but is ornamented with densely crowded spiral lines, and very conspicuously finer growth-striæ, and has a wider umbilicus. A half-grown specimen of the type lot has two curved internal laminæ, like *G. lamellidens,* with finely denticulate edges; the others have no internal armature. Four specimens from Tallassee ford of the Little Tennessee, Monroe county, Tenn., have the spirals rather more spaced, and each has two internal denticulate transverse laminæ; umbilicus about one-seventh the diameter of shell.

Of the specimens taken by Sargent, one from Ramp Cove has an internal barrier, another none; and those from Sam. Blair's, at Tallassee Ford, vary in the same way. The decussated sculpture is constant.

The species will be most easily recognized by the finer radial sculpture and wider umbilicus than *lamellidens,* as the spirals are nearly or quite invisible under an ordinary lens, though their development is an essential specific character.

G. multidentata (Binn.).

Oakdale, Morgan county, Tenn., one specimen (Clapp). Though not in the Great Smoky Mountain area, this is included as showing the southward distribution of the species.

G. significans (Bld.).

"Ramp Cove, Tuskeegee Mountain," between the headwaters of Tuskeegee creek and Yellow creek. Typical specimens taken by Ferriss and Sargent.

LIMACIDÆ.

Agriolimax campestris (Binn.).

Thunderhead Mountain, near the summit, common.

PHILOMYCIDÆ.

Philomycus carolinensis (Bosc.).

Tuckaleechee and Cade's Coves, Blount county, Tenn.; Thunderhead, to the summit, crawling on trees; Clingman Dome.

This species is common throughout the Great Smoky Mountains, and the individuals reach a very large size. In the humid atmosphere of the mountain tops *Philomycus* lives in the open, on trees and logs, not concealed beneath the bark, as in dryer localities.

Philomycus hemphilli (W. G. Binney).

"Sugar Cove," in Cade's Cove, at over 2,000 feet elevation; Thunderhead, near the summit, on moss, etc.; Clingman's Dome.

The coloration of this species reminds one of *Amalia hewstoni*, the back being black, fading on the sides to whitish beneath. The jaw in a specimen examined has a group of four contiguous ribs near the middle. The specimens collected were drowned, but all collapsed in alcohol; and probably some other method of preservation would be better.

ENDODONTIDÆ.

Pyramidula alternata (Say).

Andrews Bald; Welch Bald, Cheoah river, Tuskeegee creek and Mt. Hayo, N. C. At Glen Cove, Unaka Mountains, Graham county, N. C. (Ferriss), a distinctly depressed form, but not more carinated than typical shells, occurred.

Typical specimens of *P. alternata carinata* Pils. were taken by Ferriss at Burnside, Pulaski county, Ky. Large specimens, up to 22 mm. diam. This form is very strongly carinated, but rather more finely ribbed than typical *alternata*. See *Proc. Acad. Nat. Sci. Phila.*, 1896, p. 490. The types of the variety were taken by Mr. S. N. Rhoads, on the Emory river, near Harriman, Tenn. It is a race of the Cumberland Plateau.

Pyramidula alternata costata Lewis.

We took this strongly marked variety in Cade's Cove and on Thunderhead. It has not been found elsewhere (see Clapp, *Nautilus*, XIII, p. 41). Ferriss found a sinistral specimen in Sugar Cove, off Cade's.

Pyramidula perspectiva (Say).

Cade's Cove; near summit of Thunderhead, and near summit of Clingman's Dome. Ferriss adds the localities Welch Bald, Chamber's creek, Tuskeegee creek, Cheoah river, Mt. Hayo and Tallassee ford. Typical, and in Cade's Cove very abundant, under slabs at an old saw-mill, near Blair's place. Beautiful albino specimens were found in "Sugar Cove." *P. bryanti* does not appear to occur in the Great Smokies.

Helicodiscus lineatus (Say).

The mountain specimens are well developed, but practically typical. Specimens were taken in Cade's Cove at various points, near the summit of Thunderhead, at Block House, on the west end of Clingman, and south of the Little Tennessee on the Tuskeegee Mountains, north of Tuskeegee creek, on Bob's Bald and on Mt. Hayo.

Punctum blandianum n. sp. Fig. 1.

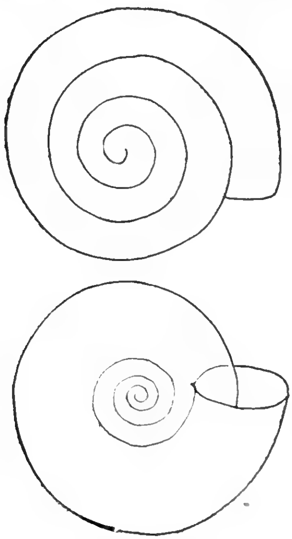

Fig. 1.

Mr. Clapp found two specimens of *Punctum* somewhere in Cade's Cove (probably in the dependent "Sugar Cove") which differ markedly from *P. pygmæum*. The umbilicus is much wider than in *P. pygmæum*, its width contained between $2\frac{2}{3}$ and $2\frac{3}{4}$ times in the total diam. of the shell. The aperture is smaller than in *P. pygmæum*. Whorls $3\frac{1}{2}$; color brown; surface-sculpture about as in *P. pygmæum*—very fine but rather sharp striæ along the growth-lines and nearly obsolete spiral striæ. The spire is low conoidal, about as in *P. pygmæum*.

Alt. .6, diam. 1.15 mm.

It is named in honor of Thomas

Bland, whose excellent work on American land shells materially advanced the science.

SUCCINEIDÆ.

Succinea obliqua (Say).

A rather thin form of this species occurs near the summit of Thunderhead, on leaves of herbage. Also found on Clingman's Dome.

PLEUROCERATIDÆ.

The mountain streams above two or three thousand feet in the Great Smokies are apparently barren of molluscan life, though full of trout. The following occurred at lower levels.

Pleurocera aratum (Lea).

Little Tennessee river, at Tallassee ford, Monroe-Blount counties, Tenn. (Ferriss).

Pleurocera hastatum (Anth.).

Little river in Chilhowee Gap, Blount county, Tenn. (Walker, Clapp and Pilsbry).

Goniobasis proxima (Say).

Welch Bald branch of Chamber's creek, Swain county; Tuskeegee creek, Graham county; and Mission creek, Hayesville, Clay county, N. C. (Ferriss and Sargent).

Goniobasis saffordi (Lea).

Chamber's creek, Swain county, N. C. (Ferriss).

Appendix.

In *The Nautilus* for January, 1898, Prof. W. H. Dall mentions, without description, a new variety of *Vitrea wheatleyi* under the "varietal name of *V. clingmani*," based upon "the large form of *Z. wheatleyi* referred to by Binney (*Manual*, p. 222) as collected by Hemphill at Clingman's Peak, N. C."

When on Clingman Dome, our party searched diligently for this shell, but without success. On applying to Mr. Hemphill for information, I learned that the "Clingman's Peak" of his label is not Clingman Dome of the charts, but a local name for a peak northeast of Asheville. Hemphill did not visit the Great Smoky range. He writes as follows:

"Black Mountain Station is on the railroad east or northeast of Asheville. From this station I walked into the mountains (north) about ten or twelve miles and stopped at a house near the foot of Mt. Mitchell, and also near the Pinnacle of the Blue

Ridge. In company with two other persons, I went to the summit of Mt. Mitchell and ' Clingman's Peak,' as they called it, and remained all night. We carried our provisions and blankets. It took nearly all day to get to the summit, and I had but a few hours for collecting the next morning. If my memory serves me faithfully, I got but little material on that trip, but judging by the name, I suppose the shell called *Z. wheatleyi clingmani* was collected at that place and time."

The specific name does not of course refer to the mountain, but is to honor Thomas L. Clingman, who made valuable observations on the geology and topography of North Carolina, and further served that State with distinction in the U. S. Senate, before the civil war.

The following diagnosis and *camera lucida* outlines have been supplied by Prof. Dall:

"**Vitrea clingmani** Dall. Fig. 2.


Fig. 2.

" Shell extremely thin and fragile, of a translucent greenish color, polished, with five rather inflated whorls; suture well marked, the enveloping whorl rising slightly above it and not suturally appressed ; sculpture in harmony with the incremental lines, consisting of at first rather close-set regular wrinkles which are obsolete on the base and more distant in the adult near the last part of the last whorl ; spire and base somewhat flattened, periphery rounded, peristome acute, the upper lip but little produced beyond the basal part; umbilicus narrow, deep; nucleus very small, smooth; major diam. 6.5, minor diam. 5, alt. 2.5 mm.

" Habitat, Black Mountain, N. C., near Clingman's Peak, Hemphill. Types 38,910, U. S. Nat. Mus.

" This form was referred to *Zonites wheatleyi* by Binney, from whose original specimens this diagnosis is drawn, but, as pointed out to me by Dr. Pilsbry, the species to which our shell is most closely allied is *Vitrea petrophila.* The latter is of a waxen whitish or pale straw color verging toward brownish, but *V. clingmani* is distinctly greenish; *V. petrophila*, though a smaller shell, has, in all the specimens I have been able to examine, a larger and more funicular umbilicus, and the lumen of its whorls is more circular."

MALLOPHAGA FROM ALASKAN BIRDS.

BY VERNON L. KELLOGG AND SHINKAI I. KUWANA.

The Mallophaga described and identified in the following notes were collected by Mr. E. A. McIlhenny from birds shot by him at Point Barrow, Alaska. The determinations of the birds were made by Mr. McIlhenny.

The two references given for each identified species are, first, to the original description, and, second, to a complete list of the Mallophaga from North American birds recorded up to the time of the publication of this paper. In this list can be found for each species all of the references to the occurrence of the parasite on North American hosts, and also a complete list of all the hosts, North American and foreign, from which the parasite is recorded.

Docophorus lari Denny, Monograph Anoplur. Brit., 1842, p. 89, pl. V, fig. 9. Kellogg A List of the Biting Lice (Mallophaga) taken from Birds and Mammals of North America, 1899, Proc. U. S. Nat. Mus., vol. XXII, p. 44.

From *Larus* sp. Previously recorded by Kellogg from a dozen or more species of *Larus* from Kansas, California and Alaska.

Docophorus alaskensis n. sp. (Pl. VII, fig. 1).

A single male taken from a Ross's Gull, *Rhodostethia rosea* (Point Barrow, Alaska). This species closely resembles *montereyi*, but differs in having the abdomen but little wider than head, while in *montereyi* the abdomen is one-fourth wider than head. It also differs markedly in shape of signature and somewhat in shape of clypeus, and the lateral abdominal bands present noticeable differences.

Description of male: Body, length 1.6 mm., width .6 mm.; head large, dark brown; thorax, with dark lateral borders; abdomen, a little wider than head, dark brown, with black lateral border.

Head, length .55 mm., width .5 mm.; uncolored front of clypeus very slightly expanded, flatly rounded with three short marginal hairs on each side in front of the suture; trabeculæ large, reaching almost to the distal end of the second antennal segment, yellowish brown; antennæ with segment 2 longest, segments 3 and 4 shortest, segment 5 a little shorter than segments 3 and 4 together, dark brown with distal end of each segment paler; eye flat, with a long hair and a short prickle; temporal margins with two long hairs and a fine prickle; occipital margin nearly straight or slightly concave; signature shield shaped with produced acuminate posterior angle reaching the mandibles, anterior margin very slightly concave ; antennal bands blackish brown, distinct, posterior ends turning diagonally inward, anterior ends, where interrupted by the suture, turning in toward the base of the point of the suture; occipital bands blackish brown, narrow, uniform, diverging, and separated from the antennal bands by a pale diagonal space ; region contiguous to the eye dark.

Prothorax short, broad, with slightly diverging sides and rounded posterior angles with one hair; lateral marginal bands blackish brown, bending inwards along posterior margin. Metathorax broadly pentagonal, with a series of seven pustulated hairs on each latero-posterior margin beginning at lateral angles; a dark lateral blotch in each lateral angle extending inward along latero-anterior sides. Legs concolorous with body, with darker markings.

Abdomen, elongate, ovate; segments 2 to 8 with one or two hairs in posterior angles; segments 2–8 with broad black lateral bands, which are narrower on the posterior segments; segments with long, transverse, dark-brown blotches barely separated medially by a paler line, widest on segments 3 and 4, and narrowing on each successive segment; transverse blotches confluent medially on segment 1, with a small, medial, angulated, uncolored emargination on anterior margin; transverse blotches confluent medially on segment 8; a narrow dark-brown transversal line behind the series of hairs in each segment; segments 2–5 with three to four pustulated hairs along the posterior margin, on each side of the middle, segments 1, 7 and 8 with one pustulated hair; segment 9 paler, posterior margin with slight emargination and a few short hairs.

Docophorus melanocephalus Burmeister; Handb. d. Ent., 1839, II, p. 426; Kellogg, List, 1899, p. 44.

From *Stercorarius parasiticus* and (straggler ?) *Oidemia* sp. (Point Barrow, Alaska). Previously recorded by Kellogg from *Sterna maxima* (Bay of Monterey, Cal.) by Kellogg and Chapman from *Stercorarius pomarinus* (same locality). Recorded by European authors from three species of *Sterna* and two of *Larus*.

Docophorus ceblebrachys Nitsch; (ed. Giebel) Zeitsch. f. ges. Naturwiss., 1861, vol. XVII, p. 528; Kellogg, List, 1899, p. 48.

From *Nyctea nyctea* (Pt. Barrow, Alaska). Previously recorded by American and European authors from same host (various localities in North America and Europe).

Docophorus cursor Nitzsch; Burmeister, Handb. d. Ent., 1839, II, p. 426; Kellogg, List, 1899, p. 48.

From *Asio accipitrinus* (Pt. Barrow, Alaska). Previously recorded by Osborn from *Asio wilsonianus* (Ames, Ia., and Lincoln, Neb.), by Kellogg from *Bubo virginianus* (Lawrence, Kans.), and by Kellogg and Chapman from *Asio wilsonianus* (Ontario, Cal.). Recorded by European authors from *Strix bubo*, *S. otus* and *S. brachyotus*.

Nirmus triangulatus Nitzsch; (ed. Giebel) Zeitsch. f. ges. Naturwiss., 1866, vol. XXVIII, p. 378; Kellogg, List, 1899, p. 53.

From *Stercorarius parasiticus* (Pt. Barrow, Alaska). Previously recorded by Kellogg and Chapman from *Stercorarius pomarinus* (Bay of Monterey, Cal.). Recorded by European authors from *Lestris*, *Stercorarius* and *Larus*.

Nirmus infectus n. sp. (Pl. VII, fig. 2).

A single female taken from a Red Phalarope, *Crymophilus fulicarius* (Pt. Barrow, Alaska).

Description of female: Body, length 1.55 mm., width .42 mm.; pale yellowish white, dark-brown head border, blackish lateral abdominal bands; slight indications of the abdominal blotches, segments 2–6 with small dark-brown median markings.

Head, length .37 mm., width .26 mm.; elongate conical, with narrow parabolic front; four short weak hairs along margins of forehead, a short hair in front of the trabeculæ; antennæ short, segments 4 and 5 most colored, segment 3 longest, segment 5 longer than segment 4, with a few short hairs on the segments; trabeculæ short but distinct; eye flat, with a long hair and prickle; clypeus transparent; temporal margins with two long hairs and a fine prickle between the long hairs; occipital margin nearly straight, with a few fine prickles; signature distinctly colored, nearly pentagonal, slightly convex in front, posterior margin weakly rounding, a dark-brown cross band in anterior middle of the signature; antennal bands distinct, rather broad, bending inward at the suture; temporal margin for a little distance behind eye with dark-brown border which narrows posteriorly; temporal bands indistinct.

Prothorax short, rectangular, with a single hair in posterior angles; blackish brown lateral borders which extend inward along anterior margin. Metathorax almost as wide as head, with flatly rounding posterior margin, with one long hair in angle and two groups of two each on each lateral half; blackish brown, lateral borders. Legs concolorous with the body, tibiæ darker than femora.

Abdomen elongated elliptical; each segment of 1–7 with distinct narrow lateral blackish bands, slightly expanding at front of segment and projecting across the sutures; abdominal blotches very slight; segments 2–6 with small dark-brown ventral median markings; two or three hairs in the posterior angles and a series of four longish hairs on the posterior margin of each of segment 2–6 and 8, segment 1 without hair, segment 7 with two hairs, segment 9 short and with slight angular posterior emarginations, two hairs on the posterior margin.

Nirmus complexivus Kellogg and Chapman; Mallophaga from Birds of California, in New Mallophaga, III, 1899, p. 78, pl. VI, fig. 4; Kellogg, List, 1899, p. 54.

From *Tringa canuta* (Pt. Barrow, Alaska). Previously recorded by Kellogg and Chapman from *Tringa minutilla*, and *Calidris arenaria* (Pacific Grove, Cal.).

Lipeurus ferox Giebel; Zeitsch. f. ges. Naturwiss., 1867, vol. XXIX, p. 195, Kellogg, List, 1899, p. 59.

From *Diomedea nigripes* (Pt. Barrow, Alaska). Recorded by Kellogg from *Diomedea albatrus* (Bay of Monterey, Cal.), by Osborn from *D. brachyura* (locality ?), and by European authors from *D. exulans, melanophrys* and *brachyura*.

Lipeurus confidens Kellogg, Mallophaga from Birds of Panama, Baja California and Alaska, in New Mallophaga III, 1899, p. 28, pl. III, fig. 2; Kellogg, List, 1899, p. 59.

From *Diomedea nigripes* (Pt. Barrow, Alaska).

Lipeurus densus Kellogg, New Mallophaga I, 1896, p. 114, pl. VII, figs. 1, 2; Kellogg List, 1899, p. 59.

From *Diomedea nigripes* (Pt. Barrow, Alaska). Recorded by Kellogg from *D. albatrus* (Bay of Monterey, Cal.), and from *D. nigripes* (off Kodiak, Alaska).

Lipeurus macilhennyi n. sp. (Pl. VII, fig. 3).

A single female taken from a Black-footed Albatross, *Diomedea nigripes* (Pt. Barrow, Alaska). This *Lipeurus* is a very well-marked species differing strongly in shape of head and body and in markings from the other *Lipeuri* of the Albatrosses.

Description of female: Body, length 3.6 mm., width .83 mm.; whole body chestnut brown with sharply defined, blackish brown marginal marking on abdomen and thorax, and distinct antennal and occipital bands on head; body long, widening posteriorly to fourth and fifth segments; head small and shorter than wide, forehead only one-third of length of entire head; clypeus broadly and flatly rounded; legs unusually large and stout.

Head, length .53 mm., width .55 mm.; decidedly short and broad for *Lipeurus;* clypeal front flatly rounded, with six short marginal hairs on each side of the front, a short hair on the margin in front of the antennæ which are short; trabeculæ small but distinct, uncolored; segment 2 of the antennæ longer than segment 1, segment 5 slightly longer than segment 3 or 4, the anterior end of segment 3 and segments 4 and 5 pale fulvous, a few short hairs on the segments; eyes prominent with a distinct ocular fleck; temples flatly convex, with three short prickles; occipital margin nearly straight without hair or prickle; whole head brown; antennal bands broad and blackish continuing beyond the suture; temples bordered by a very narrow line of blackish brown slightly broader just below the eyes; conspicuous ocular blotch blackish brown; two large blackish triangular blotches on the occipital margin; no uncolored clypeal region, and no signature.

Prothorax, very much wider than long, the angles very weakly rounded; segment chestnut brown with dark-brown lateral border extending inward, but leaving the middle portion of the segment paler, posterior angles slightly projecting; two blackish brown lateral blotches on the suture of pro and metathorax. Metathorax with lateral margin slightly concave before the middle; longer than broad; segment chestnut brown with large, lateral, marginal blackish brown blotch in front of the middle, and margin behind the blotch dark; four hairs in posterior angles, and set closely together in a small uncolored space; posterior margin slightly concave. Legs large, stout, concolorous with thorax, with distinct dark border; front legs short, femora wide with small dark-brown marginal markings; second and third pair of legs long; coxæ of third pair unusually large and flat, projecting laterally beyond the sides of metathorax; femora long and broad, with dark-brown border, tarsi short and broad at middle, with dark-brown border ; claws pale brown; several scattered hairs and spines on the legs.

Abdomen, widening posteriorly to segments 4 and 5 which are widest, segments 6 and 7 a little narrower than segments 4 and 5, and segments 8 and 9 narrowing more rapidly; first four segments with single hair in posterior angles, segments 5 and 6 with two hairs, and long hairs, increasing in length and number on posterior segments, segment 9 short and pale; segments almost wholly covered by large brown lateral blotches which leave a median paler longitudinal space and distinct transverse pale sutural lines; lateral marginal bands with conspicuous round-headed blackish brown processes projecting inward, segment 1 with a single pair, segments 2 to 7 with two pairs, none in segments 8 and 9.

Lipeurus laculatus Kellogg and Chapman, Mallophaga from Birds of California, in New Mallophaga III, 1899, p. 93, pl. VIII, fig. 1; Kellogg, List, 1899, p. 59.

From *Stercorarius* sp. (Pt. Barrow, Alaska). Recorded by Kellogg and Chapman from *S. pomarinus* and *Puffinus creatopus* (Bay of Monterey, Cal.).

Lipeurus protervus Kellogg, Mallophaga from Birds of Panama, Baja California and Alaska, in New Mallophaga III, 1899, p. 31, pl. III, fig. 4; Kellogg, List, 1899, p. 63.

From *Lagopus lagopus* (Pt. Barrow, Alaska). Recorded by Kellogg from same host (Kodiak Island, Alaska).

Although these specimens are from the same host and the host from the same region as in the case of the type specimens, there is a noticeable and constant difference in the shape of the head between the specimens of the two lots. The Point Barrow specimens have the clypeal margin distinctly flatter, and it is in the character of this clypeal margin that specific differences are most readily recognized among the *Lipeuri* of the Grouse. This case simply emphasizes the fact, referred to in the senior author's former papers on the Mallophaga, of the flexible character of specific lines in this group of insects. The peculiar habits of the Mallophaga, producing isolation of all degrees from slight to nearly absolute, renders their systematic study an intricate but interesting matter.

Eurymetopus brevis Dufour, Ann. Soc. Ent. France, 1835, vol. IV, p. 674, pl. xxxi, fig. 3; Kellogg, List, 1899, p. 64.

From *Diomedea nigripes* (Pt. Barrow, Alaska). Recorded by Osborn from *D. exulans* (Albatross expedition), by Kellogg from *D. albatrus* (Bay of Monterey, Cal.) and *D. nigripes* (North Pacific Ocean, off Alaska). Recorded by European authors from *D. exulans, nigripes* and *brachyura.*

Colpocephalum pingue Kellogg, New Mallophaga I, 1896, p. 144, pl. XII, fig. 5; Kellogg, List, 1899, p. 72.

From *Diomedea nigripes* (Pt. Barrow, Alaska). Recorded by Kellogg from *D. albatrus* (Bay of Monterey, Cal.).

Colpocephalum paetulum n. sp. (Pl. VII, fig. 4).

A single male from *Arenaria interpres* (Pt. Barrow, Alaska). This small *Colpocephalum* belongs to the group of species including *ochraceum* N. and Piaget's species related to *ochraceum* occurring on shore birds, but differs obviously from all of the hitherto described members of the group. The long hairs arranged in transverse series on the dorsal surface of the abdomen are pustulated, thus differing from *ochraceum* P. and *umbrinum* P.; there are two to three transverse series in each abdominal segment of the male thus differing from *spinulosum* P. with but one such series; there are no pustulated hairs on the head thus differing from *pustulosum* P.

Description of female: Body, length 1.7 mm., width .45 mm.; elongate with comparatively large head and legs; head golden brown with dark-brown ocular blotches; yellowish brown transverse blotches on the abdomen; a distinct pale submarginal longitudinal line parallel with the lateral margin of the abdomen; two or more transverse rows of pustulated hairs on segments 3–8.

Head, length .37 mm., width .45 mm.; front rounded, almost a semicircle, four hairs between the middle of front and the latero-anterior angle of which the last hair is the longest, a very short hair in front of the projecting tip of palpus; five hairs in the lateral angle in front of the ocular emargination of which the first is the longest; ocular emarginations deep, narrow; the eyes undivided but with a distinct medial emargination; the ocular fringes prominent; four long hairs in the temporal margin; occipital margin slightly concave, with four long hairs; color golden brown, ocular blotch dark brown, and narrow dark-brown border on outer temporal and occipital margin; indistinct narrow brown occipital bands, the dark-brown occipital margin expanded at their bases.

Prothorax, broad (nearly twice as wide as long), with a spine and two long hairs in produced lateral angles, posterior border rounded with a series of eight hairs; color golden brown with dark-brown lateral border, and a narrow transverse line across the segment in front of the middle. Metathorax showing no marginal constriction at line of union of mesothorax and metathorax; sides bare, posterior angles with a long hair and spine; posterior margin straight, with a row of long hairs; color golden brown with narrow dark lateral border. Legs, large, stout; femora greatly thickened and margined with golden brown; with scattered prominent hairs.

Abdomen elliptical; several short hairs on the lateral margins of the segments, some long hairs in the posterior angles; a row of unpustulated hairs along posterior margin of segments 1–2, two rows of pustulated hairs on segment 3 and three rows of pustulated hairs on segments 4–8, which are not strictly arranged in definite rows except the most posterior ones; color golden brown; lateral marginal blotches dark brown, separated from the median transverse blotches by a pale submarginal band, which is parallel with the lateral margin of the abdomen; median transverse blotches yellowish brown; last segment rounding, with numerous hairs on the posterior margin, two long hairs in each latero-posterior angle and a few scattered hairs, color paler.

Menopon corporosum n. sp. (Pl. VII, fig. 5).

Several specimens from a Red Phalarope, *Crymophilus fulicarius* (Pt. Barrow, Alaska), and one specimen (straggler?) from a Turnstone, *Arenaria interpres* (same locality). Differing markedly from the few other species of *Menopon* taken from the Grallatores in the very broad abdomen.

Description of female: Body, 1.8 mm., width .8 mm.; small head, with obovate abdomen; color light chestnut brown with dark-brown lateral abdominal borders.

Head, length .29 mm., width .53 mm.; front rounded, with slight indication of median angulation; eight hairs between middle of front and the ocular region; palpi projecting by the length of their terminal segments, temporal margin with three long hairs, one slightly shorter and five short ones; occipital margin concave, with four hairs on the middle third; color pale brown, dark occipital margin and black ocular blotches.

Prothorax broad, short, with lateral angles much produced and bearing two spines and one long hair; posterior margin flatly convex with ten long hairs; color golden brown. Metathorax as wide as head, narrow anteriorly with rapidly diverging sides; mesothorax distinctly separated by marginal constriction and dark transverse line; posterior angles of mesothorax bare, sides of meso- and metathorax bare; posterior angles of metathorax with four spines; posterior margin weakly convex with a series of hairs; metathorax with broad transverse yellowish brown band like those of abdomen. Legs pale brown with dark margin; femora thick, with rather long hairs.

Abdomen obovate, posterior angles of segment with one or two strong hairs and adjacent short ones; a series of hairs along posterior margin of each segment; color pale at sutures, black interrupted lateral bands, and a yellowish brown transverse band on each segment; a distinct pale and submarginal longitudinal line; ninth segment rounded behind with narrow transparent margin thickly set with a fringe of short sharp-pointed transparent hairs.

Menopon infrequens Kellogg, New Mallophaga I, 1896, p. 161, pl. xv, fig. 5; Kellogg, List, 1899, p. 75.

From *Oidemia* sp. probably a straggler from a gull. Recorded by Kellogg from *Larus glaucescens* (Bay of Monterey, Cal.) and by Kellogg and Chapman from *Larus delawarensis* (same locality).

EXPLANATION OF PLATE VII.

Fig. 1. *Docophorus alaskensis* Kellogg and Kuwana, ♂.
Fig. 2. *Nirmus infectus* Kellogg and Kuwana, ♀.
Fig. 3. *Lipeurus macilhennyi* Kellogg and Kuwana, ♀.
Fig. 4. *Colpocephalum pætulum* Kellogg and Kuwana, ♂.
Fig. 5. *Menopon corporosum* Kellogg and Kuwana, ♀.

NOTES ON THE GEOLOGY OF SOUTHEASTERN PENNSYLVANIA.

BY THEODORE D. RAND.

The work of the Second Geological Survey of Pennsylvania was very properly directed chiefly toward the economic geology of the State. Had reasonable appropriations been continued, it is probable that a more careful survey would have been made of the area southeast of the Red Sandstone region, and we might also have had what it is a disgrace to the State that we have not: a map of Pennsylvania comparable with that of the New Jersey Survey or to the Philadelphia Sheet of the U. S. Geological Survey. It being the fact, therefore, that this region southeast of the Red Sandstone has been hastily examined by the geologists of the Survey,[1] that their observations, in many particulars, do not agree with those of the First Survey under that most careful observer, Prof. Henry D. Rogers, and also that in this region there is difference of opinion even among those who studied it under the auspices of the Second Survey, it seemed not improper that I should put upon record numerous observations made in the leisure moments of a rather busy life during the past twenty years, in the hope that some little additional light may be shed upon the subject, and as an aid to those who may wish to study the region hereafter.[2]

I have written of some of the rocks discussed in this paper, but to make this one intelligible it will be necessary to repeat briefly some of the facts already published.

The region, covered chiefly with mica schists and gneisses and

[1] "In a single field season of seven months, a geologist who is to report on a county of fifty-six townships has just *three days* (on an average) to *each township;* and in a State with sixty-seven counties, all of equal importance to their inhabitants, and to practical science, it is evident that a State survey can only afford one full season to each county, unless its funds be greatly increased or its duration be indefinitely protracted."—*Second Geol. Survey of Pa.*, chap. 4, p. 20.

[2] Having experienced much difficulty in identifying localities already published owing to the changes of ownership of farms, quarries, mills, etc., I have described outcrops with particularity, perhaps greater than necessary, deeming it safer to err in the direction of clearness.

soil derived from them, is, as is well known, a difficult one for geological study. Exposures are often few and far between; advantage must be taken of every possible opportunity, such as well-digging and boring, and even of the exposures occasionally made by unusually heavy rains, while over large areas it is often impossible to find a single exposure. Besides this, some rocks of definite character are of very limited breadth, while others, well exposed, vary in width so greatly and suddenly that mapping in the usual method of connecting like exposures is very unsafe. Imagine, for instance, the well-exposed limestone and hydromica schist west and northwest of Conshohocken to be represented by scattered outcrops similar to those of the limestones and mica schists of southern Chester county, the intermediate surface being covered with soil as in that region, what geologist could possibly map the rocks as they really exist?

Of the rocks southeast of the Red Sandstone there are three prominent series as to which there is reasonable accord among all geologists:—

I. Rogers' Third Belt—possibly Laurentian, probably a considerable part plutonic. A remarkably straight outcrop of quite uniform, very hard gneissoid rocks, striking about S. 65° W., and extending almost unbroken from near Morrisville, Bucks county, opposite Trenton, N. J., to west of the Brandywine, apparently anticlinal in structure, and the oldest rock of the region. This, called Laurentian by the Second Survey and in my previous papers, I prefer to call by the safer term Ancient Gneiss.

II. Cambrian Sandstone. Rogers' Primal Sandstone, often called Potsdam, No. 1 of the Survey—the oldest fossiliferous rock yet discovered in this area.

III. Limestone, No. 2 of the Survey, Rogers' Auroral Limestone, formerly supposed to be equivalent to the Calciferous, Chazy and Trenton Limestones of the New York Survey,[3] though the recent studies of Prof. Walcott seem to prove that is Cambrian.[4] As to the remainder of the rocks, opinions differ widely. Those covering the largest areas are mica schists and gneisses. Among these gneisses and mica schists are belts of peculiar character traceable

[3] Chap. 4, p. 113, where this opinion is very forcibly asserted.
[4] *A. J. S.*, January, 1894, p. 37, and Vol. XLIV, 1892, p. 469.

for miles, for, as a rule, there are few well-marked sudden variations on the strike line.

These gneisses and schists include Rogers' first and second belts, Mr. Hall's Philadelphia schists and gneisses, and Manayunk schists and Chestnut Hill schists; Prof. Lesley's newer gneiss of the Philadelphia belt. The strike of these accords in the main with that of the ancient gneiss, local deviations being common; the subdivisions vary in width, their borders being usually more or less divergent or convergent. The almost universal dip, northwest of Darby creek, is northwestward, except close to the ancient gneiss, where it is southeastward. It should be said, however, that the apparent dip may not be the true dip, but merely schistosity due to pressure. It is a fact, however, that this schistosity seems to accord closely with changes in the constitution of the rocks.

Southwest of Darby creek a southeast dip prevails. Southwest of the Schuylkill similar schists and gneisses occur northwest of the ancient gneiss.

Minor faults are common, great ones may exist, but this has not been proved. The age of these newer schists and gneisses and their relative superposition is greatly in doubt; indeed, hardly any two geologists have agreed. Fossils not having been found, the arguments are necessarily based upon lithological character and stratigraphical position. It is, I believe, conceded that there is no considerable break of continuity on the line of strike, except that Mr. Hall regards certain hard gneisses in southern Delaware county and some gabbros, as Laurentian, underlying the newer schists and gneisses. The views of geologists may be briefly summed as follows:

Prof. Rogers supposed the structure a simple synclinal, the Chestnut Hill series, his second group, underlaid by the gneiss, which rose to the southeast and to the northwest, his first and third belts.

Above his third belt he recognized the primal (Cambrian) sandstone and a series of rocks which he regarded as of the same age stretching southwestward, and in western Chester county southward nearly or quite to the Maryland line, here overlying the Philadelphia rocks which he saw extending in a series of anticlinals dying out westward under his primal rocks.[5]

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[5] *First Geol. Survey of Pa.*, I, p. 228, quoted chap. 4, p. 68: "But to the westward of the Brandywine . . . . the primal series is spread prodig-

Mr. Charles E. Hall, finding in Montgomery county the same succession of rocks southeast of the ancient gneiss as northwest of it, particularly the Cambrian sandstone (then called Potsdam), and the limestone of Huntingdon Valley, supposed to be Silurian, argued that the schists and gneisses of the Philadelphia series succeeding to the southeast must be still more recent,[6] and likewise that the hydromica schists of the South (Chester) Valley hill were Hudson river,[7] and that these last spread through southwest Chester county.[8]

Dr. T. Sterry Hunt[9] made a study of the region, and chiefly on lithological grounds identified the Chestnut Hill series as Huronian, the Philadelphia rocks as Montalban overlying the Chestnut Hill schists.

Prof. James D. Dana referred the mica schists and gneisses of New York island and vicinity, which are certainly identical with those of the vicinity of Philadelphia, to the Lower Silurian.[10]

N. L. Britton wrote of the correspondence between the rocks of southeast New York and northern New Jersey of the gneissic and schistose group and Dr. Hunt's Montalban.[11]

Prof. H. Carvill Lewis[12] identified the newer schists and gneisses as Huronian, and in a later paper[13] contended that many, if not most, of these rocks were "of purely eruptive origin, consisting of syenites, acid gabbros, trap granulites, and other igneous rocks, often highly metamorphosed."

Dr. Frazer referred many of these rocks to the Huronian,[14]

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iously to the southward almost to the southern line of the State." *Geol. of Pa.*, I, p. 154.

A brief but remarkably accurate description of the geology of Chester county was published in a report of the Chester County Medical Society about the year 1857 anonymously. Its delineations of the chief belts of rock crossing the county show the author to have been most familiar with the region.

[6] *Second Geol. Survey of Pa.*, Vol. C^6, x, but for Pottsville, Potsdam is probably intended. *Ibid.*, p. xvii, and pp. 6 and 7.

[7] C^6, p. 12.

[8] C^4, p. 54.

[9] *Second Geol. Survey of Pa.*, Vol. E.

[10] *American Journal of Science*, June, 1881.

[11] *School of Mines Quarterly*, Vol. IX, p. 33.

[12] *Journal Franklin Institute*, third series, Vol. LXXXV, 1883, p. 424.

[13] H. C. Lewis, *Proc. British Association* in *Nature*, October 8, 1885, p. 560.

[14] "Ces mica-schistes, schistes à damourite, gneiss chloritiques et micacés representent la plus méridionale et la plus orientale des trois bandes du Huronien de ce district." *Memoir sur la géologie de la partie sud-est de la Pennsylvanie.* Lille, 1882, p. 37.

though questioning whether the limestone at Brinton's Bridge, north of Chadd's Ford, were Huronian or Laurentian.[15]

Dr. Frazer[16] regarded the South Chester Valley hill rocks as older than the limestones. He also urged[17] that much of the sandy schist area of southwestern Chester county should be regarded as Potsdam.

Prof. C. H. Hitchcock[18] referred the Philadelphia gneisses to the Montalban system of New Hampshire.

Prof. Lesley, in his Final Report, seems to regard the limestones of southwestern Chester county as Laurentian,[19] though this opinion is qualified on p. 128, where it is stated, "If the distinction between the older and the newer gneiss be a valid one, the older gneiss seems to disappear from the surface, going west from the Schuylkill into Chester county, and the newer gneiss seems to occupy the whole field south of the belt of South Valley Hill hydromica slate in Chester."

On p. 120, Vol. I, of the Final Report, Prof. Lesley gives clearly his view of the structure on the Schuylkill section as follows:

"1. The lower, or Philadelphia mica schist and gneiss group;

"2. The middle, or Manayunk mica schist;

"3. The upper, or Chestnut Hill garnetiferous schist group."

". . . . a constant general northwest dip, and these continue for another half-mile to a serpentine outcrop along the south edge of the Bear Ridge[20] older gneiss belt, but with reversed (southeast) dips. Therefore there is here a synclinal basin, and then a great fault, in which must be buried (against the older gneiss mass)

[15] *Memoir sur la géologie de la partie sud-est de la Pennsylvanie.* Lille. 1882, p. 52.

[16] *Second Geol. Survey of Pa.*, Vol. C^4; *Proc. Am. Phil. Soc.* Dec. 15, 1882, p. 517.

[17] C^4, pp. 35, 159, 311.

[18] *Trans. Am. Inst. M. E.*, 1883, 1884, Vol. XII, p. 68.

[19] "In Pennsylvania the highland gneiss areas do not show their marble beds enough to be well studied, ... but where they are thus exposed . . . . in southern Chester county . . . . they reveal the same facts as in the New Jersey Highlands" (Final Report, p. 110).

"There seems to be no probable objection to be urged against recognizing in the rocks of the Highlands of New York, New Jersey and Pennsylvania the rocks of the Adirondack region and of the Laurentian mountains of Canada; therefore the term *Laurentian gneiss* has been freely used in the reports of progress of the Survey to signify the rocks of the Pennsylvania Highlands" (*Idem*, p. 62).

[20] Probably a misprint for Buck Ridge.

the Manayunk and Philadelphia subdivisions; at least, this is the best explanation of the structure which has been obtained."[21]

From this brief summary it will be seen how very diverse are the views of the eminent geologists quoted, and why a more minute study was needed, for it seems incredible that upon the same facts, clearly and correctly stated, conclusions so varied could be reached by men so well qualified, some of whom, however, made no personal study of the outcrops.

The region is a portion of the great Piedmont plateau, but in its northern part nearly covered by the Red Rocks. The Philadelphia rocks (in part) extend southwestwardly through Maryland, where they have been studied by the late Dr. Williams, whose papers on the subject are very clear and throw much light on the questions which arise further north.[22]

Dr. Williams divides the rocks of the Piedmont belt in Maryland into two distinct classes. "One completely crystalline, and whatever their origin retaining no certain evidence of clastic structure, and confined to the eastern portion of the plateau. The second class are semi-crystalline, and while they have been subjected to a certain amount of metamorphism and alteration, they still plainly show that they were once sediments of ordinary type, not more altered than formations which in other locations have yielded fossils, so that there is no reason to suppose that their age will not be determined on palæontological evidence."[23]

That this conclusion is not unwarranted may be inferred from his remarks on the "quartz schist" under which he describes most clearly and unmistakably the Cambrian sandstone of Pennsylvania, which contains *Scolithus* in Chester county and abundant fossils further west. He says "whatever the origin of the quartz schist may have been, it is closely allied to the gneiss into which it grades by imperceptible transitions." [24]

It will be noticed that in Maryland the highly crystalline rocks

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[21] *Trans. Am. Inst. M. E.*, 1883, 1884, Vol. XII, p. 123.

[22] Extract from the *Guide Book of Baltimore*, prepared for the American Institute of Mining Engineers, February, 1892; *U. S. Geological Survey Bulletin*, No. 28, 1886; *Bulletin Geol. Soc. Am.*, Vol. II, p. 301.

[23] *Guide Book*, pp. 79, 80.

[24] "The cleavage planes of the quartz schist are due to their layers of muscovite. . . . . Its most characteristic feature . . . . long crystals of black tourmaline . . . . invariably broken and their fragments stretched along one line." (Williams' *Guide Book*, p. 103).

are to the *east* of the schistose belt. This belt, according to my observations, extends but a short distance into Pennsylvania, near the Delaware line, and is too poorly exposed to much more than indicate its existence, but there is evidence that it is largely intrusive. The map of Dr. Williams shows the rocks occupying very irregular areas in Maryland. In Pennsylvania, however, the margins of the areas are nearly straight, or at most gently curving lines, with remarkable uniformity of dip (cleavage?) over large territory.

The work of Dr. Williams was well supplemented by that of Prof. Frederick D. Chester on the gabbros of Delaware,[25] confirming Dr. Williams' results, but seemingly proving the passage of the massive gabbro into gneisses such as are common in the Philadelphia schists and gneisses.

If, starting at the northeast, we take a bird's-eye view of the region, we shall find it a triangle with the apex near Trenton, N. J., measuring about seventy miles southwestward with a base of about eighteen miles at the Octorara creek, the dividing line between Lancaster and Chester counties.[26]

At this apex we find the ancient gneiss flanked on the northwest by the Red Rocks, and on the southeast by the Cambrian sandstone, closely southeast of which are rocks typical of Mr. Hall's Manayunk series.

Southwestwardly we see the ancient gneiss widening and becoming a prominent ridge, known as Buck Ridge. The Cambrian sandstone continues on its southeasterly flank for a distance of nearly twenty miles, in its turn flanked on the southeast by limestone for a short distance, the schists and gneisses following.

Returning now to the ancient gneiss, we see it fork near Willow Grove, about eighteen miles from our starting point being divided and its central part overlaid by the Cambrian sandstone. The two branches of the gneiss continue southwestwardly, the northerly soon covered by the Red Rocks, but reappearing and covering a large extent of territory in northern Chester county, the southerly extending southwestward, narrowing, and at the Wissahickon becoming obscure or covered, then reappearing and widening

[25] *U. S. Geol. Survey Bul.*, No. 59.

[26] Except in the Chester valley, and to a very limited extent south of it, my researches have not extended west of the Octorara.

rapidly, crossing the Schuylkill with a width of a mile; Darby creek, seven miles from the Schuylkill, with a width of four miles; Crum creek, three miles beyond, with a width of five miles. Here it again forks, the southerly fork, only about a mile wide and extending not over five miles in length, narrows and ends southwest of and near Westtown School; the northerly, with a width of four miles, continues to the north of Westtown School, underlies West Chester, then narrows to a little over a mile, crosses the Brandywine just above the forks, and ends at Northbrook, about two miles beyond.

In nearly all this course we find the adjacent rocks to be schists and schistose gneisses, in which are outcrops of the sandstone.

Returning now to the vicinity of Willow Grove, we find, going southwestward, the sandstone divided by a limestone area. The northerly and much larger branch of the sandstone continues, with interruptions, to Valley Forge, whence it continues southwestwardly as the very prominent North Chester Valley Hill to Quarryville, in Lancaster county.

The southerly area of the Cambrian ranges through Edge Hill, here approaching very closely that mentioned as being on the southeasterly flank of the ancient gneiss, thence, through Barren Hill, to Spring Mill on the Schuylkill. Here it becomes obscure, but it may be traced westward as far as Wayne, Delaware county, while the sandy micaceous rocks, which seem to replace in part the typical sandstone, continue uninterruptedly. In middle and western Chester county the typical rock again appears among the micaceous rocks.

The limestone which first appears a short distance southeast of Willow Grove rapidly widens and forms the Montgomery or Plymouth Valley and westward the Chester Valley.

A little east of the Schuylkill this great area of limestone is in its turn divided by a hill of hydromica schist, with no sandstone visible between it and the limestone. West of the Schuylkill, the southerly areas of limestone and sandstone become insignificant, while the hydromica schist, not over a quarter of a mile wide at the river, broadens (chiefly by two remarkable promontories) until one and a half miles west of the river its breadth exceeds two miles, while the northerly area of the limestone forming the floor of the valley two and a half miles wide at the Schuylkill narrows to less than a mile. From the Schuylkill westward it is known as the Chester Valley.

Close to the southerly arm of the limestone occur mica schists, not unlike those on the southerly side of the southerly ancient gneiss. These schists, very narrow at the Schuylkill, widen rapidly westward, while the hydromica schists narrow. Near Northbrook Station, on the West Branch of the Brandywine, these mica schists appear to unite with those on the southeast of the ancient gneiss, while the gneiss itself disappears from view.

This disappearance is accompanied by a large outcrop of serpentine, a rock which northeastward seems to flank the ancient gneiss on both sides in scattered outcrops. Here the northerly mica schists become more quartzose and gneisses abound, much less massive, however, than the ancient gneiss, and form steep and high hills.

Included in the area of Prof. Rogers' first belt is the porphyritic gneiss, occupying a narrow outcrop at the Schuylkill but widening westward. It is remarkably uniform in its composition and from its hardness makes a prominent hill through most of its course.

In the same area are the Fairmount and Frankford gneisses, the former apparently anticlinal at the Schuylkill, the latter with the abnormal strike of nearly east and west. Both are noted for the rare minerals which they contain.

Resting on the higher summits of the newer gneisses and schists, southeast of the ancient gneiss, are patches of the Bryn Mawr gravel, described by Prof. Lewis. At a much lower level, overlying similar schists and gneisses, occur the Delaware river gravels and clays.

It would be most systematic to study the region, beginning with the most recent rocks. So far as the gravels and clays are concerned this could readily be done, but they are so much better exposed in New Jersey and Maryland and have been so well studied by the geologists of those States and by Mr. Woolman that nothing I could add would be of value.

Below these, however, it is the probably newer rocks about which there is the greatest difference of opinion, while as to the older there appears to be less question. For this reason, and also because the ancient gneiss forms a nearly straight almost unbroken ridge through about fifty miles of the region, I have deemed it best to begin with it, and to consider next the sandstone and limestone, and afterwards the more doubtful rocks.

In endeavoring to describe the rocks clearly and at the same time to avoid as far as possible the description of areas simply of geographical or political division, I have found some repetition unavoidable, which I trust will be pardoned.

The following is the classification of the rocks of the region, except the gravels and clay, by Prof. Rogers, Mr. Hall and myself, the latter showing my view of the Schuylkill section, except that the northwesterly ancient gneiss is not visible at the Schuylkill, though to be seen not very far off, both to the northeast and southwest, and that the northwesterly Cambrian sandstone and Cambrian schists are concealed at the Schuylkill. The Frankford gneiss does not reach the Schuylkill.

Prof. Rogers.	*Mr. Chas. E. Hall.*	*Theo. D. Rand.*
S. E.	Philadelphia mica schists and gneiss group.	Frankford gneiss.
		Fairmount gneiss.
First Belt.		Manayunk schists and gneisses.
		Porphyritic gneiss.
	Manayunk schists.	Manayunk schists and gneiss.
Second Belt.	Chestnut Hill schists, including steatite and serpentine belts.	Chestnut Hill schists, including steatite belt.
		Cambrian sandstone.
		Spangled schists.
		Lafayette serpentine.
		Rogers' altered primal.
Third Belt.	Laurentian.	Ancient gneiss.
		Rogers' altered primal.
Altered Primal.		Schists, spangled and garnetiferous.
		Cambrian sandstone.
Auroral.		Cambrian limestone.
Primal.	Hudson river slate.	Hydromica schists.
Auroral.	No. 2 limestone.	Cambrian limestone.
Upper Primal.		Upper Cambrian schists.
Primal Sandstone.		Cambrian sandstone.

Prof. Rogers.	*Mr. Chas. E. Hall.*	*Theo. D. Rand.*
Lower Primal.		Lower Cambrian schists and gneisses (Chester county gneiss). Lower Cambrian conglomerate.
		Ancient gneiss.
		Red sandstone.

It is well recognized that no thorough study of the crystalline rocks can be made without a study of sections under the microscope. I do not feel myself competent to undertake this, but hope it may be done by more able hands, when undoubtedly much light will be thrown on many points now obscure. To this end it is my intention to present to the Academy, as soon as I can properly label it, my collection of the rocks of the region, which I believe to be nearly complete.[27]

In preparing these notes I have been most generously aided by many persons—by information, by taking me to points of interest and by hospitality. Indeed, I may say that I have never asked assistance but it was most freely tendered by owners of farms, of quarries and others, and I regret that I cannot name all to whom I am thus under obligation, but among them I feel that especial thanks are due to Mr. Alfred Sharpless, of West Chester; to Mr. William W. Jefferis, to Dr. Charles Schäffer, to Mr. John L. Balderston and Mr. Eli Thompson, of Kennett Square; to Messrs. David and Harry Wilson, of Gum Tree; to Mr. William B. Harvey, of West Grove; to Mr. Thomas H. Windle, of Coatesville, and to Mr. Walter J. Baldwin, of Romansville; and for photographs to Dr. and Mrs. Charles Schäffer, Mr. William C. Stevenson, Jr., Mr. John C. Browne and Mr. George Vaux, Jr.

The Geological Map.

With this paper I have deposited with the Academy a map, on which I have represented the rocks as I have found them, except minor details impossible to be shown on a map of this scale.

[27] Since this was written the Pennsylvania Legislature has made an appropriation and the United States Geological Survey has undertaken the further study of the geology of the State, Dr. Florence Bascom, Professor of Geology in Bryn Mawr College having been placed in charge of the southeasterly part so that my hope will in all probability be realized within a few years.

This map is not intended for publication at present, because I have been unable to procure a trustworthy topographical base. If, as now seems certain, the excellent work of the U. S. Geological Survey, as shown in the map of Philadelphia and vicinity, shall be extended westward, it will give me pleasure to revise this work.

I do not wish to be understood as believing that the whole area upon which is represented the newer schists and gneisses is covered by rocks of one age. Future and more careful study will doubtless divide this area, and I believe it will be made to appear that paleozoic clastic rocks have been penetrated by igneous rocks both basic and acidic, and that the resulting complex has been very greatly metamorphosed and folded by dynamic action.

The topographical base of the map presented, but not published, was prepared from other maps, for the use of the Convocation of Chester, by Mr. Charles G. Darragh, to whom I am indebted for copies. From personal observation I can say that there seem to be errors in all the maps. That which I have used for fieldwork in Chester county, and probably one of the best, is Breou's atlas. The maps are of varied large scale, but when reduced to one scale will often not even approximately register, while the orientation is often in error. The boundaries shown are approximate only. Exposures are rarely sufficient to make them accurate.

The Ancient Gneiss.

The rocks forming the long, nearly straight, Buck Ridge, and extending from near the Delaware at Trenton southwestward for some fifty miles, are, I believe, universally admitted to be the most ancient rocks of the region, and to be, probably, the equivalent of the Highland gneiss of New Jersey and New York. They appear to be to a considerable extent of plutonic origin.

There has been no controversy in regard to them in their range through Bucks, Montgomery and part of Delaware counties. Exactly similar rocks continue in the same strike line to range through northwesterly Delaware county and Chester county, but in regard to this portion geologists do not agree. My observations lead me to distinguish these from what I regard as the more recent series by the following characteristics:

Ancient Gneiss.	*Philadelphia Newer Gneisses.*
Very compact and very hard, never schistose unless decomposed.	Sometimes very compact and hard, but always more or less schistose; usually very schistose, often soft.
Stratification, or foliation, generally obscure, never minutely plicated.	Stratification, or foliation, rarely obscure; often much plicated, both minutely and on a large scale.
Weather into (1) schist-like masses, which, however, will not readily cleave. (2) Frequently into very hard nuclei surrounded by concentric coats of decomposed and decomposing rock (vulg. "niggerheads"). (3) Frequently into loam containing angular fragments of blue quartz, but almost always intermixed with 1 or 2, and very rarely showing mica in the soil.	Weather into irregular masses, but more frequently into loam, often showing mica abundantly in the soil. The porphyritic gneiss only shows the concentric (boulder) decomposition.
Blue quartz very frequently present; particularly shown in the soil derived from the rock.	Blue quartz absent or very rare.
Rocks often uniform over large areas.	Rocks usually vary greatly within short distances on the dip line.
Margins usually marked by steep slopes, making a well-defined hill or table-land on the strike line.	Marginal slopes gentle, no extensive well-defined hills on the strike line, except the porphyritic gneiss and except west of the Brandywine.
Feldspars disseminated granular, rarely in crystals of any size, and when so porphyritic. Usually triclinic.	Feldspars often segregated, or in veins, beds or dykes, often large crystalline masses (pegmatite), usually orthoclase or microcline.
Micas, chiefly biotite in very small quantity and disseminated; muscovite non-existent, or very rare.	Micas, chiefly muscovite, generally abundant, often forming a large part of the rock, also in crystals and cleavage masses. Biotite, however, not rare.

Ancient Gneiss.	*Philadelphia Newer Gneisses.*
Basic trap dykes common, usually small.	Basic trap dykes unknown to the northeast (except some of the hornblende rocks, which are probably altered diorites). They occur southwest, but are not common. Granite or pegmatite common.

As has been stated, the ancient gneiss forms a hill, usually prominent, from near Morrisville, on the Delaware,[28] opposite Trenton, N. J., to Northbrook, on the West Branch of the Brandywine, a distance of about fifty miles.

In this distance it is unbroken, save by narrow gaps, most of them with high precipitous sides. In the northeast it is bounded on the northwest by the Red Rocks, and on the southeast by the Cambrian, with iron-bearing clays. As stated, the hill which it forms is known as Buck Ridge.[29] Its structure is apparently anticlinal, but it seems probable that this is due to foliation from dynamic action. The dips vary so widely in short distances, and are usually so steep, that almost any structure may be built upon them.

As has been stated, Buck Ridge forks a little west of the Pennypack, receiving a basin of Cambrian sandstone, which divides it into two areas, the northwesterly, soon concealed beneath the Red Rocks but rising beyond the Schuylkill, to form part of the azoic region of northern Chester county, north of the Cambrian of the North (Chester) Valley Hill, and extending beyond Honeybrook in the northwestern part of Chester county.

Near Feasterville is the only limestone outcrop occurring in this gneiss (Van Artsdalen's quarry). Accompanying the limestone

[28] In the final report, *Second Geol. Survey of Pa.*, Vol. I, p. 125, it is stated that the *Philadelphia group* narrows more and more, but reaches the Delaware at Easton ; but on p. 79 it is stated that the *old azoic gneiss* is seen rising from beneath the mesozoic brown sandstone at the Delaware opposite Trenton. According to my observations the gneiss hill is northwest of the Cambrian sandstone ridge which reaches the Delaware just above the Hancock street bridge, Trenton, N. J. The ancient gneiss I have not seen northeast of the cut of the Trenton Cut-off Railroad, near Woodbourne, six miles south 70° west of Trenton. The rocks exposed in the river below the Hancock street bridge and thence southeast to the Pennsylvania Railroad bridge are typical Manayunk gneisses.

[29] Bear Ridge, *Final Report*, I, p. 175, is probably a misprint. Cf. *idem*, p. 79.

were many minerals, among them graphite, or plumbago, of which a mine was opened southeast of Feasterville, and not far from Van Artsdalen's.

This is probably the mine referred to in the Final Report, p. 478, where it is stated that a mine of very pure plumbago was worked a century ago near Bustleton, Bucks county. Bustleton, however, is some eight miles to the southeast, and is in Philadelphia county.

The southeasterly arm continues as a high hill through Abington, but near Waverly Heights sinks and is shown only by loose masses, and in one quarry. This quarry is of special interest, because here we have the gneiss dividing two closely adjacent areas of Cambrian sandstone, precisely similar in character and little more than half a mile apart on a geographical line, which would be a little longer than the line of dip. The gneiss in this quarry (west of the Limekiln pike, a quarter of a mile south of Edge Hill village) dips N. 60° W. 55°, the southwesterly Cambrian S. 10° E. 70°, S. 20° E. 70°, the northwesterly strikes about S. 60° W. vertical.

A marked change in the topography is here noticeable. The long straight Huntingdon Valley (limestone) has ended, the gneiss ridge has disappeared, while the northwesterly Cambrian sandstone ridge rises to a considerable elevation, forming the southeast bounding hill of that part of the great Montgomery-Chester limestone valley known as the Plymouth Valley. This hill, however, trends more southward than the rocks, so that the ancient gneiss, the southeasterly Cambrian, and the schists which lie to the southeast of the latter strike into it. The northwesterly slope of the hill is much more steep than the southeasterly. Westward, toward the Wissahickon, the former increases, the latter decreases, until at Chestnut Hill the southeasterly slope has disappeared, while the northwesterly is quite steep and probably over 300 feet in vertical height.

Where the North Pennsylvania Railroad crosses this hill at Edge Hill village, south of Edge Hill Station, the hill is wholly of sandstone. Following the crest of the hill southwestward, we find no exposures, but soon the rock fragments in the soil are wholly of the ancient gneiss, while the northwesterly Cambrian sandstone forms a subordinate hill to the northwestward, (this last becomes more and more prominent westwardly, forming Barren Hill). The gneiss fragments are soon succeeded by schists and these soon form the entire hill from a point north of Chestnut Hill to southwest of the Wissahickon. On the north flank of this hill is apparently a nonconformable contact between the schists, the sandstone and the ancient gneiss.[30]

On the Wissahickon, I have failed to find the ancient gneiss, the schist occurring within a thousand feet of the Barren Hill Cambrian sandstone, with low ground intervening, but on Northwestern avenue, the northwest boundary of Philadelphia, it appears within two thousand feet of the Wissahickon, soon attains an elevation of some three hundred feet, and widens rapidly toward the Schuylkill. It is this rock that terminates westward toward Barren Hill, the ridge to which the Ridge Road owes its name, a narrow hill of schists and gneisses cut off from the adjacent table-lands of Germantown and Chestnut Hill on the north, Ardmore and Bryn Mawr on the south, by the valleys of the Wissahickon and the Schuylkill, which here both run in a general course nearly that of the dip of the rocks, 1.25 to 3 miles apart. The summit of the ridge is nearly level, while the flanks are much serrated by the valleys of small streams flowing eastward into the Wissahickon, and westward into the Schuylkill.

The Wissahickon and Schuylkill sections, though so short a distance apart, show clearly the great changes in the rocks of this region within short distances. On the Wissahickon, as has been stated, the schists are within a thousand feet of the sandstone. On the Schuylkill they are over a mile apart. The dips are almost all steep.

At the Schuylkill the ancient gneiss hill is most prominent. Nearly a mile in width with very steep slopes it rises to an elevation of four hundred feet. The Schuylkill gap shows almost precipitous escarpments toward the river. Westward, the same steep slopes on the sides prevail for about three miles, the belt widening westwardly. The summit is comparatively level, and is traversed for many miles by the Spring Mill road.

Near the line of the Pennsylvania Railroad and the Lancaster turnpike the floors of the adjacent valleys have risen so that the

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[30] *Proc. Acad. Nat. Sci. Phila.*, 1890, p. 90.

hill, while reaching 450 feet to 500 feet in its highest ground, is no longer very prominent. The Pennsylvania Railroad summit west of Villa Nova, in a cut about twenty-five feet deep, is 430 feet above ocean level. The gneiss is here two and a quarter miles wide. Further southwestward it still widens, extending on Darby Creek from the Roberts road and the Coopertown and Newtown road to Devon Inn, a distance of three and a half miles. Although no longer so bold a hill, its characteristics may be seen on the old Roberts road, laid out near its eastern base and so hilly that a new road, Bryn Mawr avenue, was laid out a short distance east of it, and in the schists, to avoid the hills. West of Darby Creek it still widens, and east of Crum Creek attains its greatest width, about five miles; between Crum and Ridley creeks it is divided by a valley of schists, the northerly and main arm continuing, the southern arm ending before it reaches Chester creek.

The northerly arm is about three miles wide at West Chester, thence it narrows, crossing the Brandywine above the forks and ending near Northbrook.

There being difference of opinion about the areas occupied by this gneiss in Delaware and Chester counties, they will be given somewhat in detail, premising that I include in it only the hard non-schistose rock shown in the Schuylkill section, and along the Pennsylvania Railroad between Rosemont and St. David's Stations, where it is sharply differentiated from the schists which adjoin it on both sides.

Mr. Hall found difficulty in distinguishing the schistose gneiss from the decomposing ancient gneiss,[31] but my experience has been that they weather so differently that few mistakes would be made if nothing but the soil were carefully examined. Added to this, however, it is hard to find, except in the small tract southeast of West Chester, an area of the ancient gneiss of more than a few acres without unmistakable evidences of its presence; especially is this true of the margins where erosion has been most active. Among others, the area colored correctly Laurentian in C^6, northwest of Bryn Mawr, is changed on that in C^5, to schists, Mr. Hall

[31] "Many of the syenitic rocks of the Laurentian are weathered to such an extent that it is, in many cases, impossible to distinguish them from the adjacent and overlying feldspathic schistose gneisses, and it is therefore impossible to draw a definite dividing line between them" (C^5, p. 92).

saying (p. 22), "I have since been able to trace the schistose rocks all the way from Bryn Mawr to the serpentine localities in the vicinity of Wayne in Radnor township, thus connecting the two areas and proving the schistose rocks to extend across the Laurentian belt. . . . ."

I have already published[32] a number of localities within this area where the undecomposed hard ancient gneiss of most typical character may be observed. Since that time it has been exposed in many other places within the region thus changed, notably in quarries on the Wayne estate, east of the northwest branch of Ithan creek north of the road from Radnor Station to St. David's Church; in a well 70 feet deep on Mr. Robert Stewart's property, near St. David's Station; in a large well 50 feet deep on Pennsylvania Railroad property, close to Radnor Station, dug in 1892–1893, as well as at many localities on both sides of Darby creek.

The northwest border line being the most regular and best defined, it will be traced first. With the map in C^6 my observations agree, but the later map in C^5 is certainly in error as to the northwest boundary as well as the southeast. The schists do occur north and northwest of Radnor Station, in Cream Valley, but not at all east or south of that valley. Within a short distance are at least a dozen conspicuous outcrops of unmistakable ancient gneiss. The line is nearly straight S. 63° W. from the Schuylkill through Lower Merion and Radnor, as far as St. David's Station, where the railroad emerges from it through a cut in which the rock was well exposed; thence to Devon the border line is about S. 80° W., and thence to West Chester S. 60° W. Northwest of West Chester it bends rapidly southward, crossing the East Branch of the Brandywine south of Copesville, and then still curving southward crosses the West Branch of the Brandywine east of Northbrook. The S. 60° W. line is not strictly so, but curved, with that as the general direction.

The southeasterly boundary from the Schuylkill to Rosemont is so well defined by the ridge itself as to be unquestionable.

At Rosemont (in Lower Merion, Montgomery county, but very close to the Delaware county line) in excavations about the station the spangled schists were exposed, particularly in wells and in the

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[32] *Second Geol. Survey of Pa.*, An. Rep., 1888, part iv, p. 1573 *et seq.*

trenches dug for the abutments of the railroad bridge at Rosemont Station, dipping S. 45° E. 50°. About 500 feet northwest was an old quarry showing the ancient gneiss with abundance of large masses on the surface. It is exposed also in the bed of the Delaware-Montgomery county line road, about a quarter of a mile northwest of Rosemont Station. About a quarter of a mile southwest of Rosemont Station the old Lancaster road, or Conestoga road, crosses a small stream, a branch of Meadow-brook, and then going westwardly climbs the gneiss hill. About 800 feet east of this stream the schists are exposed in the road; about 600 feet west of it the gneiss is well exposed in a quarry on the north side of the road, the rock dipping southeast 65°.

On Ithan creek the schists may be seen close to Bryn Mawr avenue, thence northward the banks are of the gneiss to its source, there being many exposures.

On the Radnor and Chester road, occupying from Ithan P. O. to the mouth of Meadow-brook the watershed between Ithan and Darby creeks, the schists are exposed near the Roberts road and Darby creek; thence northwestward for miles the gneiss is exposed at frequent intervals.

On the right bank of Darby creek, the Coopertown and Newtown Square road (in fact, the prolongation southwestward of the Roberts road) is in the schists which are exposed in the cut just southwest of the creek, while the gneiss is exposed in a quarry less than a hundred feet north of the road, and thence constantly on both banks very nearly to its source.

Immediately to the south of this road is the large serpentine outcrop (the continuation, I believe, of the La Fayette belt) which contained Moro Phillips' chrome mine, and which extends from east of Darby creek through Marple township. In a cut made for the Chester County Railroad, the gneiss is well exposed a short distance northwest of the serpentine and of Fawkes run, close to the Radnor-Newtown township line.

Mr. Hall maps the whole area from Ithan creek on the east to Crum creek on the west (and beyond it) as far north as Camp run, Reese's run and Central Square as of schists, but the three localities last mentioned, embracing many outcrops, are within this area, and show the rock unweathered and indisputable.

The southerly border of the gneiss is not well defined between

Darby and Crum creeks, but the rock appears on the latter at the mouth of Hunter's run. It is well defined at Ridley creek, close to the serpentine of the Blue Hill Schoolhouse, two miles north of Media. The schists are well exposed southeast of the serpentine, and typical ancient gneiss close northwest of it.

Across the creek from the Blue Hill Schoolhouse, that is on the right or westerly bank, the southerly border of the gneiss forms a high hill very steep on its south side, divided by a branch of Dismal run into two, known locally as Poplar Hill and Round Top ; but west of this the border is not clear, exposures being few and poor, and the gneisses of the newer series adjoining it on the southeast being of unusually hard and heavy bedded character, and being possibly altered gabbros. There can, however, be little doubt that it extends south of Howellville, but not as far as Lima, and that before reaching Chester creek the margin turns northward and then eastward (forming the southerly hill of the valley in which the Street road runs) to a point a little east of the Willistown Inn, on the Philadelphia and West Chester road, this hill outlining the southerly branch of the gneiss referred to. From Willistown Inn the southerly edge of the northern and larger branch pursues a west-southwest course to a point north of Oakbourne Station.[33]

[33] On the map in C^5 the gneiss area of Radnor and west is made to end north of Newtown and Central Squares, the schist areas to the east being extended across Newtown and Edgemont to the Chester county line. Southwest of this schist area is represented a large area of the gneiss, extending along Ridley creek from Sycamore Mills to the Chester county line. Westward it forks into three very irregular areas, one trending a little south of west, another southwest and the third south-southwest. But the Radnor gneiss is very conspicuously continued through Newtown and along Crum creek, and the schists and schistose gneisses are equally conspicuous on the south of the gneiss from Sycamore Mills to south of Howellville. Prof. Lesley seems to doubt these areas, for although on p. 91 of his *Final Report* he refers to irregular areas of old syenitic azoic gneiss in Delaware and southern Chester counties, he says (p. 128): "If the distinction between the *older* and the *newer gneiss* be a valid one, the older gneiss seems to disappear from the surface going west from the Schuylkill into Chester county and the newer gneiss seems to occupy the whole field south of the belt of South Valley Hill hydromica slate in Chester."

Within the limits described there is no scarcity of outcrops of the typical rock, but at very few of them can the dip be measured ; the following may be selected as typical exposures within the area designated as schists on the map in C^6 :—

Cut of the Philadelphia and Delaware County Railroad, northwest of Fawkes run and near The Hunt station.

Road between Newtown Square and Central Square.

Forks of the road .75 m. west of Newtown Square and thence westward on both roads to Crum Creek. On the southerly it is shown in one outcrop, In the region northwest of Oakbourne, that is near West Chester, there is no longer difficulty in finding the line. The ancient gneiss is exposed a short distance northwest of Westtown School, while the schists are exposed west and south of it. Thence the line curves northwardly and changes from west-southwest to nearly west, the gneiss appearing one-tenth mile northwest of the schoolhouse at Sconnelltown, while serpentine succeeded by schists lies southwest of it.

On the Brandywine the line is close to the forks, and on the right bank is marked by a steep conical hill. It is at this point probably not over half a mile wide. A mile to the westward it forms a separate high ridge known as Brag Hill, separated from the conical hill by the deep valley of a small affluent of the Brandywine; the gap affording an easy passage for the State road.[34] A mile further, near Northbrook, it has become still narrower, occupying but the northerly slope of the hill, with schists and serpentine on both flanks. A mile southwest of Northbrook it appears to end, the schists on both sides uniting and a large outcrop of serpentine appearing.

The limits of the ancient gneiss above given accord closely with those of Prof. Rogers,[35] but as stated differ materially from those in C^5, while in C^4 no distinction is made upon the map between the ancient gneiss and the schists, though they are separated in the text. They differ also from the more recent geological map of the whole State (1893).

Prof. Lesley says of the gneiss "from the gorge of the Nesham-

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300′ east of serpentine, dipping S. 25° E. 75°, and in another, 200′ west of the serpentine, S. 50° E. 75° along and south of the West Branch of Ridley creek, north of Howellville.

[34] In C^4, p. 56, it is stated that the area of this gneiss, which is the continuation of that of Delaware county, has a western limit in the vicinity of West Chester, but that a small area occurs at the junction of the East and West branches of the Brandywine, surrounded by mica schists and micaceous gneisses similar to those along the northern edge of the syenite east of West Chester. This does not at all agree with my observations. The northern border is very well defined with numerous outcrops and quarries along Taylor's run to the East branch of the Brandywine and thence through the Worth farm (southeast of serpentine) to the West branch at Seeds Bridge and thence westward across the State road to Northbrook. The southern border passes between the Philadelphia and West Chester road, which is wholly within it from Willistown Inn to West Chester, and the Street road which is in the schist valley. The area appears to narrow rapidly toward the Brandywine, the union of the two branches of the creek being at the border. In this area it is constantly and well exposed.

[35] *Geol. of Pa.*, I, p. 78.

iny to the gorge of the Pennypack it makes what is locally known as the Buck Ridge, with a constant width of two and one-half miles. At Willow Grove it splits, ... its southern fork keeping on as a narrow thread into Delaware county, where it spreads out into three separate areas, the northern one passing on into southern Chester and the southern one into the State of Delaware.''[36]

I cannot believe that Prof. Lesley personally examined this region, for instead of being a narrow thread in Delaware county it there attains its greatest width, more than double its width between the Neshaminy and the Pennypack; the northern area does not extend into southern Chester county, neither does a southern one pass into Delaware, unless the northwesterly extension of the Delaware gabbro be so regarded.

A prominent feature of this belt is its trap dykes. None are large, none can be traced for any distance, the latter fact being due probably to the gneissic rock resisting decomposition equally with the trap, but evidence of its presence is to be found very frequently. In the cut of the Pennsylvania Railroad southeast of Radnor Station two systems of dykes were exposed, one a diorite in narrow veins, dipping about 65° east-southeast, cutting an older granite dipping 60° to 80° west-southwest. Much trap lies on the surface over the ancient gneiss area, and there are numerous outcrops in place—*e. g.*, three-tenths of a mile northwest of Radnor Station (diabase of a reddish tint) on Ithan creek, on the Radnor and Chester road near the old Lancaster road, on Johnston's quarry at Wayne (diabase), near Van Artsdalen's quarry in Bucks county (norite).[37]

Dr. Bascom identified as norite a rock found on the property of Miss Martha M. Brown near Radnor Station.

The Cambrian Sandstone.

Prof. Rogers divided his primal series into three, based upon the exposures in the North Chester Valley Hill, of which the middle member is by far the most uniform and characteristic:—

1. A lower shale, or slate, the lower primal;
2. The middle, or sandstone proper;

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[36] *Final Report*, p. 79.
[37] Dr. J. F. Kemp, *Trans. N. Y. Acad. Sci.*, XII, p. 71.

3. An upper, sandy, micaceous, shaly or schistose rock, next below the limestone.

The sandstone formerly supposed to be the equivalent of the Potsdam sandstone of New York is undisputed by all geologists who have examined the region. It is abundant and widespread. Lithologically it is remarkably uniform. Its most usual aspect is thus described by Prof. Rogers: "A thin-bedded yellowish-white, very compact rock, presenting in its composition much imperfectly developed feldspar,[38] and showing a tendency to a rhombohedral fracture; . . . . other bands contain likewise many minute partings of crystalline talc, and the surface of the more solid feldspathic beds exhibit very frequently at these partings innumerable minute crystalline specks of pure black schorl."[39]

To this may be added that the rock is often a soft sandstone, while at times very compact and hard, indeed a quartzite, preserving all the other of the above characters; that the tourmaline crystals (of which, when Rogers wrote, schorl was the common name) are not always minute, and that they are generally disrupted.

It should further be noted that at that time the varieties of muscovite of the damourite group were not separated from talc, so that with our present light we should translate talc into damourite, sericite or hydromica in many cases in which Prof. Rogers uses it.

In some portions the markings of *Scolithus linearis* are abundant, particularly west of the Valley Forge Gap. This fossil, though of little value otherwise, distinctly marks the rock as in the paleozoic column, while the unusually definite character of the rock enables us to identify it readily when the markings are absent. This uniform character is remarkable when we consider the numerous outcrops far separated, not only on the strike line but also on the dip. The same rock is described by Dr. Williams as occurring in Maryland.[41]

[38] Kaolinized feldspar.

[39] *First Geol. Survey of Pa.*, I, p. 155, quoted C[4], p. 109.

[40] In the *Final Report of the Second Geol. Survey*, p. 177, it is stated "some of the beds show needles of hornblende and a little crystallized talc." This I think is not the case.

[41] "Quartzite, or quartz schist, . . . such a clearly marked type that it serves at many other localities to fix a definite horizon. There is always present a perfect foliation due to parallel layers of muscovite at varying distances from each other. In these foliation planes there is an abundant de-

The lowest beds, best shown near Willow Grove, are of a conglomerate chiefly of quartz pebbles, united by a siliceous cement. The same rock seems to be poorly exposed westward of Valley Forge.

The Cambrian enters the State near Morrisville, flanking the ancient gneiss on its southeast side, forming a prominent narrow straight hill, in most of its course called (as is also the corresponding outcrop on the northwesterly side of the ridge of ancient gneiss further southwest) Edge Hill, also Rocky Hill. It is here separated from the ancient gneiss by about a thousand feet, chiefly of unctuous variegated clays, which resemble those of the iron ore beds further southwest. On the Trenton Cut-off Railroad, where it is well exposed, it dips N. 50° .W 70° to 80° toward the gneiss.

From this point it continues to Huntingdon Valley, and is exposed on the Neshaminy and in quarries. It seems to narrow westwardly, and at the Pennypack it is not visible; about one mile west of the Pennypack a much overgrown quarry shows indications of it, and masses may be seen in walls in the vicinity; this is immediately north of the limestone of Huntingdon Valley. About four miles further west, it is well exposed in a quarry on the Waverly road near the Limekiln pike, at Waverly Heights, and here is separated from the sandstone northwest of the gneiss by but half a mile; it dips S. 10° E. 70°, S. 20° E. + 70°; S. 25° E. 80°. It is almost identical in aspect with the northerly sandstone, a little more micaceous, a little darker in color, somewhat harder, with cherty layers more abundant, and in this it differs also from the outcrops in the same belt to the eastward. This outcrop is about a mile in length, but is clearly exposed only in this one quarry; it appears to strike into Edge Hill, the topographical continuation of the northerly sandstone hill, more fully described hereafter.[42]

A similar rock, but still more micaceous, and with mica schists interstratified, appears nearly in the line of the strike, about two

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velopment of black tourmaline, whose crystals are always transversely broken and their fragments more or less broken as if by stretching."—Geo. H. Williams, *Bul. Geol. So. of Am.*, Vol. II, p. 308.

[42] Prof. Lesley, *Final Report*, I, p. 86, writes of it as forming a low ridge running three miles from Waverly Heights to near Chestnut Hill, but I have been unable to find it beyond the outcrop in the Waverly road about a thousand feet west of the Limekiln pike.

and a half miles to the southwest, on Paper Mill lane north of the Bethlehem turnpike, dipping steeply S. 10° E., while the ancient gneiss, poorly exposed 200 feet north of it, strikes S. 35° W. vertical.

While probable, it is not certain that this outcrop is of the true Cambrian sandstone. If it is, then the adjacent and interstratified mica schists must be of the same age. It may be a rock made by the degradation of the Cambrian and be more recent. Comparing this outcrop with the Waverly Heights outcrop, and that with the exposures near the Neshaminy, we find that the change from Waverly Heights westward is not much if any greater than from the Neshaminy to Waverly Heights.

West of this Prof. Carvill Lewis identified it close to the serpentine, southeast of the gneiss, northwest of La Fayette on the Schuylkill. West of the Schuylkill, in the same line, occur sandy mica schists with rhomboidal jointing, which may or may not represent it. On the Roberts' road south of the Conestoga road, and on the latter west of the Roberts' road (Radnor township) close to the gneiss, a rock appears very closely resembling it; containing, however, no tourmaline. It occurs in narrow beds in the mica schists much as in Paper Mill road; a chert-like quartz accompanies it.

This is the most westerly point at which I have observed any similar rock close to the ancient gneiss on its southeast side, but to the southwest, in Chester county, are numerous outcrops which will be best considered after the more prominent ones to the northeastward.

The Cambrian Northwest of Buck Ridge.

This first appears, as has been mentioned, a short distance east of Willow Grove, where the gneiss forks, and the sandstone appears as the end of a synclinal. This is about ten miles northeast of the Schuylkill. Here the rock is a coarse conglomerate of bluish quartz pebbles in a siliceous paste, followed by the typical rock.

About a mile southwest of Willow Grove, the synclinal of sandstone is in its turn overlain by a synclinal of limestone, the easterly end of the limestone of the Chester-Montgomery valley, dividing the sandstone into a northwesterly and southeasterly arm. The former is soon covered by the Red Rocks, but appears at intervals. West of the Schuylkill it is very prominent, attaining a height of + 600 feet at Valley Forge, and thence westward forming the North (Chester) Valley Hill.

The rock is well exposed by Valley creek flowing from the Chester Valley through this high hill into the Schuylkill, though the hill dies down to an insignificant elevation eastward within little more than a mile. At this point, as described by Prof. Rogers, the hill appears to be composed, as already stated, of three beds of the Cambrian: (I) a sandy micaceous, shaly or schistose rock (Upper Primal of Rogers') between the sandstone and the limestone of Chester Valley; (II) the sandstone proper, and (III) a shale or slate more argillitic (Rogers' Lower Primal) underlying the sandstone, while underlying the argillitic shale is a conglomerate, poorly exposed, but exactly like that of Willow Grove.

About four miles west of Valley Forge the sandstone appears to end suddenly, on the east side of the gap through which a branch of Pickering creek, rising on the northerly side of the Chester Valley, flows northwardly and then eastwardly into the Schuylkill. In this gap we find no sandstone, but a rock of very different character, probably that mentioned by Dr. Frazer in C^4, p. 272—"A coarse-grained, heavy-bedded rock, called variously in my field notes feldspar-porphyry, conglomerate, granite and heavy-bedded gneiss"—which, from Valley Forge westward, appears to underlie the sandstone with but little, if any, intervening slaty or shaly rock. This rock is well exposed in Williams' quarry on the Phœnixville Branch of the Pennsylvania Railroad, near Aldham Station. It sometimes resembles a pegmatite, often a very feldspathic gneiss, occasionally it is a hornblende or a mica schist or a micaceous gneiss. I have termed it provisionally the Chester county gneiss. North of it is a much harder gneiss, containing blue quartz and closely resembling the ancient gneiss of Buck Ridge, probably the continuation of the northerly arm at Willow Grove, before mentioned.

Further west the upper of these becomes a true mica schist, as on the road south of Caln Meeting-house, and still more markedly north of the Pennsylvania Railroad west of Pomeroy, where the

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[43] *Proc. Acad. Nat. Sci.*, 1894, p. 457.

schist contains in small quantity feldspar (probably microclin), coarsely crystalline, tourmaline and garnet, and very closely resembles the mica schists of Rogers' first group. At Pomeroy, just north of this schist, are the great quarries in the sandstone whence has been obtained much of the stone for the foundations of Broad Street Station and other recent structures for the Pennsylvania Railroad. These quarries are in the sandstone proper, dipping S. 35° E. 30° to 50°.

On the map in C[4] this upper schist and much of the true sandstone are colored the same as the gneissic areas on the northerly side of the sandstone, and it is not shown further east than a mile east of Pomeroy, but as extending westwardly, widening rapidly to the Octorara.[44]

On the West branch of the Brandywine the sandstone is met about 200 feet from the railroad, which runs nearly on the strike; it dips S. 25° E. 55°, while on the railroad the schists dip S. 30° E. 50°. About 600 feet further north a harder and less evenly bedded sandstone, some of it quartzite, dips S. 25° E. 50°; two miles north of this is a high bluff of the sandstone in massive beds striking N. 70° E. nearly vertical, at the base of which the creek flows nearly on the strike. On the right bank is the Chester county gneiss.

A half-mile west of the creek the Lancaster pike crosses the railroad and rapidly rises on the slope of the hill; here the schists are again well exposed, as noted by Dr. Frazer,[45] but a careful examination forced me to the conclusion that the apparent inclination of the rock visible close to the railroad is due wholly to creep, as is very evident a short distance northwest where the probable normal dip of S. 35° E. 70° shows, upwards, a northerly dip of loose rock as is so often the case in this sandstone.

Nearly four miles west of Coatesville we reach Pomeroy, and just beyond it Buck Run. Here the exposures are excellent.

[44] Of this, Dr. Frazer says under the heading "West Caln": "The Potsdam sandstone. . . . gradually leaves the contact of the limestone below the borders of this township, permitting an uneven wedge of the older crystalline rocks to intervene between it and the latter in Sadsbury and Valley."

C[4], p. 256, and on p. 267: ". . . . from Octorara Creek branch to and beyond Pomeroy. At no place within the distance does the limestone touch the quartzite or sandstone, though removed from it by a belt of varying width, nowhere very broad except at the two points mentioned."

[45] C[4], p. 271.

The sandstone has been largely quarried on both banks of the Run and within 500 feet of the railroad, dipping quite uniformly about S. 35° E. 50° in the four quarries. Included in the sandstone are thin micaceous beds not unlike the schists on the south. On the railroad, southeast of these quarries, and within a quarter of a mile, the mica schists appear; here containing small segregations (?) of microlin(?) and tourmaline, and resembling closely those of Delaware county. One dip was S. 18° W. 75°, others steep S., but there is reason to suspect creep. Within .25m. west, on a private road, about 400 feet north of the railroad, the sandstone is exposed, dipping S. 32° E 80°, succeeded to the southeast by a more schistose variety and within fifty feet a mica schist, dipping irregularly northwest, exposed only in a deep washed-out gutter. The strike is about N. 60° E. The northwest dip is probably due to creep.

About two miles west of Pomeroy is Parkesburg, through the easterly part of which flows a westerly branch of Buck Run. On this, within .1m. of the railroad, is a quarry in the sandstone, dipping S. 15° E. 40°, overlaid conformably by mica schists. About 700 feet about S. 20° E. of this quarry is an exposure of limestone on the south side of the Strasburg road. This road, here running nearly west, forms the main street of Parkesburg, but nearly opposite the railroad station it resumes its west-northwest direction and ascends the hill. Near the foot the mica schists appear poorly exposed, dipping northwest steeply but irregularly, doubtless owing to creep. Following this, about 150 feet of the road is filled with the sandstone dipping S. 15° E. 70°, then sandy mica schists appear with the sandstone for nearly half a mile, the sandstone outcropping at frequent intervals, with a cliff on the northwest side of the road near the summit S. 28° E. 60°. On the summit are no exposures. One mile from Parkesburg the limestone road crosses the Strasburg road. On the former the sandstone is poorly but extensively exposed. West of this to the Octorara I have seen no exposures of the sandstone, but fragments, some very large, are quite common. On the old Valley road northwest of Lenover sandy mica schists appear; no black gneiss was seen. At the Octorara, however, we have a repetition of the section near Coatesville and Pomeroy.

The sandstone is particularly well exposed where the Octorara flows southward through it. This gap and the adjacent one to the northward through Copper Mine Ridge have been taken advantage of by the Pennsylvania Railroad to pass by easy gradients from the Chester to the Lancaster (Pequea) Valley. The railroad, turning from its nearly west to a northwest course along a shelf quarried out of the precipitous left bank of the Octorara exposes the rocks most clearly. To the southeastward, next to the limestone, there is a somewhat plicated dark-colored mica schist S. 30° E. 80°, perhaps 200 feet in breadth, then the typical sandstone S. 28° E. 72° about 300 feet, then sandstone fragments, and then a bluff of the sandstone, about fifty feet high and a hundred and fifty feet wide, dipping S. 28° E. 70°.[46]

The sandstone continues west of the Octorara as a narrow but high and conspicuous hill, bounding the limestone valley on the north; as in Chester county, its crest is nearly straight, S. 60°–70° W., and for several miles almost level about 200 feet above the Octorara or 660 feet above tide. The hill seems to be composed almost wholly of the sandstone, the Chester county gneiss forming the floor of the valley on the north and the hills further north to Copper Mine Ridge. The rock is abundantly exposed, occasionally, but not frequently, in such manner as to show the dip beyond doubt. The bearing of the Valley road is almost coincident with the strike. About two miles west of the Octorara, just west of the road to Steelville (Chester county), a dark mica schist appears on the north side of the road with the sandstone with some

[46] In Prof. Lesley's *Final Report*, Vol. I, p. 177, this ridge is apparently confused with the parallel ridge to the north, "Copper Mine Ridge." It is there stated "In the North Valley Hill, the gaps of the East and West Brandywine and at Gap Station show the beds to be about 100′ thick." Gap Station, however, is on the northerly side of Copper Mine Ridge, a parallel northerly outcrop of sandstone, separated from the North Chester Valley Hill by more than two miles of gneissoid rocks, and according to my observations this separation continues far into Chester county, Copper Mine Ridge ranging eastwardly to within a hundred yards of the West branch of the Brandywine near Wagontown as a distinct narrow ridge of the typical sandstone, evidently referred to in C^4, p. 262.

It may also be observed that on the map in C^4, the yellow color, which is stated on p. 160 to be "confined to the quartzite and sandstone beds alone, and does not include the underlying much weathered feldspar porphyries, conglomerates, etc., which (following Prof. Rogers) he regards as part of the Potsdam or primal formations No. 1," is broadened to four miles, viz.: from Compassville to Parkesburg, thus connecting the sandstone of Copper Mine Ridge with that of the North Valley Hill. I was unable to find such connection, for a broad belt of the "feldspar porphyries, etc.," intervenes, as stated by Rogers, I, p. 84, etc. (quoted C^4, p. 163, etc.).

interlaminated dark mica schist on the south, strike of road and rock N. 70° E.

The further discussion of this ridge will be found in connection with the limestone of this portion of the valley.

North of the North Valley Hill, in the vicinity of the branches of the Brandywine, are three other outcrops of the sandstone, as noted by Prof. Rogers.[47]

The southernmost ranges a little north of east from west of the Lancaster county line south of Compassville to a point within .2 m. northwest of Wagontown. It forms a low ridge conspicuous north of Stony Hollow Schoolhouse, and seems to end in a very narrow outcrop on the farm of Abraham Bubaker, just north of a steatite outcrop. It appears to be the continuation of the sandstone of Copper Mine Ridge in Lancaster county, the southerly boundary of the Pequea Valley limestone.

The middle outcrop is much more prominent and is locally known as the Baron Hill. It ranges in an east-northeast direction from the Lancaster county line, or west of it to the East Branch of the Brandywine, at Cornog's Station. In most of its course it is a high hill, with comparatively steep slopes, and throughout the greater part of its course entirely in forest, thus making a prominent feature of the landscape. North of Martin's Corner it is, by barometer, 850 feet above tide, the valley south of it of ancient gneiss being 750 feet and north of it 690 feet, limestone.[48]

The northernmost outcrop forms the Welsh Mountain, on the summit of which is the Chester-Lancaster-Berks county line. It is also the watershed between the Delaware and the Susquehanna, with an elevation of 850 to 1,000 feet above ocean level.

Returning now to Willow Grove, we may trace the southeasterly arm of the sandstone synclinal southwestward. As far as the cross-

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[47] I, 177, quoted C^4, pp. 154, 155.

[48] On the map, C^4, the sandstone area north of Martin's Corners is represented as two miles wide, extending of nearly that width to the West branch, there cut off by the ancient gneiss, with two outlying islands of this sandstone to the eastward. With this my observations do not agree. North of Martin's Corner it is not much over a quarter of a mile in width. Along the West branch it is conspicuously exposed between a point .5 m. below Ferndale Station and Brandamore Station, dipping S. 25° E. 50° E. Northeast of this it continues unbroken as a narrow, mostly wooded hill to the East branch, near which it seems to terminate in the ancient gneiss. A road on or near the summit affords a series of very beautiful views Brandywine Manor is on this hill.

ing of the Northeast Pennsylvania Railroad the conglomerate continues with the typical standstone overlying it. From east of Weldon to west of Edge Hill village the sandstone forms a prominent hill, and probably the highest ground of the vicinity, known as Edge Hill, giving name to many places in the neighborhood. The North Pennsylvania Railroad levels are Chelten Hills 190, Junction Northeast Pennsylvania Railroad 254 (259 ?), Edge Hill 293, Camp Hill (the northerly ancient gneiss) 178. The levels of the Northeast Pennsylvania Railroad crossing the sandstone about a mile north of the North Pennsylvania Railroad are Junction North Pennsylvania Railroad 259 (254 ?), Summit 342, Willow Grove 259.[49]

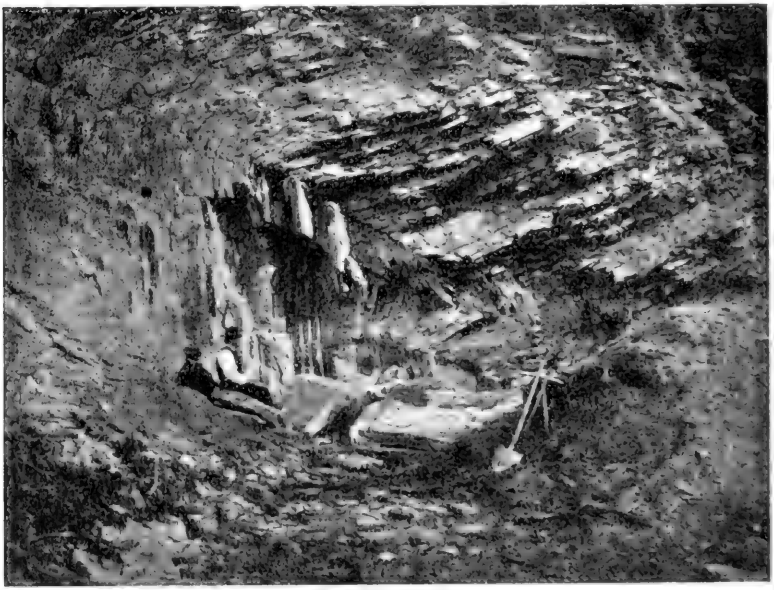

FIG. 1.—Cambrian Sandstone, Edge Hill, Pa.

At Edge Hill village, where the sandstone is crossed by the North Pennsylvania Railroad and the Limekiln turnpike, it is well exposed in a cut about thirty feet deep, and in quarries which show very plainly the "creep" to which the upper part of this rock

[49] These (mean ocean) levels are taken from Tables 60 and 62 in *Second Geol. Survey of Pa.*, Levels above Tide N.

has been subjected, shown in fig. 1, a photograph taken by Mr. John Coates Brown. Its strike is about N. 55° E.; it is nearly vertical, probably 85° S. E., and is very regular. In a quarry close to the Northeast Pennsylvania Railroad its dip is S. 30° E. 65°, hence toward the ancient gneiss; these dips are well below all possible creep.

It is here that the sandstone southeast of the ancient gneiss appears a half-mile to the southeastward, with the gneiss intervening, but not prominently. It is not improbable that the two areas were once connected at this point over the gneiss, if indeed they were not over a much more extended area.

West of this, Edge Hill, as has been stated, continues topographically to the Wissahickon, but the geological formations strike through it westwardly, that is strike about S. 60° W., while the bearing of the hill itself is about S. 40° W., so that soon the Edge Hill sandstone forms a separate, slightly divergent hill, known as Barren Hill. It crosses the Wissahickon on the place of Mr. John T. Morris, where it is well exposed. It continues probably from Barren Hill to the Schuylkill, though not well exposed except close to the latter at Spring Mill, where it appears to dip S. 45°, though the exposure is not entirely satisfactory. There is limestone here ± or about 500 feet northwest of it.

So far no slates or schists are visible in its vicinity, though some beds of the sandstone are very micaceous and rather quartz schist than sandstone. The strike from the Spring Mill outcrop carries it into that portion of the Schuylkill which flows about N. 70° E. along the base of the ancient gneiss from Conshohocken to Spring Mill. On the westerly bank the flanking gneiss, Rogers' Altered Primal, and the limestone are well exposed, but the sandstone is not distinctly visible, and its place appears to be taken by mica schists, some garnetiferous, not unlike those between the Cambrian and the limestone on the north side of the Chester Valley, the Upper Primal of Rogers already described. These are on the south side of the narrow valley between the gneiss on the southeast and the hydromica schists on the northwest, a narrow but typical straight limestone valley known as Cream Valley. As a prominent valley it is five miles in length, ending at Wayne, but with two drainage systems; the upper three and a half miles draining by Gulf creek through the Gulf (a gap in the northerly hill), the lower mile and a half directly to the Schuylkill.[50] The divide is low and from the high hills on each side hardly noticeable. While the prominence of the valley ceases at Wayne, a depression follows the line of strike to the West Branch of the Brandywine and beyond, as will be more fully described when considering the limestones.

On the northerly slope of the ancient gneiss the sandstone appears at intervals. In the *Final Report* (I, p. 174) this is discredited, but I have given[51] my reasons for reiterating these occurrences as they seem to explain the structure without the need of a fault. I may repeat briefly that the sandstone may be observed of typical character and in the same relation to limestone at distances from the Schuylkill of one and a half, two, two and a half, two and three-quarters, three and a half and four miles. It appears to be interstratified in mica schists, but all the exposures are poor. It is certainly very narrow.

West of Wayne the schists continue, but the typical rock is absent or concealed. The latter is not improbable, as the line of strike is in comparatively low ground with few outcrops between the gneiss and the hydromica; these outcrops being of mica schist, serpentine, or diabase trap. In western Chester county, however, it again appears near the Poorhouse quarry, and still more extensively near Doe run, as mentioned in the discussion of the limestones of that region.

The locality near the Poorhouse quarry limestone is Hayes' whetstone quarry, a mile nearly west of the limestone. It is of the typical rock, overlaid by sandy mica schists and underlaid immediately by the same with more compact and heavy-bedded schists to the northwest. It dips S. 30° to 50° E. 20° to 25°. It is in Newlin township, close to the West Bradford line. Thirty or forty years ago there was a considerable output of whetstones from this quarry, as I am informed, by Mr. William M. Hayes, owner of the Hayes farm, who was then engaged in their manufacture.[52]

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[50] F. Bascom, Ph.D., *Am. Geologist*, Jan. '97, XIX, No. 1, p. 56.

[51] *Proc. Acad. Nat. Sci.*, December, 1892, p. 445.

[52] In C^4, p. 314, this quarry seems to have been confused with a quarry of dark-green chlorite schist used in the neighborhood for flagstone. The latter quarry, known as Fulton's, is on the Speakman farm, about a mile west of the Hayes quarry.

Southwest of the Poorhouse quarry is a series of limestone quarries (Embreeville, Pierce, Edwards, Guest, Doe run), but there are no exposures of the sandstone until the Guest quarry is reached. West of it and east of Doe run it is found abundantly. A detailed description will be found in the discussion of the limestones.

Southeast of the ancient gneiss ridge and of the outcrops just described, which seem to belong to the series northwest of it, the gneiss itself ending near Northbrook and west of Chester creek, are several outcrops of the sandstone accompanied by limestone, both having been quarried, the limestone very extensively and for at least a half a century. In view of this well-known fact, it is strange to find the contrary stated in the *Final Report of the Second Survey.*[53]

Of these outcrops, the easternmost is in Thornbury township, Chester county, one mile north-northwest of the Delaware county line, where the typical rock, interstratified in schists, appears on the road next northwest of the Wilmington road, half a mile south of the Street road, on the farm of John Wyeth. The rock is in place, but the exposure poor. There is an outcrop of limestone about three miles south of this, Bullock's quarry in Birmingham township, Delaware county, but the closely adjacent rocks are not visible.

About a mile southwest of this it is exposed on the Wilmington road, dipping about southeast 30°, with mica schists apparently conformable both above and below it. A half-mile southwest it is exposed in a quarry about three-quarters of a mile north-northwest of Dilworthtown. The dip is N. 35° W. 80°; nothing but the sandstone is visible. Half a mile nearly south from this quarry, many loose masses are visible in the road which leads to West Chester, next southwest of the Wilmington road, where the road from Dilworthtown to Birmingham Meeting-house crosses it. About three-quarters of a mile nearly west of the quarry just mentioned and less than a half-mile northeast of Birmingham Meeting-

[53] "There is no sandstone, no limestone to be found in the Atlantic coast country southeast of the Buck Ridge gneiss, except just at its southern edge. The country between it and the Delaware river is occupied by a great series of azoic rocks, . . . among which not a single stratum of sandstone or limestone can be found." *Second Geol. Survey of Pa., Final Report,* I, p. 86.

house is limestone exposed in a quarry and dipping S. 40° E. 50°. No other rock appears in place, but thousands of schist fragments lie to the southeastward of the limestone; a quarter of a mile south, schists dip S. 30° E. 30°.

Along the Brandywine the rocks are well exposed; the limestone is visible in Harvey's quarry, at Brinton's Bridge, about a mile above Chadd's Ford, and the sandstone ought to be visible, but it is not. But under the limestone of Huey's quarry, about three-quarters of a mile east-northeast of Brinton's Bridge, there is exposed a quartz schist dipping N. 60° E. 20° under the limestone, and further westward the sandstone is exposed abundantly close to the Red Lion Hotel in East Marlborough township and thence westward and two miles south in Kennett township, east, north and west of Kennett Square.

If the outcrops mentioned be plotted, it seems clear that they cannot be ranged in one or two synclinals, unless very undulating. It seems equally certain that no succession of anticlinals can be made out of the Brandywine section. The country, except along the large streams, is covered with mica schist and gneiss fragments, with occasional outcrops of the same rock in place with pyroxenite and gabbro. The peculiar sandstone, where it occurs, is of typical character, the adjacent schists both above and below the sandstone closely resembling Rogers' Upper Primal of the North Valley Hill, and there seems no marked distinction between those above and below.

It may be briefly stated that in Chester county, south of the Chester Valley, there are several outcrops of the typical rock. So far as can be observed, all dips are southeast under southeast dipping limestone, with possibly one exception to be hereafter noted (Taylor's quarry).

1. One mile west of the limestone of the Poorhouse quarry, dipping S. 30° E. 25°, with schists dipping about the same above and below (Hayes' whetstone quarry, already mentioned), the limestone dipping S. 40° E. 5° to 25°.

2. West of Logan's quarry, west of Unionville, dipping probably S. 75° E. 30°, with schists S. 55° E. 70° above and S. 55° E. 55° below; the limestone about S. 40° E. 50°, with garnetiferous schists S. 30° E. 45° overlying.

3. Northwest of Eli S. Bailey's quarry and southwest of

Logan's quarry are two well-exposed outcrops about 150 feet apart, with mica schists above, between and below, all dipping about S. 40° E. 30°.

4. A half-mile northwest of the Guest quarry, West Marlborough, dipping southeast probably 45° and less, the limestone dipping gently southeast with sandy mica schist between, also probably the same bed, .2 miles west of the quarry.

5. Two hundred feet west of the Enos Bernard quarry south of Doe Run village, dip not visible, the limestone dipping either 30° or 80° nearly west; also about .2 miles east of the Enos Bernard quarry; fragments only visible.

A little over a mile south-southwest of the Enos Bernard quarry and northeast of Marlborough Hall Schoolhouse sink-holes indicate underlying limestone, while in the east and west road close sandstone is shown by numerous loose masses.

6. The most important belt stretches from east of the Red Lion through London Grove village to west of Chatham, bordering on the north the Street road limestone outcrops. Near the Red Lion it dips S. 25° E. 15° to 50°, mica schists underlying. West of Taggart's cross-roads S. 5° E. 15° to 20° toward the limestone.

At London Grove it is well exposed in a quarry .3 miles southwest of the meeting-house, S. 35° E. 30°, with sandy mica schist overlying and a harder schist underlying.

7. South of Lewis Bernard's quarry it is poorly exposed at the northern foot of the hill between Bernard's and Story's quarry.

8. Southeast of Story's quarry it is clearly exposed in a quarry about .2 miles east of West Grove Meeting-house, overlying mica schist and dipping S. 50° E. 20° under the limestone of the Avondale Lime and Stone (formerly A. G. Hughes & Co.'s) quarries, northwest of Avondale, in which the limestone dips S. 40° E. 20° and less, with mica schists overlying.

9. North and west of Kennett Square and also east of it, bordering the Kennett limestone on the north.

Reviewing these sandstone outcrops in western Chester county, and taking a section line about S. 15° E. from Honeybrook township to London Britain township, we find the following succession:

North	Red sandstone and trap,	Turkey Hill, Forest Hill.
1.	Limestone,	Churchtown, Lancaster county.
	Sandstone,	Welsh Mountain.
	Ancient gneiss and igneous rocks,	Southern part of Honeybrook township.
2.	Limestone,	Southern part of Honeybrook township.
	Sandstone,	Baron Ridge.
	Ancient gneiss (gabbro?),	South of Martin's Corner.
3.	Sandstone,	North of Wagontown.
	Chester county gneiss,	Wagontown and south.
	Ancient gneiss,	Siousca Station.
	Chester county gneiss.	
4.	Sandstone,	North Chester Valley Hill.
	Mica schist,	Caln Meeting-house.
	Limestone,	Chester Valley.
	Hydromica schist,	South Valley Hill.
	Mica schist,	South of Modena.
5.	Sandstone,	Southeast of Doe Run village.
	Mica schist,	Not over 500 feet wide.
	Limestone,	Guest quarry.
	Mica schist,	Not over a mile wide.
6.	Sandstone,	Northwest of Logan's and Bailey's quarries.
	Mica schist,	Not over 500 feet wide.
	Limestone,	Logan's and Bailey's quarries.
	Mica schist,	About a mile wide.
7.	Sandstone,	London Grove.
	Mica schist.	
	Limestone,	Street road line.
8.	Sandstone(?),	South of Bernard's.
	Mica schist,	South of Bernard's.
	Limestone,	Story's quarry.
9.	Sandstone,	Road Avondale to West Grove.
	Limestone,	Hughes quarries.
	Mica schist and gneiss.	
10.	Sandstone,	In same valley north of limestone to the eastward.
	Limestone,	Watson & Jones' quarry, Avondale.
11.	Limestone,	Nevin's quarries.
	Mica schists.	
12.	Limestone,	Eastburn quarries.
	Mica schists.	

(The brackets connect those outcrops which appear related.)

It will be seen by this table that we have eight certain lines of outcrops of the sandstone, with two uncertain and eleven of limestone.

North of the Chester Valley, the limestone is close to and north of the sandstone, while in the valley and south of it the limestone is usually close to and south of the sandstone. Among the whole, in this section, there is not one from which we can with certainty infer an anticlinal or synclinal structure, except perhaps in the limestone of the Nevins' quarries and in the easterly part of the Doe Run Valley. If the first is synclinal, the northerly sandstone leg is concealed by the Red sandstone. At the second, rocks apparently identical with those elsewhere referred to the ancient gneiss lie closely adjacent to the limestone on the north, and with some undoubtedly igneous rocks separate it for at least two miles from the northerly Cambrian sandstone, while the southerly sandstone forms a high hill and is the nearest visible rock, perhaps 500 feet being concealed. South of this sandstone hill is again the ancient gneiss, including possibly some areas of the Chester county gneiss, extending about two miles to the Wagontown-Copper Mine Ridge sandstone hill, followed by about two miles of the Chester county gneiss, with possibly some areas of ancient gneiss, extending to the North Valley Hill. The sandstone in this hill was believed by Prof. Rogers[54] to be not over a hundred feet in thickness, and its apparent width to be due to compressed anticlinals and synclinals, but I think the evidence of these inconclusive.

The sandstone, however, dips under the limestone, a thin stratum of mica schist intervening from Caln Meeting-house westward, and does not rise on the southerly side of the Chester Valley, as it does on the northwest. There is, however, nearly south of the King of Prussia, and thence westward for a mile or two and north of Paoli, a narrow outcrop of sandstone with iron ores. The best exposure was on the Trenton Cut-off Railroad, north of Paoli.[55]

Prof. Rogers writes of this as occurring also east of Downingtown, and further says:[56] "In the vicinity of Coatesville and west of it this well-marked rock . . . . projects conspicuously in

[54] I, 171, quoted C^4, pp. 147–148.
[55] *Proc. Acad. Nat. Sci.*, 1891, p. 119.
[56] *First Geol. Survey of Pa.*, I, p. 166.

rugged outcrops at the entrance of the numerous ravines and gorges, thirty or forty feet thick."

I have tried in vain to find these outcrops, not only by personal examination, but also by inquiry of observing residents, who have assured me that there is no sandstone visible in that vicinity on the north slope of the South Valley Hill.

This sandstone, while at the locality near Paoli resembling that of the North Valley Hill, is so very limited in area that the probabilities are that it is a more recent rock overlying the limestone. It lacks the characteristic tourmaline crystals.

South of the limestone is a mile of the hydromica schists, followed by three miles or more of mica schists, many of them heavy-bedded and hard, followed by the sandstone, and then softer schists and limestones, the dips in the hydromica being steep to the south in its northerly part, mostly vertical in its middle and southerly portions, and the mica schist and almost all other rocks from it southward dipping toward the southeast with angles rarely above 35°. It is true, however, that at this limestone outcrop feldspar and hornblende gneisses appear close on its northerly side further eastward, and that still further eastward the sandstone appears on its southerly side.[57]

Still going southward, and passing a region almost without outcrops but with a soil suggesting the schists and containing schist fragments, we find outcrops of the sandstone, followed by a narrow stratum (300 feet to 500 feet) of mica schist, and then the limestone of Logan's and Bailey's quarries. South of this, mica schists, at times garnetiferous, extend for a mile, followed by the extensive outcrops of the sandstone at and near London Grove, overlying which are mica schists, and over them the limestone of the Street road line. At one locality south of and near Bernard's limestone a small outcrop of sandstone appears, but the exposure is so poor that not much reliance can be placed upon it. South of it is a hill of mica schists and about a mile south of Bernard's the limestone of Story's quarry, south of which are very clear outcrops of the sandstone, followed by the limestone of the Avon-

[57] About three quarters of a mile south of the Embreeville outcrop of this belt is a stratum of white quartzite with tourmaline shown in loose masses only, but in quantity. While unlike the sandstone this may possibly represent it and make the structure synclinal.

dale Lime & Stone Co., which dips very gently south and is overlaid by garnetiferous mica schist. This is followed by the limestone of the Watson & Jones quarry, Avondale, almost certainly of the Kennett series, and if so, further east undoubtedly underlaid by the sandstone well exposed.

The " Potsdam " is stated by both Dr. Frazer[58] and Prof. Chester[59] to underlie the limestone of extreme southern Chester county and northwestern New Castle county, Del. I was unable to find any exposure of sandstone either north or south of Nevins' quarry. The limestone of this quarry being clearly anticlinal in structure,[60] the sandstone, if it occurs to the southeast, can hardly underlie the limestone.

In the schists of Rogers' first and second groups are occasionally and abundantly sandy schists which have much the aspect of these schists associated with the type rock, but the latter rock itself is absent. The outcrops in Thornbury, Birmingham, near Doe Run, in London Britain and in East Marlborough show conclusively that the type rock is underlaid and overlaid by mica schists not infrequently garnetiferous. There seems, therefore, no reason to doubt the conclusion of Prof. Rogers and of Dr. Frazer, that these schists belong in the paleozoic column, as certainly do those north of Pomeroy and Parkesburg.

The argument in Cream Valley is not less conclusive. Here we have east and west of the Schuylkill a succession of rocks uniform, except that a mica schist in the west takes in part the place of the typical sandstone two miles to the eastward. Besides this, we have in this very schist further west a chert-like quartz and the typical sandstone at several localities and in abundance, associated as usual with limestone. It is reasonable, therefore, to believe that the mica schists of Cream Valley are likewise Cambrian. These schists we can follow with constant outcrops in a narrow line to a point near West Chester, where they widen rapidly and again show limestone. Further west they still widen, the limestone becomes more frequently exposed and again we find among them the typical sandstone. But here apparently the same schists may be traced southward without a break, until they unite

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[58] C^4, 328.
[59] *Proc. Acad. Nat. Sci.*, 1884, p. 239.
[60] C^4, 327.

with those of East Marlborough, Kennett, etc., which is another confirmation. That there are repetitions, in spite of the uniform southeasterly dip, is most probable, but the data are too meagre to define them.

Again, the mica schists of the Huntingdon Valley must be of Cambrian age or more recent. They very closely resemble those of Cream Valley. But if all these schists are of Cambrian age, why should greater antiquity be claimed for the very similar rocks of the Philadelphia newer schists and gneisses?

Along the north slope of the North Valley Hill, at several localities, is a very compact sandstone which I have not seen in place, though often local outcrops show a similar rock. This particular rock is more quartzite than a sandstone, weathers of a light yellow color and not infrequently shows white-ribbon-like markings. These are curved, branched, swell out and contract, and seem to indicate an organic origin.

Limestone.

In discussing the limestone outcrops in this region it will be convenient to divide them into groups, ranging along west-southwest lines, based upon their geographical position, following the usual strike of the rocks:

1. That of Van Artsdalen's quarry, Bucks county.
2. Those of the great Chester-Montgomery (Plymouth) Valley.
3. Those of Edge Hill, Flourtown, Spring Mill, West Conshohocken, Cream Valley, Cope's quarry northwest of West Chester, those of the valley stretching southwestward from the East branch of the Brandywine above Copesville to Embreeville, and of the Guest quarry.
4. Those of the Doe Run Valley.
5. That of the Huntingdon Valley southeast of the ancient gneiss.
6. Those of Pocopsin township, Logan's quarry and Elisha Bailey's quarry, in Chester county.
7. Those in West Thornbury, Birmingham and northeastern Pennsbury township, Chester county, and Birmingham, Delaware county, and westwardly much more largely exposed to the south of the Street road westward of the Red Lion Hotel, toward West Grove.

8. Those in the valley through which the Baltimore Central Railroad runs; that is, in central Pennsbury, Kennett, northern New Garden and London Grove townships, Chester county.

9. The small areas on the southerly line of New Garden and London Britain townships, Chester county, and those of New Castle county, Del.

10. Several small outcrops in northern Chester county.

The first, that of Van Artsdalen's quarry in Southampton township, Bucks county, is a small isolated outcrop in the ancient gneiss of a highly crystalline limestone much mixed with other minerals, of which the variety made this locality famous, but, like many others, the quarry has not been wrought for years. It appears to be clearly within the ancient gneiss and to have no relation to any other outcrop, no other limestone having been exposed in any part of the fifty lineal miles of this gneiss exposed in this region. Near by is a dyke of norite. Prof. Kemp suggests that it may be an included piece of limestone caught up in a flow of igneous rock.[61] It is much folded and contains considerable graphite; the other minerals most prominent are pyroxene and wernerite.

II. Limestone of the Chester County.

The second is by far the most important, and has been the object of the most study. The valley underlaid by the limestone extends unbroken from Willow Grove on the northeast into Lancaster county on the southwest, where, according to the observations of Dr. Frazer,[62] it joins the great outcrop of the Lancaster and Pequea Valleys.

In Montgomery county its length is about fifteen miles, in Chester thirty and in Lancaster ten, a total of fifty-five miles. In width it varies greatly and suddenly, the greatest being about two miles and the least a quarter of a mile. It is well exposed in numerous outcrops, and has been extensively quarried. It dips with much uniformity steeply to the southeast, and, while local deviations are common, no systematic undulations appear. Compressed anticlinals have been exposed—*e. g.*, in the cut of the Schuylkill Valley Railroad below Potts' Landing, and in that of

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[61] J. F. Kemp, *Trans. of the N. Y. Academy of Natural Sciences*, Vol. XII, p. 77.

[62] CCC., pp. 75, 76.

the branch of the Pennsylvania Railroad from Chestnut Hill to the Trenton Cut-off near Camp Hill. Of these the former is instructive. The limestone here formed a high bluff, the base of which was the left bank of the Schuylkill river. In a bench cut into the limestone the Norristown Railroad was located, and there was exposed a series of strata dipping quite uniformly to the southeast. More recently, the Schuylkill Valley Railroad, running parallel with the former, was forced to quarry more deeply into the hill, when it appeared that some of the apparently parallel strata formed opposing legs of an anticlinal. It seems to be admitted that this structure is common, though not usually apparent, and that the limestone is not nearly so thick as would be inferred from its general width.

West of the Schuylkill river this valley is remarkably straight, especially on its south side. Its streams rarely flow for any great distance along the axis of the valley, indicating that the present courses of the creeks and rivers were established long before erosion gave us the present contour lines. This apparently erratic flow is emphasized by the present contour, for it is possible for an observer to stand at points overlooking the valley, with its high and well-marked bounding hills, and see seven streams leave the floor of the valley and flow, toward the east-northward, toward the west-southward, through the apparently impenetrable walls, forming gorges with precipitous sides, rising at times three or four hundred feet above the valley.

In its northeast part there seems to be no question about the relation of the limestone and the adjacent rocks, for we have apparently without doubt a basin of the peculiar sandstone, the Primal of Prof. Rogers, the Potsdam and No. 2 of the Second Survey, now generally believed to be Cambrian, underlying and surrounding the limestone. This sandstone, at times concealed by the newer Red Rocks on the northerly side, seems clearly to bound it on the north to the westerly termination of the valley at Quarryville, Lancaster county, forming usually a high hill.[63]

In the portion of the valley east of the Schuylkill river, known as the Plymouth Valley, the limestone has been and is largely

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[63] As more fully referred to in the discussion of sandstone, Dr. Frazer believes an area of older rocks to intervene between the sandstone and the limestone from Pomeroy westward. C^4, pp. 256–267.

quarried, formerly as a flux for iron furnaces, as well as for building uses. The iron furnaces having been abandoned, it is now quarried for the manufacture of lime, for railroad ballast and road material, and for concrete, except a comparatively small amount used as building stone. Near the Schuylkill, on both sides of the stream, a slaty limestone, containing much quartz, mica and graphite, has been largely quarried for foundation stone. For large buildings in Philadelphia it has been used probably more than any other stone, as it can be obtained in masses of any desirable size, with easy and smooth fracture, or more properly cleavage, in one direction. At the Schuylkill the limestone is probably as wide as at any point, extending from Swedesburg to the northerly part of Conshohocken, a distance of about two miles, the river flowing nearly on the line of dip. The northerly boundary is the Red sandstone, quarried in and about Norristown. At Norristown the Cambrian sandstone is reported to appear in limited areas, but I have not been able to find the typical rock at the Schuylkill.[64] West of the Schuylkill, however, are two prominent hills, one near the river northwest of the Trenton Cut-off Railroad, the other two miles to the westward, northwest of Henderson Station. Exposures in these hills are poor, but abundant fragments and one or two quarries indicate on the side toward the limestone a fine-grained mica schist, and next northwestward a conglomerate very closely resembling that underlying the sandstone to the northeastward. In one quarry near Bridgeport the dip is S. 10° E. 50°; in one near the northwest end of the hill nearest the river S. 50°.

The limestone on the river bank dips S. 10° to 20° E. 30° to 60°. It seems probable, therefore, that this is the basal conglomerate of the Cambrian, the typical sandstone being absent or concealed.

The southerly boundary is a prominent hill of hydromica schist. About a mile west of the Schuylkill the valley is suddenly and greatly narrowed by the widening of the hydromica schist hill from about four-tenths of a mile at the river to over a mile and a half two miles to the westward.

A little over two miles west of the river is Henderson Station, geologically important from the discovery by Mr. Martin B.

[64] C^6, p. 74.

Stubbs in Shainline's quarry of fossils in orbicular quartzite, identified by Prof. Heilprin as *Lituites orthoceras* (*Gyroceras*), *Maclurea* or *Pleurotomaria*, and *Murchisonia*, of which specimens are in the collection of the Academy. Unfortunately, all the masses found were loose in the decomposed limestone soil overlying the common limestone. A rock very closely resembling that in which the fossils were found occurs in great abundance in the railroad cut west of Henderson Station, here also probably not in place, and almost certainly in place about a mile to the eastward, where the highway was shifted northward at the time of the construction of the Trenton Cut-off Railroad. At this locality, notwithstanding the rock was largely exposed, no trace of fossils has been discovered. A similar rock occurs eleven miles further west in small quantities and in loose masses only, near Sidley Station on the Phœnixville Branch of the Pennsylvania Railroad, but no fossils have been found. It occurs also on the west side of and near the Schuylkill below Norristown, and also in loose masses but very abundantly about a mile and a half northeast of Norristown, at which place some of the quartz crystals were arranged in cylindrical forms, giving rise to a newspaper paragraph that the rock contained fossil Indian corn. This rock resembles the calciferous sandrock of New York.

The hill near Henderson Station in which this rock occurs is skirted on the north by the Swedesford road, while the Trenton Cut-off Railroad and the Chester Valley Railroad cut its southerly base. The northernmost rock, shown in fragments only, is a conglomerate of blue quartz resembling the basal member of the Cambrian. Next, also only in fragments, is a schist or slate like that exposed in the Valley Forge gap. This slate seems to form the summit of the hill. The southerly portion is of clay and gravel, chiefly of quartz pebbles, but with some pebbles which apparently were of gneiss, now much decomposed. In this, as far as can be seen, occurs the orbicular quartzite, of which the masses appear not to be rounded. In the bottom of the cut a large mass of limestone appears. The hill near the Schuylkill presents much the same features. Near the King of Prussia the area of Red sandstone which overlies the limestone near the Schuylkill, from east of Norristown northwestward, suddenly narrows, exposing the limestone floor nearly or quite to the river at Port Kennedy, where the unconformable contact of the two is well shown. Here the high North Valley Hill of Cambrian sandstone begins, and in a distance of about a mile rises to a height of over 500 feet, cut, however, a mile beyond by the deep gorge of Valley Creek at Valley Forge. From the longitude of Valley Forge to that of Frazer, about seven miles, the valley continues with a width of about two miles wholly of limestone, except small areas of a hydromica schist apparently interbedded. At this point the North Hill, ranging from 550 feet to 670 feet above tide, with but a slight gap at Diamond Rock, suddenly ends, and a north-and-south valley intervenes with an elevation of about 380 feet. Here, on the north edge of the valley (near Devault Station on the Phœnixville Branch of the Pennsylvania Railroad), a branch of Pickering creek rises and flows northward and eastward into the Schuylkill, while close by is the source of the Valley creek, which flows southeastward, then eastward, then north through the Valley Forge gap into the Schuylkill. In this valley of the branch of the Pickering creek there is not a trace of the sandstone, though but a half-mile to the eastward or westward it is prominent. In the Chester valley in this vicinity are large limestone quarries, wrought chiefly for building lime, the largest being those at Cedar Hollow, at the foot of the hill, about .75 mile southeast of Devault Station, and those of the Knickerbocker Co., about 1.75 miles southwest. From this point westward the valley is narrower, averaging about a mile in width, though the rock margins are rarely to be seen, being deeply buried, especially on the north side, so that while the valley is well defined, it is but a supposition that the base of the hill is the border of the limestone.

Opposite Glen Loch is a watershed across the valley and the highest ground in it, by barometer about 380 feet above tide, from Frazer as datum 490 feet. Bacton is 365 feet, Sidley 370, Devault 375, Aldham (descent into Pickering Valley) 305. This watershed and the gap just below make an easy gradient for the Phœnixville Branch of the Pennsylvania Railroad.

In the vicinity of Glen Loch large marble quarries were formerly wrought and also mines of limonite iron ore. Near Bacton Station are large deposits of kaolin near the abandoned Trimble Iron Mine, famous as a locality of wavellite and cœruleolactite.

In the valley, between the longitudes of Berwyn and Glen

Loch, are outcrops of a schist, whether interbedded in the limestone or folded is not certain. On the Schuylkill section we find very slaty limestone (Bullock's quarry, etc.), and also, in the limestone, beds not over two feet thick of a hydromica schist or slate. North-northwest of Berwyn about one mile a similar slaty rock forms a hill on the farm of Mr. A. J. Cassatt, and thence westward appears at intervals. At Cassatt's dips, not very satisfactory, were toward the north S. 10° E. 60°, and towards the south S. 10° E. 90°. About 600 feet west-southwest of this is a quarry in limestone, with dips of S. 30° E. 80° on the northerly side and middle and S. 20° E. 70° on the southerly side. The easterly face of this quarry showed a small compressed synclinal, and the slate is not far from the line of this synclinal. To the westward it again appears just south of the large quarry at Howellville. A little less than a mile west of Howellville and about a mile north of Paoli Station it forms a prominent hill. On its southerly slope a slaty limestone dips S. 25° E. 85°. In the road which passes through a small gap in it the rock itself is not exposed, but limestone on both sides, dipping S. 20° E. 70° to 90°. The slate itself is exposed in a small quarry on the hill, and appears to dip S. 10° to 20° E. 80° to 85°. On the north flank of this hill the Chester Valley Railroad passes through a cut in limestone S. 20° E. 75°.

Five hundred feet westward the slate hill is again prominent, with a small limestone quarry on its north flank. The hill is quite regular for about a mile, showing one gap through which a small stream flows northward. It ends a little east of Cedar Hollow Station, Chester Valley Railroad, with limestone on the north flank dipping S. 20° E. 75° and S. 30° E. 60°.

Nearly three miles to the westward, on the left (north) bank of Valley Creek, and less than a half-mile northeast of Mill Lane Station (Chester Valley Railroad), is a high hill of the same schist. This, being wooded, is a prominent feature in the landscape, especially looking from the line of the Pennsylvania Railroad, which, opposite, descends the northerly slope of the hydromica schist ridge and continues westwardly near its foot, affording a succession of fine views. In this hill I found no outcrop of the slate which could be satisfactorily measured. At one place the strike appeared to be N. 60° E., and the dip probably southeast. There is limestone on the north side within 500 feet of the schist, and on the south side within twenty feet, dip S. 30° E. 65°. That on the south has been very extensively quarried by William B. Irvine and Andrew Carty (Knickerbocker quarries). The dip is about S. 30° E. 60° in the quarries.

North of this hill limonite pseudomorphs after pyrite occur loose in the soil. Rarely a portion of the enclosing rock is attached. It is a damourite schist. They occur also in the schist of the hill east of Cedar Hollow Station.

In the Knickerbocker quarries a narrow vein was filled with fine crystallized, crystalline and fibrous aragonite.

Nearly due south of this, and less than a half-mile north of Frazer, hence very near the south margin of the valley, is a small hill of similar schist north of the Lancaster turnpike with limestone on both sides within 500 feet. It appears to dip S. about 30° E. about 80°, the limestone S. 25°–35° E. 55°–60°. This, of course, is not at all in line with the outcrops near the Chester Valley Railroad, but nearly on the strike of this outcrop at Glen Loch, a mile and a half further west, is another on the farm of Mr. William E. Lockwood, forming a low hill striking more southwest than the trend of the valley. I found no good exposures.

At Catanach's quarry, near Cedar Hollow, a gravel of quartz pebbles overlies the limestone; a similar gravel occurs south of the Valley Forge gap, on the road to Devon. About four miles west of Downingtown the valley narrows to about a half-mile. At Coatesville it is crossed by the West branch of the Brandywine; thence westward it becomes still narrower.

At the west boundary of Chester county it is crossed by the Octorara creek and is again of greater width, about a half-mile. In Lancaster county it continues just as clearly defined as in Chester, though the floor of the valley is higher and the slopes of the bounding hills less steep. These hills are just as in Chester county, hydromica schist on the south, Cambrian sandstone and schists on the north.

Dr. Frazer's tracing of the probable connection of the limestone of this valley with that of the Lancaster Valley is one of the most valuable contributions to the geology of this part of the State. The identification of the limestone of these two valleys carries with it the identity of the bounding sandstone.

The discovery of fossils in the Lancaster limestone[65] seems to prove that part at least of the Lancaster limestone is Cambrian, and hence that part at least of that of the Chester Valley must be of the same age.

There seeming to be no doubt that the easterly end of this limestone is a synclinal near Willow Grove, I carefully examined the westerly termination. As I deem the structure not certainly made out, I desire to place my observations on record, in hope that future work by abler hands may solve the problem.

Going westward by the main route of travel, the Pennsylvania Railroad, the casual traveler passes out of the Chester Valley almost without noticing it, and is apt to regard the next valley on the north as its continuation; whereas, on approaching the Octorara, the railroad bends quite abruptly to the north, and ascending the left bank of the Octorara a very short distance, passes by the gap of that stream through the sandstone of the North Valley Hill, crosses the Octorara to the town of Christiana, then passes over two miles of gneissoid rocks and then through Copper Mine Ridge (Cambrian sandstone) to Gap Station, on the southeasterly edge of the Pequea Branch of the great Lancaster Valley.

Beginning at Midway, now the western edge of Coatesville, and near the point at which the Lancaster turnpike leaves the valley and takes a more northerly course, the Valley road[66] is an important highway through Quarryville to the Susquehanna. For so hilly a region it is remarkably free from steep hills, and yet deviates very little from a straight line. Running westward along the foot of the North Valley Hill, it crosses the Octorara about a mile and a half west of Atglen, and then ascends the hill to its summit, which is here very narrow, so that in passing along the road the adjacent valleys, both north and south, are visible, the elevation being about 665 feet or about 200 feet above the creek.

The descent of the floor of the limestone valley from Parkesburg

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[65] *Olenellus* and *Obolella*, one mile northeast of Gap Station. C. D. Walcott, *Am. Jour. Soc.*, Vol. XLVII, Jan., 1894.

[66] Now often called the Old Valley road, to distinguish it from a comparatively short highway also called Valley road, laid out more recently from Parkesburg to Atglen, and lying in the valley about half a mile south of the Old Valley road, which runs along the North Valley Hill near its base.

westward to the Octorara is quite gentle, as is also its ascent to the westward of that creek.[67]

The floor of the gneiss valley on the north rises much more rapidly, so much so that at about five miles west of the Octorara the gneiss rises to the level of the sandstone, the northerly valley ends and thence westward the drainage is, as in Chester county, from the gneiss region across the valley southward, except the first creek, Valley run, which flows southward through the North hill into the valley, which it follows eastward to the Octorara, and except also the Quarryville drainage which is northwestward. The ridge trends S. 60° W. for two and a half miles, then S. 70° W. Throughout this distance the typical Cambrian sandstone is shown by fragments, by the sandy soil and in occasional outcrops in place. One dip, at a good exposure, half a mile from Christiana, was S. 20° E. 65°. Two miles beyond, the strike is N. 65° E., dip uncertain. On the rise of the hill beyond this, and about 100 yards west of the road to Steelville, the rock is exposed on both sides of the road, which is almost exactly on the strike S. 70° W. On the north side it is typical Cambrian sandstone, on the south the same with thin layers of dark sandy mica schist. This continues for nearly 500 feet, and then, near the top of the hill, the rocks are less exposed, but there are mica schist fragments on both sides. About .25 m. west of the road to Steeleville the road and hill trend S. 75° W., quite level, to and beyond a road leading north to Smyrna. East of this cross-roads the sandstone, unusually hard and massive, approaching quartzite, is visible in large loose masses—one of several tons weight, but not certainly in place. The soil is very sandy. At the cross-roads the sandstone outcrops

[67] In C^4, p. 17, it is stated that the Pennsylvania Railroad crosses the Chester Valley west of Caln, and gradually rises upon the north slope to "The Gap," in Lancaster county, and that from Pomeroy westward the floor of the valley rises rapidly into Lancaster county, but not so fast as the railroad. This does not accord with my observations.

Tested by barometer the levels of Pomeroy and the Octarara creek, here the boundary between Chester and Lancaster counties, are nearly the same. The railroad rises from Pomeroy westward to the watershed between Buck Run and the Octorara, but immediately descends as shown on p. 18 where levels are given, Pomeroy 483′, Parkesburg (2 m.) 537′, Summit 562′, Penningtonville (5 m. from Parkesburg) 500′. In *Levels Above Tide*, Christiana, in Lancaster county, about half a mile from the Octorara, is given about 491′. Moreover, the drainage of the valley from a point two miles west of Pomeroy is westward into the Octorara. The railroad, however, as above stated, leaves the valley before entering Lancaster county.

S. 20° E. 75°; .2 m. west of the cross-roads is a quarry in the sandstone on the north side of the road S. 30° E. 35°. It is near this that the valley on the north is almost obliterated by the rise of the floor, and here also the Valley road begins to leave the summit, but the deviation is slight. The road now crosses the Sadsbury-Bart township line, and soon crosses a small creek about sixty feet below the summit. This is Valley run, which flowing southward from the gneiss into the valley flows eastward through it to the Octorara.

West of this creek the road rises gently about thirty feet in .3 m. to a cross-roads (north nine miles to Williamstown). The road continues to rise, as does also the hill and the floor of the valley. In the latter are abandoned iron mines (between Bart Post-office and Nine Points). No fast rock is visible along the road, but much quartz in fragments, some white, some rusty and some smoky, closely resembling that occurring north of the same hill in Chester county.

After a descent of about seventy feet the road crosses the creek which drains the Gap nickel mine. Here the sandstone is not visible, but north of the road and on the left bank of the creek is a bold bluff of dark mica schist with quartz, showing minor plications and dipping N. 35° W. 80° to 85°. The road rises beyond this creek about seventy feet, and then descends fifty, to cross the westerly branch of the last-mentioned creek; beyond this the road ascends ninety feet, and then descends slightly to cross a small creek. This is about a mile and a half east of May Post-office. Here the schist is again exposed, together with a large amount of loose trap, a fine-grained olivine diabase.

Beyond this the road passes through a very soft unctuous micaceous rock, very fragile, resembling that which occurs with the iron ores.

Two-tenths of a mile west of the trap masses of hard Cambrian sandstone become very abundant; the fences are made of it, and great quantities lie in dumps, together with a few masses of trap. About .1 m. beyond a road goes south into the valley. Opposite this road, about five hundred feet north of the Valley road, is a precipitous cliff, about fifty feet high, of the typical sandstone. It is much jointed, very compact and hard, approaching quartzite. The base of this cliff is 100 feet above the road.

From this westward the sandstone is abundant to May Post-office near which is trap, but insignificant in quantity compared with the outcrop a mile further east. West of this is a gradual descent for three-quarters of a mile, the road bearing S. 80° W., and then a gradual descent of about one hundred feet in 1.25 miles S. 60° W. to Quarryville.[68]

South of the valley, in Lancaster as in Chester county, ranges the straight and little-varying South Valley Hill of hydromica schists. South of Quarryville its elevation is 150 feet to 170 feet above Quarryville Station, which, taken at about 488 feet would give an elevation of from 638 feet to 658 feet.

From points near the summit a bird's-eye view of Quarryville and the adjacent country may be had, beautiful in itself and instructive geologically. Looking eastward the valley is seen as far as the eye can reach, bounded northward by the Cambrian sandstone hill. Westward, high, apparently irregular hills close the valley and end the view. Northward, or rather north-northwestward, stretches the irregular valley of the Big Beaver creek, bounded east and west by high hills, but northward permitting the view to extend to the great Lancaster limestone valley.[69]

Examining more closely, these eastern and western hills are seen to send forth promontories overlapping each other, as pointed out by Dr. Frazer, so that while the valley is continuous it is tortuous, as is most evident to a traveler upon the railroad which follows it.

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[68] C^4, p. 114, "Prof. Frazer shows that the valley limestone lies on Potsdam sandstone from the Schuylkill to near Coatesville; that here, for a short distance, thin mica schist layers come in between the limestone and the sandstone (these would be Prof. Rogers' Upper Primal slates), and that west of Pomeroy and all the way to Quarryville, in Lancaster county, no sandstone underlies the limestone; but, instead of that, the limestone rests upon feldspathic gneiss beds, gneissoid mica schists, etc. (these would be Prof. Rogers' Lower Primal slates)." But, so far as I have seen, nowhere east of Coatesville is the typical sandstone much better shown than in the gap of the Octorara, thence westward for a mile and at the locality mentioned near May Post-office, and it is as well shown for the greater part of the intervening distance as it is north of the valley in Chester county.

[69] Dr. Frazer well describes the westerly ending of the valley: "The north boundary wall sweeps up to the northwest, leaving the level limestone land between itself and Quarryville. The south wall sweeps around Quarryville and almost closes up the valley a short distance due north of that town and west of the Mount Holly schoolhouse" (CCC, p. 75). The trend of the westerly hills is, however, nearly north-northwest, bordering Big Beaver creek, a branch of which rises a little south of Quarryville and flows nearly north-northwest and then northwest, so that the angle of the two valleys is much more than a right-angle.

Bearing in mind Mr. Hall's demonstration of the synclinal structure of the easterly end, " where the Potsdam sandstone borders it on the south, and where its round basin-shaped east end is perfectly manifest" (C^4, p. 116), and his further demonstration that in the middle of this half-round basin-shaped end lies the northeastern end of the hydromica schist of the South Valley Hill, I sought for evidence of the structure of the hill at this westerly end. Exposures of the hydromica schist are few and poor—one .4 m. south of Quarryville was S. 10° E. 40°; further south strike N. 50° E., dip uncertain; .5 m. dip southeast; .7 m. S. 50°; .8 m. S. 20° E. 70°; 3 m. S. 30° E. 65°. This was near Mechanics' Grove; three miles northwest of Mechanics' Grove and southeast of The Buck, S. 20° E. 45°.

About a mile northeast of The Buck a fence was seen, composed of a quite hard plicated gneiss, containing white feldspar and quartz beds or veins. This appeared to be of quite limited extent and was the only exception to the hydromica. About two miles nearly north of The Buck the road descends eastward a long hill of the schists, which near the top dip west 10°, further down S. 40° E. 20°; these were soft, even-bedded and sectile. This was about three miles a little north of east of Rawlinsville. Then descending a small branch of the Pequea Creek, the same schists were very largely exposed, dipping S. 80° W. ± 10°. This was in the vicinity of Smithville, and on the road from Rawlinsville to the Spread Eagle. Eastward toward New Providence no exposures were seen until about a mile west of New Providence, when much loose quartz appeared, and then a mine of limonite iron ore and, a quarter of a mile further, a hard limestone, N. 30° W. 35°, with minor plications. This point is probably three miles at least north of a line in the prolongation of the southerly side of the sandstone of the North Valley Hill. Northwest of New Providence, about a half mile, a plicated limestone dips south to S. 10° W. ±16°. About 500 feet east of New Providence a schistose limestone coming out of the quarry like flagstones, but some portions plicated, N. ± 40° W. 10° to 20°.

About 500 feet north by west of New Providence limestone dips N. ± 40° W. ± 45°. About 1000 feet further, N. 20° W. 30° to 40°. About a half mile south of New Providence, in a quarry, strike N. 60° E., dip in one place 70° northwest, in another, inaccessible, it seemed from a distance to be gentle southwest. On the railroad .6 m. south of New Providence the limestone is just visible, but at about one mile, in quarries, it is from 0° to S. 15°. This is about 2.25 miles northwest of Quarryville. Nearly north of Quarryville is Hawksville, and here limestone outcrops N. 45° W. 35°. On the Valley road east by north of Quarryville .25 m. limestone dips 0, further east, northwest gentle, then sandy mica schists shown in fragments only, and at one mile Cambrian sandstone, abundant, the road leaving the valley and ascending at a very acute angle the southerly slope of the North Valley Hill.[70]

The road north from May Post-office, that is, near the westerly edge of the tableland, ascends the valley of a small creek flowing southward across a broad tableland, continuous northward from the North Valley Hill, and free from steep slopes, except on its westerly border, where it ends abruptly at the valley of Big Beaver creek in the series of promontories before described.

One-tenth mile north of May Post-office the sandstone is in great quantity and extends for nearly a mile. Here a road goes east to Georgetown, and a dark sandy schist appears. About 1.3 miles from May Post-office another road goes east to Georgetown, and at 1.4 a road west to Camargo; between these the only rock is quartz in loose masses. It does not resemble that of the Cambrian sandstone. At about two miles another road goes west to Camargo, and a schistose sandy rock dips S. 70° W. 15°. This, I think, is the Cambrian. In the vicinity the loose masses are of the typical rock.

A little beyond this is the Bowery Church, the road attaining its greatest elevation, 810 feet. North of the church it descends into a small valley which heads perhaps .2 m. to the eastward and descends to the valley of Big Beaver creek, on the north side of Camargo. Near New Providence the easterly branch of the creek, which flows through this side valley, is joined by the south branch (not shown on the map C^3) which, heading in the limestone southeast of Quarryville, flows northwestward. The valley of

[70] In the map of Lancaster county (C^3), the Valley road is represented as within the limestone area four miles east of Quarryville. I think, however, it leaves the limestone three miles further west, as around May Post-office the Cambrian sandstone is very abundant.

this south branch is taken advantage of by the Quarryville branch of the Reading & Lancaster Railroad, which passes through this rugged region by easy grades, and with very moderate cuts and fills, though with little straight track.

In the valley of Big Beaver creek (south branch) the limestone seems to be almost, if not quite, continuous. There is, as Dr. Frazer notes, one narrow ridge .2 miles northwest of Quarryville, which appears to cut it off. This is of hard heavy-bedded mica schist, and is the ridge on which Hawksville is situated, though at Hawksville limestone appears, dipping N. 45° W. 35°. The schist is gnarled and twisted. The dip appears to be steep, but I could obtain no satisfactory measurement. It is not over .25 mile wide at the creek.

The fact that the hydromica schists of the south hill occupy the region in the strike of the valley west of the limestone at Quarryville seems to negative the theory of a fault along the south side of the valley bringing up the schists from below.[71]

My view of the westerly end of the valley would be that on the north the gneiss and mica schist (Rogers' Lower Primal) and the Cambrian sandstone end in a high tableland with promontories projecting into the Big Beaver valley, but that other areas of the sandstone overlie the gneiss and mica schist east of the Big Beaver valley, but none of these rocks appear west of it near Quarryville; that the limestone, with a general westerly dip of low intensity, sweeps northwest along the Big Beaver toward the Lancaster valley; the hydromica schist, widening first southward, widens west of Quarryville northwardly overlying the limestone.

III. Limestone of Flourtown, Cream Valley, Etc.

The third series should really not be separated from the second, for there can be no question, I think, that they are identical; the Spring Mill sandstone and limestone being the southeasterly legs of the synclinal of which the limestone of Plymouth and the sandstone of Cold Point are the northwestern,[72] as shown on Mr. Hall's map, C^5, for we can trace the limestone of the Chester-Montgomery valley around the northern end of the hydromica to the Schuylkill and find it in its turn surrounded by the Cambrian

[71] Dr. Frazer, *Proc. Am. Ass. A. S.*, 1884, p. 394.
[72] *Final Report*, I, p. 174; C^4, 303.

sandstone. Their supposed absence westward has led to several theories.[73]

As far as to the Schuylkill this structure seems to be admitted.[74] It is west of the Schuylkill where the diversity of opinion is manifest, and this, I believe, arises from a failure to recognize the topography of the region and the rocks which are actually there.[75]

A glance at the topographical map of Philadelphia and vicinity of the U. S. Geological Survey will show that west of and near the Schuylkill there are, southeast of the great Chester Valley, three subordinate valleys, all trending west-southwest, and separated by high hills of hydromica schist. The northwesterly two

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[73] Prof. Lesley's *Notes of the Geol. of the Schuylkill River*, 1884, p. 6.

[74] "Its acknowledged synclinal structure in Montgomery county, where the Potsdam sandstone borders it on the south, and where its round basin-shaped east end is perfectly manifest." C^4, p. 116.

If tradition may be trusted, the source of the great spring which gives name to Spring Mill is in the northerly leg of the synclinal though the spring itself is in the southerly valley. The following facts I obtained in 1893, from the well-known Dr. Hiram Corson, of Plymouth, he being then over ninety years of age. There was a large sink hole near Plymouth meeting-house filled up when the Plymouth railroad was built. When he was young it was reported and currently believed that chaff thrown into this sink hole was ejected at Spring Mill.

On the property of Mrs. Hovenden near the meeting-house was a well fifty feet deep, at the bottom of which was a swiftly flowing stream.

A quarter of a mile west of this was a sink hole in a quarry (since filled up) at which the sound of running water could be clearly heard.

The spring is said to flow twenty-two hundred gallons per minute. The limestone area, southeast of the hydromica, seems insufficient to yield so great an amount while the northwest area is very much greater. So far as I have been able to ascertain no large spring rises in the northwest valley.

[75] In C^4, p. 127, it is stated: "The southerly border of the limestone belt crosses the Schuylkill at Spring Mill and follows Gulf Creek into Chester county a little less than a mile south of the Baptist meeting-house"—presumably the Great Valley Baptist Church, 1.5 miles north-northwest of Devon Station. In Prof. Lesley's summary of the arguments for and against the synclinal structure of the Chester Valley (C^4, pp. 116 *et seq.*) he seems to regard the topographical valley alone, and to esteem the limestone and sandstone outcrops southeast of the hydromica schist as of no importance because they are so much smaller than those on the northwest.

But in the quotation from p. 127 he clearly recognizes the limestone at Spring Mill as the southerly border and traces it along Gulf Creek, but no one who has visited the locality can possibly unite the limestone of Spring Mill with that on Gulf Creek near its mouth. The identity of the Spring Mill limestone with that of West Conshohocken cannot be doubted, while between the latter and the limestone on Gulf Creek, between the Gulf and its mouth, intervenes the hydromica schist hill just as it does east of the Schuylkill between the limestone of Spring Mill and that of the Plymouth Valley. It is possible, however, that the outcrops on Gulf Creek west of the Gulf may be intended, for these are the continuation of the Spring Mill limestone, but if so, several miles of the schists separate them from the limestone of the Chester Valley near the Great Valley Baptist Church.

are soon lost on the hydromica schist highland, the southeasterly continues along the southeast foot of the hydromica schist hill. The Gulf Creek, rising in the southeast valley about 1.5 miles south of the Great Valley Baptist Church, follows it to the Gulf, then turns abruptly north through the hill by a deep and precipitous gorge, and then follows the northwest foot of the southeasterly hydromica schist hill and along the southerly edge of the Chester Valley limestone to the Schuylkill; this hill is here quite narrow, the strike line of the two northwesterly hills being occupied by limestone continuous with that of the Chester Valley, but a mile or two to the westward the three hills unite to form a tableland nearly two miles wide southeast of the church. Some of the difficulty may arise from the fact that the Schuylkill river, flowing on the line of dip across the Chester Valley or Plymouth limestone and the hydromica past the upper part of Conshohocken, turns almost at right angles, along the base of the opposite ancient gneiss ridge and on the line of strike of the Spring Mill-West Conshohocken limestone for over a mile, when it resumes its southeast course and passes through a gap in the ancient gneiss hill.

On the left bank, just above this gap, is Spring Mill. The limestone appears on the left bank at and above Spring Mill, and to the southeast of it the sandstone. Southwest of these outcrops the limestone and sandstone appear to be covered by the longitudinal flow of the river, so that while the river is but about a quarter of a mile wide the distance between the outcrops at Spring Mill and West Conshohocken is about one and a half miles.

On the right (west) bank the limestone appears in considerable quantity in the long, straight, narrow Cream Valley and supplied the Merion furnaces with flux during their whole existence.

West of West Conshohocken there are but three actual outcrops of the limestone of this belt in Montgomery and Delaware counties, viz., at Gulf Mills, at Stacker's or Brooke's quarry, .25 mile west of the Montgomery-Delaware county line and on the farm of Peter Pechin, one-half mile northwest of Radnor Station. Limonite iron ore, as usual, overlies the limestone and was extensively mined east of the Gulf and less largely on Pechin's farm, north-northwest of Radnor Station and Fenimore's, a half-mile further west, and also south of Devon Station, Chester county. On and west of Pechin's there are sink holes near the Eagle road, between the King of Prussia road and that leading to St. David's Station, and in Wayne, due north of the Presbyterian Church and south of the Eagle road, the last now filled up, also about a half mile northeast of Sugartown, Willistown township, Chester county.

The above limestone outcrops are, respectively, .1, 1.25, 2.5 and 3 miles from the Schuylkill; the sink holes 3.4, 3.6, 3.7, 4.1 and 10 miles.

As already stated, the sandstone is well exposed on the left bank of the Schuylkill, about 500 feet southeast of the limestone, dipping S. 40°. On the right or west bank the sandstone is not visible, its place being taken by, or it being concealed in, mica schists, which border the limestone on the southeast and which also appear between two adjacent outcrops of limestone. The southeasterly limestone dips about S. 30° E. 80°; the schist S. 28° E. 74°, the northwesterly limestone about 80° northwest.

Five miles from the Schuylkill the valley is no longer prominent, its floor having risen to 400 feet above tide, almost to the level of the adjacent hills, nevertheless a depression can be traced southwestward, in which north of Sugartown there is the sink hole above mentioned, but for nearly sixteen miles no limestone is visible.

North of West Chester and about fifteen miles from the Schuylkill the valley is once more well marked, its floor occupied in part by the garnetiferous schists, its southeast boundary the ancient gneiss hill on which West Chester is situated, and its northwest the South (Chester) Valley Hill, precisely as near the Schuylkill, except that here the mica schists make the southerly part of the hill and that a ridge of serpentine appears in the valley. In this valley, about a mile and a half northwest of West Chester, at Cope's, the limestone once more appears at the surface, accompanied by the garnetiferous schists which adjoin the limestone of West Conshohocken and appear at close intervals the whole distance and which to the westward include the sandstone.

The schists here appear between two outcrops of limestone about 100 feet apart, the northwesterly very slightly exposed, showing now only one mass of limestone, dipping apparently gently to the southeast or toward the larger quarry and under the schists.

The southeasterly quarry has been wrought in a stratum of limestone only thirty feet to sixty feet in thickness, and for a distance of about 200 feet. Both walls are visible. The northwesterly is of garnetiferous mica schist, or gneiss, including masses of feldspar, exactly resembling that of Cream Valley, Radnor. It dips N. 45° W. 65°, the limestone in contact with it N. 55° W. 60°, but they appear to be strictly conformable and the slight difference is probably due to irregularity of the surface measured. The southeasterly wall is a hard schistose gneiss, containing much feldspar, some apparently porphyritic, and some an aggregate of crystalline feldspar. The limestone, however, appears to rise in an anticlinal over this and to dip gently southeast beyond it, but, apparently, of a thickness of but a few inches. The gneiss surface toward the quarry is curved, but in the straight part toward the southwest end dips N. 30° W. 65°, while over it the limestone appears with a northwest dip of not over 20°. The appearance further east is as if the limestone was folded completely over this gneiss. This limestone is not far from the strike of the serpentine, which, however, does not make its appearance.

About a mile west of Cope's the East branch of the Brandywine flows in a nearly southeast direction across the strike of the rocks, and at the crossing of the creek by the Strasburg road is Cope's Bridge, or Copesville. About a quarter of a mile above is a small valley in the hard mica schists and gneiss. Above this for .3 mile is a coarser gneiss and hornblende schist, dipping S. 30° E. 60° to 70°, followed by another valley seemingly in prolongation of a limestone valley west of the Brandywine about to be described. In the line of the upper valley the creek changes its direction for nearly a half-mile from southeast to nearly northeast. The limestone of Cope's quarry appears to be in this intermediate hill, not far from the strike of the southerly valley, and it does not appear in either valley east of the creek.

In the northwesterly valley we find the spangled mica schist full of garnets, forming the northwest hill and dipping very clearly and regularly S. 45°. In the southerly hill no exposures were noted except along the Brandywine, but the loose rocks are hard feldspar and hornblende gneiss. The Conshohocken trap dyke (diabase) passes near the summit of this hill on its southeasterly slope, but reaches the Brandywine only about .1 mile above Cope's Bridge, the southerly valley not extending over .3 mile from the Brandywine.

Opposite the northerly valley, on the right bank of the Brandywine, but a little higher up the stream, a well-marked limestone valley stretches west-southwest. Southeast of it is the high hill of the schists on which Marshallton is situated. The first quarry is that of George March, about .8 mile northwest of Copesville. It is wholly in compact limestone, dipping quite regularly S. 30° E. 20°. Over it are quantities of loose mica schist, with some large masses about 100 feet south of the quarry. About .3 mile north-northwest of the quarry the nearest rocks on that side appear on a lane on the Ingram farm. They are hornblende and feldspar schistose gneiss, striking N. 80° to 90° E., and dipping 60° and upwards nearly south, or toward the limestone. As stated, the valley is here well marked, the north and south hills rising to a height of 150 feet or more. A section of this point shows continued widening of the schists, which form the Marshallton hill.

The gneisses and schists here, as pointed out by Dr. Frazer, bear much resemblance to those of southern Delaware county,[76] and this not only in their essential constituents, but also in their containing both blue and gray kyanite. The more micaceous schists are nearly a mile in width to the border of the ancient gneiss, which is a little north of the Fairview Schoolhouse, the serpentine being here, as at Taylor's mill, close to the old gneiss. The harder and more feldspathic and hornblendic rocks north of the limestone are succeeded northward by mica schists to Hawley's mill, a mile north of the limestone, the dips being to the southeast, averaging below 45°, and are there succeeded by the hydromica schists nearly 90°, but about .25 mile above Sugar's bridge there is a small outcrop of very sandy schist closely resembling those occuring with the typical sandstone.

A mile northwest of this on the farm of Wilson Young's estate, and in the valley of the creek flowing into the Brandywine at Hawley's mill, is a small outcrop of dolomite containing much green talc or chlorite. The country west of the Brandywine is much more hilly than that to the east, a succession of hills trending about S. 70° W. rising 250 feet above the adjacent valleys.

About .4 mile south-southwest of March's quarry is a smaller one on the farm of Moses Woodward, almost obliterated, mica schist fragments abundant on the south, but no good exposures. Just

[76] C^4, p. 61.

beyond this there is a low watershed in the valley, the westward drainage being into the West branch through Broad run. On this run, about .7 mile from March's, was Moses Bailey's quarry.[77] This quarry is quoted from Rogers (C^4, p. 70) as being the most easterly. It is probable the more easterly quarries were not opened when Rogers wrote.

On the Strasburg road, a short distance east of this quarry, is a large outcrop of pegmatite, or coarse granite, with garnetiferous mica schist very close to it to the northwest, both near the floor of the valley, but probably on its southeast side, while on the northwest the hill is composed of schistose gneiss dipping steeply northwest and forming a high hill. Immediately south of the limestone quarry are garnetiferous mica schists, and in them was found a large and distinct pebble of the ancient gneiss. This corresponds closely with the similar occurrence in the Stacker-Brooke quarry in Radnor township.

Three-quarters of a mile west-southwest is the most prominent quarry of the region, known as the Poorhouse quarry. It has been wrought nearly northeast into the side of a comparatively steep hill and wholly in limestone, except the top of the north west end. The limestone is hard and highly crystalline, but full of small irregular cavities in which occur crystals of pearl spar, quartz, chesterlite and, more rarely, rutile. On the northwest side, near the entrance, the dip is clearly S. 40° E. 45°, but on the same side of the quarry further in (northeast) the dip seems to decrease rapidly to about 5° southeast. The back of the quarry (northeast) shows sixty feet or seventy feet of limestone overlain by ten feet to twenty feet of mica schist, perfectly conformable though showing in one place a breaking down, due probably to a sink hole in the limestone. The dip of this northeast side is about 5° southeast, though there is in it a distinct small anticlinal forming an arch probably twenty feet wide fifteen feet high, but apparently merely local and not disturbing the upper strata. The nearest rocks observed to the southeast are hard porphyritic schistose gneisses on the left bank of the West branch of the Brandywine, west of Glen Hall Station, Wilmington and Northern Railroad, nearly horizontal, succeeded by fine-grained and plicated schists,

[77] Boardsley run, C^4, p. 40, and Boardley run, p. 70, Broadley in the index, are probably typographical errors for Bread run.

which at the Glen Hall bridge dip N. 70° W. 10° to 40°. This dip is distinct, but most of the rock appears to have an irregular waving gentle southerly dip. The nearest northwest are on a road bearing north-northwest on the west side of the quarry, and about .3 mile from it, where a cut shows decomposing schists and gneisses with thin strata of quartzite, the bedding or cleavage quite regular S. 40° E. 50°, becoming steeper southwardly.

From Cope's to the Poorhouse quarry, there seems to be a very decided difference in character between the rocks above and those below the limestone. Assuming those dipping under it to be really below geologically, as seems almost certain, we have the same succession as has been observed in the dolomites of New York island, the underlying rocks being much harder and containing hornblende and feldspars in considerable quantity, while those overlying are comparatively soft very schistose rocks, without hornblende and much less feldspar.[78]

About a mile nearly west of the Poorhouse quarry (probably a little less than a half-mile on the dip line) is the Hayes' whetstone quarry, of typical Cambrian sandstone interbedded in sandy mica schists. The sandstone dips S. 30° to 50° E. 20° to 25°, or toward the limestone.

This is the first clear outcrop of the sandstone on this line west of Wayne, though one specimen was found loose not far from the Cope quarry, and a quartzite with tourmalines occurs near the limestone quarries east of the Poorhouse quarry, but here the sandstone is on the northwest side of the limestone with moderate southeast dips, whereas near the Schuylkill it is on the southeast side.

Standing on the hill above the Poorhouse quarry, a fine view of the Brandywine valley is had. To the eastward and westward it is narrow, with high steep bordering hills, but southwest it is broad and flat, with the creek forming an S bend and flowing 1.5 miles in a lineal distance of .5 mile. Further southeast a depression leads from Embreeville southwestward. At Embreeville, one mile

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78 "As Prof. Dana has noted (*Am. Jour. Sci.*, III, Vol. XXI, p. 439), the beds underlying the limestone of New York county are highly quartzose, while those overlying them are chiefly micaceous. Throughout Westchester county south of the latitude of Sing Sing the writer has found this lithological difference to prevail." Merrill, *Metamorphic Strata of Southeast New York*, *Am. Jour. Sci.*, III, XXXIX, p. 387.

S. 50° W. from the Poorhouse quarry, is a small limestone quarry in which the dip is S. 45° to 50° E. 60°. Less than 200 feet northwest of this, mica schists, garnetiferous and spangled, are well exposed, dipping regularly S. 45° to 55° E. 30° to 45°, hence clearly under the limestone. In these schists is a dyke, bed or vein of a partly kaolinized feldspar.[79] To the southeast are gneisses dipping S. 50° E. 55°. A mile and a half S. 60° W. from the Embreeville quarry are the quarries of Pierce and Edwards, near the Green Valley Baptist Church, the limestone dipping S. 50° E. 35°, and .5 mile further S. 60° W. Job Hayes' quarry near the south line of Newlin township, the rock dipping S. 30° E. 35° The adjacent rocks are not exposed. In almost the same direction 1.25 miles further are the extensive Guest quarries, spoken of by Rogers as Connor's quarry. Rogers gives the dip as southeast, and mentions the white sandstone as dipping to the southeast north of it with the older primal slates also dipping southeast beyond.[80]

My own observations give varied gentle dips in different parts of these quarries to the southeast, southwest and northwest, but the general dip is probably to the southeast quite gentle. In the immediate vicinity small loose masses of the typical sandstone are abundant, while large flat slabs of it are in use as flagstones at the farmhouse north of the quarry, but I was unable to ascertain exactly whence they were obtained. About 700 feet north of the quarry mica schists dip S. 30° W. 20° toward the quarry. Iron ore occurs on the Doe run road about .7 mile southeast of the quarries, and also at Pennock's iron ore mines .5 mile a little east of north. Here considerable ore (limonite) appears to have been taken out. On the Doe run road a half-mile northwest of the quarry, and thence southward, the typical sandstone is very well and largely exposed, forming a hill about seventy feet high northwest of the Guest quarry. An exception to any other locality in the whole region, it is here much plicated. It dips southeast 20° to 30°, with sandy mica schists immediately southeast of it dipping 15° S. E., and mica schists just west of it dipping S. 70° W. 45°. About half-way between the sandstone and Guest's quarry decomposing mica schists dip about 45° S. E. South of the

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[79] Soda-Orthoclase, T. C. Hopkins, *Journ. Franklin Inst.*, CXLVII, p. 13.
[80] *First Geol. Survey of Pa.*, I, 230. Quoted C[4], p. 72.

quarry are no exposures, but the soil is full of fragments of mica schist and gneiss.

This is the last quarry that can be certainly referred to the series mentioned. Prof. Rogers, after discussing this series from Broad run to the Guest quarry, says: "The furthest opening in the limestone in this synclinal is that of Baker's quarry, half a mile east of the west line of West Marlboro' township."[81]

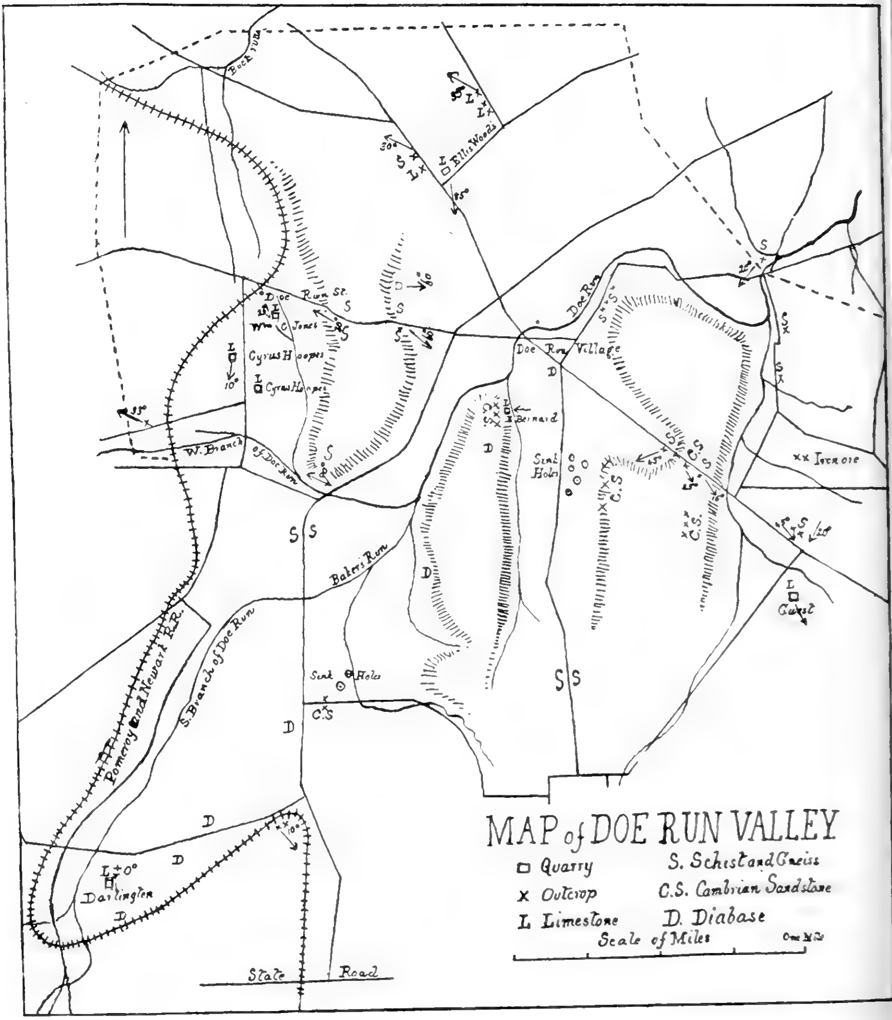
The only quarry in this location would be the large one in the bend of the Pomeroy & Newark Railroad, formerly Edwin Chandler's, now Walter Darlington's, near the source of the south branch of Doe run, but it seems impossible to consider this as being in a synclinal continuation of the former line for two hills, probably 150 feet in height, of sandstone and gneiss, intervene. Geographically it is nearly on the line of the quarries mentioned, but it seems to belong to the range of quarries north of it (William C. Jones, Isaac Hoopes) of the Doe run valley, presently to be mentioned.

IV. The Doe Run Valley.

The fourth or Doe run limestone seems geographically to be simply a continuation of the third, but I have deemed it best to consider it separately because in the subdivision I have made I have intended to include in each series those outcrops only which appear to be not only of one horizon, but also, in all probability, continuous underground when not visible at the surface, or at least not distinctly cut off. The accompanying is a sketch map of this valley.

Going northwestward along the Doe run road from the Guest quarry, as already stated, we cross southeast dipping mica schists, then southeast dipping Cambrian sandstone, then northwest dipping mica schist, and then no exposures, but a descent toward Doe run. To the north are high hills of gneiss and mica schist, through which Doe run and Buck run flow northeastward to the Brandywine. In front is Doe run valley, stretching in a general southwest direction. The floor of the valley is low and flat. It appears to be bounded on all sides by mica schists and gneisses, which also make prominent hills which subdivide it in part. Including these hills it is about a mile and a half from east to west

[81] *First Geol. Survey of Pa.*, I, p. 230. Quoted C^4, p. 72.


MAP of DOE RUN VALLEY
Quarry
Outcrop
L Limestone
S. Schist and Gneiss
C.S. Cambrian Sandstone
D. Diabase
Scale of Miles
Doe Run Village
Ellis Woods
Wm. C. Jones
Cyrus Hoopes
W. Branch of Doe Run
Bakers Run
S. Branch of Doe Run
Pomeroy and Newark R.R.
Darlington
Sink Holes
Iron ore
State Road
Bernard
Guest

and about two and a half from north to south. Its southerly and westerly border is followed by the Pomeroy & Newark Railroad, which, going north, crosses the divide between White Clay creek and the Brandywine near Pusey Station, at about 470 feet above tide. A half-mile beyond, its direction changes abruptly from north to about west by south around the base of a high hill of hard schistose hornblende rock, dipping about 10° S. E. After keeping the west by south course for nearly a mile it crosses the headwaters of the south branch of Doe run, and then turns north by east along the high hill of mica schist bounding the valley on the west to Doe Run Station, about 374 feet above tide.[82]

In the valley are two prominent hills, both trending nearly north and south, in echelon, the westerly projecting from the northern highland, the easterly from the southern, from which, however, it is cut off by a branch of Doe run. On both sides of the westerly hill and on the east side of the easterly are limestone outcrops. The easterly hill, as shown by loose masses only, which, however, are in great abundance, is of hornblende schist and gneiss, but on its eastern flank near its northern end is an old limestone quarry (Enos Bernard's), in which the strike is very nearly north and south and the dip west, but whether 30° or 80° could not be decided, as the quarry has long been abandoned and but one mass of rock was well exposed. Within 150 feet west of the limestone Cambrian sandstone outcrops in abundance, but it is not exposed sufficiently to measure. The summit of this hill commands an excellent view of most of the valley. Across this hill the Downingtown diabase dyke strikes nearly southwest.

Looking southeast toward the Guest quarry, a mile and a quarter distant, there is a marked depression in the hills.

East of this hill is a road leading south to Chatham and north to Doe Run village. Just east of this road are five sink holes on land of Pusey Buffington and George Elvin, east-southeast of which is a hill about sixty feet in height, covered with sandstone fragments.

It seems not improbable that we have here a north and south

[82] These are from table 3, Levels above Tide, *Second Geol. Survey of Pa.*, *N*. This table, however, gives Avondale 281.6, while table 141 gives it as 227. The geater elevation is probably most nearly correct as by table 141 Chadds Ford Junction is given as 129, but by table 41, 175. My own observation by barometer from West Chester as datum gave 170.

synclinal basin of the limestone and sandstone underlaid by mica schist, then an anticlinal of the schist, the limestone eroded, but appearing at the Guest quarry overlying the southeast dipping sandstone.

West of this hill, through low and flat ground, flows the main Doe run, beyond which is the westerly hill of hard and heavily bedded garnetiferous schists and gneisses, with limestone on both flanks, no sandstone being visible. This hill is fully a quarter of a mile wide and probably 150 feet above the valley. At its southern termination, near which unite the north, west and south branches of Doe run, the strike is N. 25° E., the dip nearly 90° The rock is hard, heavy-bedded gneiss. The road from Doe run to Gum Tree crosses the hill about a half-mile to the north, the strike of the gneiss being N. 40° E., the dip probably about 60° S. E., or under the limestone, which has been quarried about 500 feet north of this road (I. H. Thompson's quarry, formerly McNeal's). The limestone dips nearly east, 50° to 70°, and is more highly crystalline than at any other of the Doe run quarries. On the west slope of the hill a hard micaceous gneiss dips N. 60° W. 30°, about 700 feet northwest of Jones' limestone quarry. This hill, therefore, appears to be an anticlinal underlying the limestone, but exposing no sandstone. On the same flank of the hill as Thompson's, but a half-mile north, is the quarry of Ellis Woods,[83] where the limestone dips S. 80° E. 85°, bounded westward by the same garnetiferous schist, dipping N. 60° W. ± 35°, which appears also in fragments on all sides. The limestone is exposed on a northwest and southeast road, .25 mile northwest of Woods', dipping N. 65° W. 35°.

Crossing this anticlinal ridge westward, we descend into the western and most uninterrupted branch of the valley, drained in its northern part by a branch of Buck run and by the north branch of Doe run, and in its southern by the south branch. The northwesternmost quarry is that of William C. Jones, .1 mile south of the Doe Run-Gum Tree road. The limestone is much plicated and rolled with mica schist interbedded at the northern end. Dip at the northeast part, S. 30° E. 35°; north end, ± S. 20°; south side, S. 10° E. 20°. About a quarter of a mile south of Jones are quarries of Cyrus Hoopes, in plicated limestone like that of

[83] Hayes' quarry, C[4], p. 70, but not Hayes' quarry, p. 309.

Jones' quarry, dipping S. 10° W. 10°. A little west of south of these, 1.5 miles, the intervening space occupied first by the westerly affluents of Doe run and then by the southerly branch, and almost at the head of the latter, is a very large quarry on the farm of Walter Darlington, formerly Edwin Chandler, and being almost certainly that mentioned by Rogers as Baker's quarry.[84] Here the limestone is nearly horizontal, with a quartzose mica schist overlying it, in some places twelve to fifteen feet thick; some pieces of the schist resemble somewhat the schists adjacent to the Cambrian sandstone, but most of it does not; its dip is likewise nearly 0°. This schist is well exposed in the cut of the railroad immediately southeast, where it does not at all resemble that close to the sandstone. East of it is a narrow outcrop of coarser mica schist, then the diabase of the Downingtown dyke.

There seems no great difficulty in regarding these westerly outcrops as the westerly leg of an anticlinal overlying the mica schist, and this would bring them into accord with the easterly outcrops. There are, however, two objections:

1. The sandstone is in great quantity at the easterly outcrops and is not found in the western.

2. The observed dips in the mica schist are steep, those in the limestone gentle.

On the map in C^4 the limestone is made continuous from Guest's to and including all the Doe run quarries, and to and including Logan's quarry west of Unionville. Fully three-fourths of this area show the underlying rock to be gneiss, schists or sandstone; the schists and gneisses forming high hills with abundant exposures, and there seems no reason to suppose that limestone underlies more than a fraction of the remaining one-fourth.

West of the Doe run valley there are no outcrops of limestone, and indeed, except within a mile or two, very few of any kind, and those of mica schist and gneiss; but in the southwest part of Highland township, on the limestone road, are two outcrops of limonite iron ore, in former years extensively mined. They are respectively .3 and .9 of a mile nearly south of the Fairview public school. About half a mile south-southeast of the southerly iron ore outcrop, on the farm of John H. Esbenshade, about a mile nearly east of Cochranville on the road to Gum Tree, is a sink

[84] *First Geol. Survey of Pa.*, I, 230. Quoted C^4, p. 72.

hole about 50 x 100 feet, and four or five feet deep in the centre. It seems not improbable that limestone underlies the schists in this vicinity.

V. Huntingdon Valley.

The fifth, the limestone of Huntingdon Valley, is the most concealed and probably the most limited in extent, but one of the most interesting geologically, for as shown by Mr. Hall[85] it is a very strong argument in favor of the paleozoic age of the Philadelphia schists and gneisses.

Huntingdon Valley is a straight narrow valley on the southeast side of the ancient gneiss of Buck Ridge. It is crossed by the Pennypack creek and drained by Paul's brook flowing east, and Huntingdon creek west, into the Pennypack. The valley proper extends in a straight line N. 70° E. for about four miles, but it may be traced further east less distinctly. East of the Pennypack creek the Cambrian sandstone intervenes between the limestone and the ancient gneiss, increasing in prominence eastwardly. West of the Pennypack, while there are indications of it in the same relation, they are not beyond doubt. The limestone itself is very obscure. It has been reported in wells and in pits dug for iron ore and by Mr. Hall[86] in the bed of Paul's brook, but the only place I have seen it is in the cellar of an old mill, now a wagonhouse on the property of Mr. Penrose Hallowell, who informed me that many years ago there was a quarry in the limestone west of the wagonhouse. He pointed out a quarry of sandstone about 500 feet northwest from the limestone, not wrought for years. The rock in this quarry resembles the Cambrian sandstone, but it is coarser, more feldspathic, and not as well defined as at Waverly Heights, but in walls of the vicinity were slabs of the typical sandstone said to have come from this quarry. The sandstone apparently dips southeast, steeply, the limestone 60° southeast, and the spangled mica schist, well exposed 1000 feet southeast, S. 30° E. 60°, followed by the wood-like garnetiferous schist, nearly vertical.

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[85] C^6, p. 62.

[86] C^6, p. 67.

VI. The Limestone of Pocopsin Township, of Logan's Quarry and of Elisha Bailey's Quarry.

The first of these outcrops, perhaps, should not be grouped with the last two, the only ground for the grouping being their geographical position. Indeed, the first is in geological position nearer that of Huntingdon Valley, lying as it does about half a mile south of the ancient gneiss near the extreme western outcrop of the latter. It is in a small valley about .3 mile south of the State road, and about the same distance west of the road leading south from Pocopsin Inn to the Red Lion. It has not been wrought for nearly fifty years and now shows nothing but a hollow filled with water from a large spring. There is, however, besides tradition, a quantity of limestone fragments, and a little to the northeast a large sink hole. The limestone is granular and crystalline. It was wrought by James Gawthorp, and is now on the farm of L. M. Larkin. It appears to be surrounded by the schists, but no good exposures were seen. About 500 feet north of it is an outcrop of talc schist.

Four miles nearly due west of this quarry and 1.75 miles N. 70° W. of Unionville is the quarry of Eli Logan. This is still in operation. The dip, omitting one remarkable fold or roll, is quite regular, S. 35° to 50° E. 30° to 50°. On the Doe run road, immediately south of the quarry, garnetiferous mica schists dip S. 40° to 50° E. 40° to 50°. About .1 mile west of the quarry, mica schists dip S. 55° E. 70°, and about 300 feet further west Cambrian sandstone S. 75° E. 30°; this is close to the township line between East and West Marlborough. A little west of the line a road goes south to Upland (Marlborough Inn). On this road the sandstone is well exposed in two outcrops about 150 feet apart, with mica schists above, between and below the sandstone, all dipping about S. 40° E. 30°.

A remarkable feature of Logan's quarry, unique in the limestone quarries of this region, is the occurrence of a massive rock chiefly of plagioclase feldspar with some quartz, exceedingly tough and hard, containing much tourmaline. This has much the aspect of a sheet of igneous rock. It was observed by Rogers, who supposed it to overlie the limestone and to be possibly "a highly altered form of the upper primal slates." It seems to have escaped the notice of the Second Survey. Quarrying, since the date of Rogers' notes, has shown clearly that it is a sheet or vein, apparently parallel with the dip of the limestone.

S. 50° W., 1.1 miles from Logan's quarry, is that of Eli S. Bailey, a half mile or less west of Upland.

This quarry, when in active operation thirty or forty years ago, was a famous locality for tremolite, which was found in larger quantity and in better specimens than elsewhere in the State, but almost nothing is showing now. The dip is probably southeast. The strike of the sandstone west and southwest of Logan's would bring it west and northwest of this quarry. It is not exposed nearer than the road north to Upland, but southeast dipping mica schists with considerable quartzite appear to the westward, on the State road.

VII. The Street Road Limestone.

The seventh group comprises a series of outcrops (on nearly all of which quarries have been opened) extending in a line about S. 70° W., somewhat curved to the north at the eastern end, and having a total length of thirteen miles. The easternmost exposure is about a quarter of a mile nearly due north of the south corner of Thornbury township, Chester county. It is in very sandy limestone, dipping S. 40° E. 50°. No other fast rock is exposed, but schist fragments are abundant, especially to the southeast. About .25 mile south a schist dips S. 30° E. 30°. A half-mile nearly east and about the same distance southeast typical Cambrian sandstone outcrops abundantly, dipping at the former N. 35° W. 80°, and a little further east S. ± 40° E. 20°, with schists above and below, dipping from 0° to 60° S. E.

The second outcrop is in Birmingham township, Chester county, about a mile and a quarter S. 35° W. of the first, on a small stream which empties into the Brandywine just above Brinton's Bridge. Evidently much rock has been removed, but the quarry is filled with water and mud. Southwest of it a trench was dug for drainage, showing a hard quartz schist, with the unusual dip of N. 60° E. 20° under the limestone. I could see no reason to doubt this dip.

The third, about .75 mile S. 70° W. from the second, is on the right bank of the Brandywine at Brinton's Bridge, about a mile above Chadd's Ford, at Harvey's quarry. Here the limestone and adjacent rocks are well exposed. The latter are schists and gneisses, dipping S. 10° to 40° E. 25° to 70°. The limestone dips about S. 20° E. 45° under a hard quartzose mica schist, with quartz in serpentine forms, like those seen in the Manayunk schists. The schist as well as the limestone is plicated, one stratum making two 90° bends within a few inches. Under the limestone is a similar schist, less quartzose and finer grained, dipping S. 25° E. 25°.

It is very rare in this region to find a section as good as that afforded by the Brandywine. It is unfortunate that it does not show the structure more clearly. Prof. Lesley examined it and thought the limestone a tongued anticlinal.[87] While this may be the fact, I incline to the opinion that it is interbedded in the gneiss. The limestone of this quarry contains chondrodite, the only occurrence of this mineral in the region so far as I am aware. Dr. Frazer classed this limestone and that of Honeybrook township as Huronian or perhaps Laurentian.[88]

It is not certain whether these outcrops belong strictly to the Street road line about to be described, or to those in the valley to the south followed by the Baltimore Central Railroad, or one or more to each, or whether they constitute an isolated line. When we possess a good topographical map of the region it may be possible to determine.

About 1.25 miles north of Harvey's quarry the Brandywine is crossed by the Street road, which occupies an almost continuous nearly straight depression about S. 60° W. from a mile northeast of the southeast corner of Westtown township nearly ten miles to the Red Lion, in East Marlborough. It then bears about S. 80° W. to a point beyond White Clay creek and then about southwest through Oxford. In its vicinity is the line of quarries well described by Rogers under the title "Street Road Limestone Line."[89]

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[87] *Proc. A. P. S.*, Vol. VIII, p. 282; also C^4, p. 239, where a drawing is given.

[88] "Calcaire Huronien. Il parait y avoir des examples isolés de calcaires intercalés dans les gneiss et les mica-schistes, un de ces examples se recontre dans le township de Honey Brook comté de Chester, et un autre se trouve sur la Brandywine a une courte distance de Chad's Ford. Dans ce dernier cas il est possible en réalité que le gîte de calcaire appartienne au Laurentian, dont une des bandes étroites passe ici dans l'aire du Huronien." *Memoir sur la géologie de la partie sud-est de la Pennsylvanie.* Lille, 1882.

[89] *First Geol. Survey of Pa.*, I, p. 226. Quoted C^4, p. 74.

For nearly its whole extent, east of Pocopsin creek, the Street road passes through mica schists, but after passing the creek and Parkerville the schists become very sandy, and near the Red Lion there is abundance of the typical sandstone with mica schists apparently on both sides of it, the dips being to the southeast and moderate. An exposure on the Street road near the schoolhouse .2 mile west of Red Lion, quite satisfactory, gave sandstone S. 25° to 27° E. 15° to 50°, with mica schist underlying within twenty feet S. 20° E. 25°. From this point a narrow straight valley trends nearly southwest. A mile and a quarter west of Red Lion, and .1 mile south of the Street road, is a quarry on the land of Barclay Cope, formerly Reynolds' quarry, then on the farm of Jacob Way.[90] The quarry is now full of water, no rock being visible. .75 miles west of this is Taggart's cross-roads, Willowdale P. O.; .75 mile west of this, on the farm of William Scarlett, formerly John Baily's, were, as I am informed, several sink holes, now filled up and farmed over. In the Street road, just north of this, the sandstone dips S. 5° E. 15° to 20° very clearly. Close west of the road which bounds this farm on the west are the quarries of Joseph H. Taylor, followed S. 50° W. from it by quarries of Henry Pusey, one north, the other south of an east-and-west road, at distances respectively of .3 and .6 mile from Taylor's. These quarries are in operation.

At Taylor's there are two quarries. The eastern, recently abandoned, shows clearly a mica schist containing tourmaline, dipping S. 30° E. 30° immediately southeast of the limestone. The westerly quarry is very close to the former and shows a highly crystalline limestone full of cavities, some water-worn, others not, with occasional quartz crystals in the cavities. From the upper portion the cementing material of the crystalline grains has been removed, leaving a lime sand which is utilized. The dip is southeast, probably less than 10°; overlying is the mica schist, much plicated, with a stratum about eighteen inches wide of the typical sandstone, with its rhomboidal jointings, micaceous partings, and stretched tourmalines; apparently the same rock that is dipping toward the limestone, about a half-mile to the northwest.

Within 500 feet southeast of the Taylor quarries is a mica schist, dipping S. 50° E. 50°, but including a sharply folded mass of the schist, and a convoluted mass of hard biotite gneiss.

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[90] C^4, p. 319.

Three-tenths of a mile S. 50° W. from the Taylor quarries is an old and large quarry on the farm of Henry Pusey[91] still wrought. On its southeast side the limestone dips S. 25° E. 50° under mica schists, in the northeast corner N. 25° W. 15°. Near the northwest corner sandy mica schist containing tourmaline appears next to the limestone for about twenty feet, and then a hard quartzose stratum of which very little is exposed, N. 35° W 70°.

Three-tenths of a mile S. 50° W. is the other Pusey quarry. Here the walls are not visible, nor the southeast part of the limestone, but on the northwest side the dip is N. 30° W. 10° to 15°. A peculiarity in this quarry is that the rock is partly blue and partly pure white, both very compact, but the change from one to the other occurs, not in what appear at first sight to be the lines of stratification, but at the joint planes nearly at right angles, which would seem therefore to indicate bedding planes.

Regarding the Taylor quarry and the northerly Pusey quarry, close together as they are, the presence of the sandstone in the former and its apparent total absence in the latter is remarkable. The exposure in the Pusey quarry is unusually good, especially the northwesterly wall, while in the Taylor quarries the southeasterly is best shown. If the dips at Pusey's are trustworthy we have the summit of an anticlinal, but the curves in the adjacent mica schist suggest caution. Dr. Frazer gives the dip (probably about 1879) as N. 30° W. 60° on the south face,[92] while our observations on the north side agree within 5°.

About half a mile west is the West Marlborough township line, and about .1 mile west of it a quarry of considerable size on the farm of Chalkley Bartram, formerly Eli Thompson, showing now nothing of interest. The next farm is that of Edward S. Marshall, on which there was a considerable quarry. Here sandstone fragments are abundant. The westerly boundary of this farm is the road leading south from Marlborough Inn (Upland) to Toughkenamon, being also at this point the west line of the tongue of West Marlborough, which projects southward. About a mile north of the limestone here, the sandstone is very well shown in large quantity, being the most extensive outcrop south of the North

[91] C^4, p. 312.
[92] C^4, p. 312.

Valley Hill. Its best exposure is on the road from London Grove Post-office to Chatham, at distances of .25 and .5 mile southeast of London Grove, the former a quarry in the typical rock, overlaid by sandy mica schist, both dipping S. 35° E. 30°, the latter exposures on the road showing the sandstone underlaid by mica schist, S. 25° E. 30° to 60°.

On the west side of the road from Upland to Toughkenamon, about .2 mile north of the north line of New Garden township, is a limestone quarry on the farm of Joseph Sharpless, formerly Ephraim Wilson, and another a little further west on that of Benjamin Swayne. The latter shows a dip of S. 35° E. 15° to 40°.

About a mile west-southwest of Swayne's is a quarry on the farm of Francis W. Hicks, formerly Elias Hicks, and a mile further in the same direction a very extensive one on the farm of Aaron Baker, known as Baker's, subsequently as the Acme quarry, and more recently wrought by the Avondale Marble Company. Originally this quarry was wrought for lime for building and agricultural purposes, but the decline of this industry impelled the owners to put down diamond drill holes. The cores obtained showed a good quality of marble. A large plant was erected and now for some years excellent building marble has been obtained in large blocks. The inferior grades are readily split, with little waste, into rectangular blocks, which find a market. The marble at the north end of the present excavation is about seventy feet below the surface, and it dips nearly S. about 20°. Overlying it is a mica schist of great compactness which was quarried out in large blocks and is used for retaining walls, foundations, etc.

The limestone of this quarry shows plications, but there is evidently a gentle southerly dip throughout, except near the south end where the limestone dips N. 25° W. 25° and abuts against mica schist, dipping S. 40° E. 45°, the contact (a thrust fault ?) being well shown in the railroad cut, nearly under the office.

Near the middle of the west side of the quarry is a stratum of limestone containing much tremolite, phlogopite and quartz, minutely disseminated, forming a very hard rock, sold as "granite," and apparently in demand.

A short distance south of the marble quarry, on the Jacobs farm, close to Baker Station, schistose gneiss, some of it with feldspar porphyritically enclosed, dips S. 35° to 40° E. 50° to 55°.

A little over a mile, a little south of west of the Acme quarry, is one of large size, but abandoned for years. This is the Levis Bernard quarry, with a dip of S. 62° E. 20° in the most regular portion, but the limestone is much plicated. This is the most western quarry in this line and is that mentioned by Rogers as the most westerly quarry.[93]

South of the Street road line at its westerly end, that is south of the Benjamin Swayne, Elias Hicks, Avondale Marble and L. Bernard quarries, there are several outcrops of limestone which will be discussed after the consideration of the next belt to the south.

VIII. The Kennett Limestone.

At about two miles south of the Street road line there is, west of the Brandywine but not far east of it, a valley even better defined than that of the Street road. This has been taken advantage of by the Baltimore Central Railroad, which, descending rapidly from Brandywine Summit to the Brandywine[94] (from 273 above tide to 129 above tide in three miles), crosses the watersheds between that stream and the branches of Red Clay and the east branch of White Clay creek, with a rise of but 183 feet, while the hills to the north and south are from 50 feet to probably 175 feet higher. At intervals in the bottom of this valley outcrops of limestone appear. The easternmost exposure is at Mendenhall's quarry, in Pennsbury township, about 1.2 miles west of the Brandywine. At the quarry almost nothing is now visible, but one apparently clear dip in the limestone was S. 60° E. 20° About .2 mile east of this, hence over it, was a coarse mica schist with much mica in distinct cleavages, with pegmatite and porphyritic feldspar and quartz, dipping S. 25° E. 20°. Westward there are no exposures near.

About two miles from the Brandywine is Fairville Station. A half-mile north-northwest of it is a quarry in hard schistose gneiss, dipping nearly S. ± 40°, and about the same distance, west by south, in a cut of the railroad, S. 20° to 40° E. 60° to 80°, while to the south of the railroad are large quarries of feldspar in a coarse pegmatite.

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[93] *First Geol. Survey of Pa.*, I, p. 227. Quoted C^4, p. 75.

[94] These are from table 141, "Levels above Tide," N., p. 158, but by my observations by barometer are about 50′ too low.

About three miles west of the Mendenhall quarry, and about 1.25 miles nearly east of Kennett Square, is the Sharpless quarry. The greater part of this quarry, which has yielded a large amount of limestone, is under water, so that a measurement could be had at one point only, giving E. 10°; .3 mile northwest, a sandy feldspathic mica schist dips S. 25° E. 25°, while a half-mile northeast there is a decomposed very sandy schist, with feldspathic and quartzite layers and rhombic fracture very closely resembling the typical Cambrian sandstone, dipping S. 10° W. 30° or toward the limestone. From this vicinity westward the same sandstone appears to bound the valley on the north wherever the rock is well exposed as far as West Grove,[95] except for a short distance near Avondale where a gneissoid mica schist, containing garnets and tourmaline, forms the north hill, known in a large part of its course as the Toughkenamon hill. This rock seems to underlie the sandy schist and to form the greater part of this hill. It is fire-resisting and has been much used for lining limekilns and is called, locally, firestone.

The southerly hill, for about four miles at least, contains a very hard compact hornblende gneiss with nearly vertical dips, not improbably an altered intrusive rock. Near it are indications of mica schist, but no clear outcrops, the hornblende rock being the chief rock visible, but, except southeast of Kennett Square, it appears in large loose masses only.

One mile west of Kennett Square Station, and just east of the western line of New London township, close to the right bank of the west branch of Red Clay creek, is Joseph A. McFarlan's quarry. This is of large size and is wrought at present in a small way for building stone. A spring of considerable volume rises in the quarry. The rock is a pale blue and white limestone, very compact. Two dips about 600 feet apart were S. 20°. North of the quarry are no exposures, to the south ± 700 feet there is a hill of some fifty feet in height of mica schist and schistose gneiss, striking north to N. 30° E. and dipping about 70° W. to N. 60° W., or toward the limestone.

Half a mile a little north of west of McFarlan's quarry was one on the west branch of Red Clay creek, north of the railroad.

[95] That is, if the valley in which is West Grove be the continuation of that under consideration. This will be further discussed.

It is wholly overgrown. A quarter of a mile nearly west of this is a quarry on the State road, showing a jointed very sandy mica schist, dipping S. 33° E. 35°. This is .2 mile northeast of Toughkenamon Station. On the Newark road, about .2 mile north of Toughkenamon, similar schists are exposed near the schoolhouse, dipping nearly 0° at the north part of the exposure then steep northerly, while toward the south they dip ± 70° ± S. 45° E.

About .6 mile, a little south of west of Toughkenamon, was the Roberts' limestone quarry, now of Mr. Sharpless. The dip in this is S. 33° E. 35°.

Three-quarters of a mile west of this quarry is Avondale, and the apparent ending topographically of the valley which we have followed from the Brandywine. Here the high northern hill is cut by White Clay creek, of which the two northerly branches, one flowing nearly south, the other southeast, unite in this gap.

Nearly in line with the quarries mentioned and about two hundred yards south-southwest of Avondale Station is a quarry, now full of water, but with the limestone walls still in evidence. This quarry is the most interesting of the region if, as seems probable, it is that in which Dr. Frazer found, adjoining the limestone, the sandstone containing *Scolithus.*[96]

This is the westernmost quarry certainly of this series. A little more than a mile to the north is the Street road line of quarries; hence the two are closer than at the Brandywine. Between the two and to the westward are a number of limestone outcrops briefly referred to before, but worthy of detailed description. They, and the western part of the Street road line and the Watson & Jones' quarry, are within a parallelogram less than two miles from north to south and three miles from east to west, with Avondale in the southeast and West Grove in the southwest corner. From Avondale radiate three prominent hills of mica schist and gneiss:

1. Eastward the Toughkenamon hill, practically continuous to the Brandywine.

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[96] C^4, p. 333 and p. 324. The quarry is on the land of Watson & Jones, but is not far from the John Williamson property, and is on the road leading south. At present no sandstone is visible. The limestone dips nearly west about 30°. Northeast of it and within 30′ is a hard gneiss dipping with and under the limestone. Dr. Frazer's dips for the sandstone were "W. 20° N., W. 10° N. to W. 10° S. with a dip of about 28°," and for the limestone "W. 10° N. 40°."

2. Westward a hill of mica schist, gneiss and pegmatite convex to the north, bounded northward by the westerly branch of the east branch of White Clay creek.

3. Northwestward the hill on which much of Avondale is built, and along which the Gap and Newport pike runs.

The eastern line of the parallelogram is nearly the eastern line of New London township, and is occupied by the rather flat nearly north-and-south valley of the northerly branch of the east branch of White Clay creek. In this valley, and near the creek, are outcrops seemingly connecting the Street road and Kennett series. To the north is the Benjamin Swayne quarry of the Street road series, S. 35° E. 15° to 40°, and half a mile south of it, on the bank of the creek, an outcrop S. 50° E. 30°, the former just north of the northwest corner of New Garden township. A quarter of a mile further south is the quarry of Joseph Quarll, in which the limestone dips nearly S. ± 15° on the south side, nearly 0° on the north side, and N. ± 10° on the west side; no adjacent rock is visible. A half-mile south-southeast are three quarries close together, the northerly one wrought chiefly for a lime sand, or highly crystalline limestone or marble altered by partial decomposition, by which the cohesion of the grains has been destroyed. This sand is used largely by florists for propagating purposes, and is said to be superior for that use. Some of the limestone under the sand is highly crystalline and pure white, a true marble. It is wrought by Michael Murphy. The dip is about S. 20° E. 20° About 200 feet south of this is Watson's quarry, a very impure limestone in large solid blocks, used, I was informed, for building purposes, and not for lime. The only exposures are on the south side, due S. 40° and S. 20° E. 25°, S. 65° E. 10°. As before, high hills, apparently wholly of mica schist and gneiss, are to the east and west. Seven-tenths mile south-southeast of this, mica schist and gneiss dipping S. 30° E. 15° to 50° intervening, we have the limestone of the quarry on property of Watson & Jones, seemingly of the Kennett series, already mentioned. As already stated, all these six outcrops are in a line almost due north and south, and within the space of a little over one mile.

To the westward and near the north line of our parallelogram are the quarries, already described, of the Avondale Marble Co.

and of Reuben Barnard. South of the latter is a high hill of garnetiferous mica schist, south of which are two quarries, both known as Storey's, one on each side of the road leading north from West Grove to Barnard's quarry. They lie in a small east-and-west valley on an affluent of the west branch of the East Branch of White Clay creek. The eastern is quite small; it shows a dip of N. 45° W. 65°. The western, though larger, is but a small quarry compared with most of those of the region; it shows, however, a distinct anticlinal structure, dipping on the southeast side S. 30° E. 30°, at the west end about the same, and on the northwest side N. 60° W. 65° within twenty feet of the moderate southeast dip, the intervening space being concealed by talus.

On the northerly side a small spring issues from the limestone, the water bearing with it at the time of my visits a continuous stream of lime sand.

North of the Storey quarries and separating them from the Barnard quarry, the westernmost of the Street road line, is the hill of mica schist above mentioned, somewhat garnetiferous, on the north slope of which, near the foot, is an insignificant outcrop of the sandstone, loose fragments only, but apparently in place. The mica schist is decomposed at the surface, and I was unable to find any satisfactory dips. Dr. Frazer, however, writes of this hill as one "in which the chloritic mica schists lie almost flat, or with very small angles of dip. These schists seem to be similar to those in and below the South Valley Hill. . . . . Without some change of structure which surface indications offer no right to suppose, there is here a limestone synclinal holding a hill of chloritic mica schists.

"On the south side of the West Grove quarry[97] the dip is S. 30° E. 30°, showing that it has been opened on an anticlinal which is, however, of very insignificant breadth as the sand rock (Potsdam) curves in a few hundred yards below it with a dip of W. 10° N., raising the calcareous beds beyond our present surface."[98]

It is much to be regretted that the outcrops here are so few and poor. Dr. Frazer's interpretation may be correct, but the small outcrop of the sandstone on the Chatham road southeast of Lewis Barnard's quarry and the gentle southeast dipping outcrops to the

[97] Probably the westerly Storey quarry.
[98] C^4, p. 332.

southeast of the Storey quarry are difficulties. The decomposing garnetiferous mica schists of the hill between Barnard's and Storey's do not appear to me to resemble in the slightest degree the hydromica schists of the South Valley Hill, but more to resemble the mica schists lying to the southward of the hydromica, and clearly overlying the limestone of the Poorhouse quarry and of the quarries on the right bank of the East Branch of White Clay creek. The westerly Storey quarry certainly exhibits an anticlinal structure, as Dr. Frazer observes, "of insignificant breadth." The dip of the sandstone W. 10° N. I did not observe. About .3 mile southeast of the quarry there is a quarry in the sandstone giving an excellent exposure and a dip of S. 50° E. 20°. A quarry in similar rock but harder .25 mile to the eastward dips S. 35° E. 30°. The sandstone forms a hill about a hundred feet in height between the Storey quarries and the very extensive quarries of the Avondale Lime and Stone Co., formerly Hughes quarries, on the right bank of the East Branch of White Clay creek, about a mile west-northwest of Avondale and about a mile east of the Storey quarries. Here the limestone has a varying but very gentle southerly dip, probably averaging S. 10° to 20°, and is overlaid by garnetiferous mica schists conformably. The rock is highly crystalline with interstratified beds of mica schist. It has been wrought to a depth of over one hundred feet.

Although the limestone of this quarry seems to have throughout a regular very gentle southerly dip, evidence of peculiar folding is seen, as shown in the annexed photograph taken by Mr. George Vaux, Jr., a view of a small part of the south wall of the quarry. Here, although the stratum has nearly horizontal surfaces on this section, there is a complete fold within the stratum which was about three feet in width.

In this quarry is a stratum which contains masses of quartz of lenticular form, as if flattened pebbles. These have a coating of damourite, and have sharply defined parallel partings, also coated with damourite. A variety of this quartz was uncovered in 1897, partially filling what had evidently been a crevice dipping southwardly about 45°. The aspect of the quartz was exactly as if it had been a viscid substance like asphalt, flowing over an edge down a slope, forming masses like flattened stalactites, joined at the top only. They were a foot and less in length, about a half-inch thick at the thickest part, and from an inch to three or four inches wide, all tapering downwards. All had a thin coating of damourite except at the top.

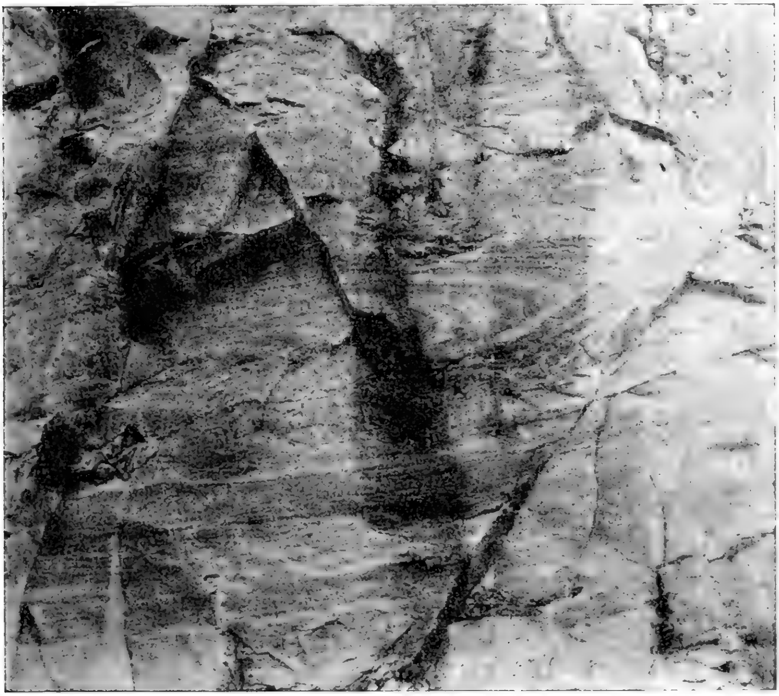

FIG. 2.—Fold in Limestone Quarry, one mile W. N. W. of Avondale.

On both sides of the Hughes quarries are outcrops of coarse pegmatite, that to the eastward being in contact with the limestone striking nearly northeast and southwest ; just north of it schists dip S. 40° E. 63° ; that to the westward is less than .1 mile distant from the westernmost quarry, and strikes N. 30° E. The northerly hill, which the Gap and Newport pike ascends northwest from Avondale, is of garnetiferous mica schist, in part at least. Southwest of this on this line no sandstone has been observed, but the valley continues.

Prof. Rogers construed these limestones as forks of the Street road line, seeing it divide westward into " three subordinate narrower valleys, all of them containing limestone more or less continuously, and all of them ending westward in the vicinity of West Grove Friends' Meeting-house."[99]

While this may be the structure, including in the northerly subordinate valley the marble quarry and Barnard's, in the middle Quarll's and Storey's, and in the southerly the Avondale Lime and Stone Co.'s, it cannot include the quarries south of Quarll's. Moreover, as we have north of the Street road line a wide and persistent outcrop of the Cambrian sandstone, we should find more of it to the south than the small outcrops south of Barnard's and southeast of the Storey quarries.

IX. The Limestone of Nevins' Quarries.

The southern portion of New Garden township, Chester county, is a triangle, bounded eastwardly by the curved portion of Mason and Dixon's line (twelve miles from New Castle as a centre). Here and to the westward, in London Britain township, we find the most southerly Chester county outcrops of limestone, ranging in a general east-northeast and west-southwest direction in Broad Valley drained by Broad run, an affluent of White Clay creek. There are four quarries in Pennsylvania and one in Delaware. The latter is Jackson's quarry, near Hockessin Station on the Delaware & Western Railroad, near extensive kaolin mines. It is a highly crystalline limestone, but now shows nothing of the adjacent rocks.[100]

East-northeast of this limestone, among the schists and gneisses of southwestern Delaware county, in Birmingham township, is a single outcrop of limestone mentioned by Mr. Hall,[101] though represented on his map as serpentine. It was known as Bullock's quarry and, as I am informed by Mr. T. E. Bullock, was wrought by his grandfather, Thomas H. Bullock, fifty or sixty years ago and burned into lime on the spot. Kaolin was afterwards mined close to it and the outcrop obliterated. It is one mile west-northwest of Elam, about two miles from the Brandywine and one and

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[99] *First Geol. Survey*, I, p. 226. Quoted C^4, p. 74.

[100] "The magnesian marble which outcrops . . . . at Nevin's runs into Delaware, and appears at the surface in the Jackson quarry at Hockessin. Here the rock forms a clearly defined anticlinal fold; . . . . the limestone is overlaid by the mica schists." F. D. Chester, *Proc. Acad. Nat. Sci.*, 1884, p. 248.

[101] C^5, p. 47.

three-quarters from the Delaware line. It does not fall in line with any of the nearby outcrops, being south of the Kennett line and of the outcrops near Brinton's bridge. About two miles nearly west of Jackson's quarry, near Broad Run Station, is the quarry of David M. Brown, with a dip S. 60° E. 25°, with some gentle waves.

About a mile and a half west of the Brown quarry limestone outcrops in the road, and a little west of this, east of the East Branch of White Clay creek, an affluent of the Christiana, is the David Nevin's quarry, or Septimus Nevin's, showing a dip on the south and west sides quite regular S. 25° E. 25°, while on the northwest side the exposure was poor, but dip apparently nearly 0° to 10° S. E.

Of this quarry Prof. Rogers wrote as follows, these quarries then being in active operation: "D. Nevin's quarry, on the east side of the East Branch of White Clay creek. The strata dip at a gentle angle southeastward, and a low anticlinal undulation, or saddle, lifts the talcose slates underlying the limestone to the bed of the quarry. . . . . The limestone is overlaid by the ordinary very micaceous rock dipping on the south side of the quarry gently south, and there is a dyke of granite at the south margin."[102]

West-southwest of David Nevin's is one of Edward Sharpless, now showing no good exposures, and in the same direction about three-quarters of a mile from the former are two closely adjacent quarries of John Nevin; of these the easterly gives excellent exposures. On the northwest side the dip is N. 50° W. 25° with mica schist and gneiss overlying apparently conformably, on the southeast side S. 50° E. 10°, on the northwest side at the northeast end N. 60° W. 40°, becoming more gentle toward the middle to 0°, then débris conceals the following probably southeast dip.[103]

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[102] *Geol. Survey of Pa.*, Vol. I, p. 225.

[103] Of this quarry Prof. Rogers wrote: "An anticlinal axis runs through the quarry about N. 60° E. On the north side of this saddle the dip is about 45° under a micaceous gneissic-looking rock. The dip on the south side is to the south about 30°." Vol. I, p. 225.

Of one of the quarries, but which one is not clear, Dr. Frazer writes: "At Nevin's quarry the limestone dips W. 10° N. 10° to 20° in the middle portion of the quarry and steep at the extremities, which, compared with the southeasterly dip of the quarries in New Garden and just within the northeast border of London Britain (which latter is ± S. ± 20)" (probably the David Nevin's quarry—T. D. R.) "compel one to regard the structure here as an anticlinal of limestone though one of very gentle dips. . . . A

I was able to find no rock closely adjacent to the limestone on the southeast side; on the northwest the rock clearly is not the sandstone, but mica schist and gneiss. One dip on the Delaware & Western Railroad (or Wilmington & Landenberg Railroad), nearly a mile west of the Brown quarry and .2 mile northwest of limestone exposed near the Nevin's quarries, was S. 60° E. 30° to 60° in decomposing mica schists.

About three miles nearly south of the Nevin's quarries and near Peach's kaolin mines, in New Castle county, Del., is a series of large quarries, known as Eastburn's, on the easterly slope of a hill, two on the east and two on the west of the road to Newark, Del. Unlike the Chester county outcrops, these four quarries are nearly on the line of dip; two of them are quite extensive. The limestone is much plicated. Overlying the southeast quarry on the southeast side are fragments of mica schist and pegmatite. The north wall of this quarry is a mica schist dipping N. 65° W. 65°, but northwest of this and within 200 feet is the next quarry with limestone dipping S. 40° to 50° E. 20°, with no rock exposed except the limestone and schist fragments. No sandstone was observed, except in indistinct fragments, one of which contained rutile.

X. Outcrops in Northern Chester County.

In northwestern Chester county we have successive outcrops of the sandstone with adjacent beds of limestone, most of them very clear, but one obscure and with resemblance to those south of the valley. In the north is the great sandstone outcrop of the Welsh mountain, with the Lancaster Valley limestone northwest of it. Going southward the limestone does not appear south of the sandstone, but a very hard gneiss, like the ancient gneiss, with dykes of igneous rock. South of this is a valley with limestone near the southerly edge of Honeybrook township, followed by the prominent

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mass of quartz sand rock and quartzite fragments underlies this limestone to the southeast coming in from the State of Delaware." C^4, p. 327.

Dr. Frazer does not explain how this is possible in view of the anticlinal structure and gentle southerly dips on the southerly side. On the map in C^4 an area of sandstone (Potsdam) is shown nearly surrounding these outcrops. Prof. Chester, however, states that in the northwest part of Delaware a coarse quartzose rock underlies highly crystalline magnesian marble which must be referred to Potsdam and Calciferous. F. D. Chester, *Proc. Acad. Nat. Sci.*, 1884, p. 239.

Baron ridge of the sandstone, extending unbroken from Lancaster county to a point east of the East Branch of the Brandywine in Wallace township. South of this, in the western part of West Caln township, is the easterly end of the limestone of the Pequea Valley. South of it is another prominent ridge of sandstone, probably connected with that of the Baron ridge close to the Lancaster border, but giving place to gneiss in the valley of Birch run. This ridge of sandstone, much smaller than that of the Baron ridge, reaches but apparently does not cross the West Branch of the Brandywine north of Wagontown, its easternmost outcrop being on the Brubaker farm just north of a steatite outcrop, an old Indian quarry. South of this is gneiss and then the sandstone of the North Valley Hill. The sandstone, as usual, forms high nearly straight ridges. Gneiss appears in the intermediate valleys. Possibly there is limestone in these valleys, for that in the valley in the south part of Honeybrook was exposed in one quarry only, and is now invisible.

There are outcrops of limestone in Chester county east of the Brandywine, but none of any magnitude. Thirty to fifty years ago when lime was in demand for farming purposes, it was the custom of farmers near limestone outcrops to have kilns of their own. Wood was abundant, and in winter labor also. By this means every outcrop was quarried, the hauling being one of the most serious items of expense. All this being changed the quarries have been abandoned, filled up and grown over and even forgotten by the present generation. While this is true of outcrops in many parts of Chester county, it is particularly true of those in the section now under consideration, the outcrops having been mostly in low ground and small in size. Nothing, therefore, can be added to Prof. Rogers' descriptions, made when most of the outcrops were wrought. He describes ten in Charlestown, East Pikeland, West Pikeland, East (West ?) Vincent, South Coventry, Nantmeal, Warwick and Uwchlan townships.[104]

In discussing the relation of these rocks it may be useful, first, to sum up the facts that seem to be beyond question:

(1) The peculiar sandstone is below the limestone of the Chester Valley.

(2) Mica schists occur between the two.

[104] *Geol. Survey of Pa.*, I, p. 231. Quoted C^4, p. 82.

(3) All the limestone outcrops south of the Chester Valley are among schists and gneisses which appear to cover by far the greater part of the area, the dips being almost invariably to the southeast and not steep.

(4) Some of these schists are very sandy and not infrequently include strata of the peculiar sandstone.

(5) Nearly every line of limestone outcrops has adjacent to it outcrops of the sandstone, usually on the northwest side, with mica schists usually intervening.

(6) At no locality (except one in the Doe Run Valley) do we find, with satisfactory clearness, an orderly succession of rocks, making an undoubted synclinal or anticlinal.

(7) At several of the localities south of the Chester Valley mica schists, sometimes garnetiferous, overlie the limestone conformably and clearly.

There is no lithological evidence of the identity of the limestone of the different outcrops. The variation in this rock is so great that even in the same quarry the most diverse characters may be found. The opposite, however, is true of the sandstone. It has a very peculiar and well-marked character in its rhomboidal jointings, its micaceous partings, and its stretched and broken tourmalines. While it must be admitted that lithological evidence is of little weight in determining the age of a rock, yet when the lithological character is so well defined and when, in addition, the close association with the limestone is marked, together with the fact that the outcrops are not widely separated, the evidence of identity of age is not weak. But if the sandstone is of one age, it seems difficult to believe the limestone which seems to accompany it so closely is not of the same age as that which overlies the sandstone of the North Valley Hill, unless, indeed, there is one limestone just below and another just above the sandstone with mica schists intervening. Of this the only evidence is Taylor's quarry, and that is very meagre. The sequence of rocks at nearly all the localities would be satisfied by southeast dipping sandstone overlaid by schists and they by limestone and it by schists, and this longitudinally faulted, but as the succession is at least eight times repeated such explanation is not satisfactory. Equally does a succession of anticlinals and synclinals fail, for surely we could not then have so uniform gentle southeast dips and we should have a more orderly succession.

A curious feature is the westerly ending of several of these lines in north-and-south limestone valleys—thus the Chester Valley in the valley of Big Beaver creek; the Cream Valley-Poorhouse-Embreeville-Guest line in the Doe Run Valley; the Street road and the Kennett lines in the valley of the East Branch of White Clay creek. Another feature is that in all these north-and-south valleys the dip of the limestone is much less steep than that of the other outcrops and of the adjacent schists. These taken alone would indicate flat synclinals of which the axes rise westwardly.

When, however, we attempt to fit any theory to the facts, we find constantly one or more stubborn ones which block the path.

Taking the second and third series, those of Chester Valley and of Cream Valley, the facts all agree perfectly with a synclinal structure, both legs of the sandstone and limestone appearing with the hydromica in the middle, the rock which is wholly sandstone on the north being only partially so on the south and largely mica schists, but with enough of the peculiar sandstone to identify it clearly. However, when we trace westward what appear to be the same strata we find the sandstone among similar schists to the northwest of the limestone instead of to the southeast.[105] Again, along and north of the Street road line the sandstone is very well shown for a distance of eight miles nearly continuously, with first schists and then schists and limestone overlying, but in Taylor's quarry in this series the sandstone appears interbedded in the schists overlying the limestone. It is true that it is but eighteen inches thick, and is visible in but one small quarry and is not shown in a much larger one only about .3 mile south-southwest.

If Dr. Frazer's conclusion is correct that the limestone of Barnard's and Storey's quarries are opposing legs of a synclinal, the hill of schists between overlying, then the hill to the south, whether it be regarded as the continuation of the Toughkenamon hill or as an independent ridge, must represent the London Grove sandstone. Dr. Frazer[106] gives a dip in the sandstone of W. 10° N. (N. 80° W.), which would be in accord, but, as above stated, there are quarries in this narrow hill giving excellent exposures

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[105] Poorhouse quarry ; Guest quarry.
[106] C^4, p. 332.

with gentle dips to the southeast, according with the dips of the limestone further southeast.

The Hydromica Schist.

For these schists I prefer to retain Prof. Dana's name, although not free from the objection that the mica is probably not more hydrous than that of those known as mica schists. The term talc-mica is certainly incorrect. In them I include only the soft micaceous schists such as are everywhere to be seen on the northerly slope of the South (Chester) Valley Hill.

This rock is composed of minute scales of mica, perhaps damourite, with quartz. With rare exceptions it is soft and, on the broader surfaces at least, unctuous to the touch. When almost free from quartz, it forms a rock so ductile that the blow of a hammer upon a mass will not break it, but simply indent it, or if not too thick make a hole. Strata of this variety occur of considerable thickness, but more commonly much quartz occurs with it, usually in lenticular masses, the quartz more or less cellular and rusty, the surface of the quartz coated with closely adherent mica. Rarely the quartz occurs in beds of one to three feet in thickness. It forms the whole of the hill from its beginning near Marble Hall, Montgomery county, to East Goshen township, Chester county, except the comparatively small space occupied by the Conshohocken trap dyke. As far west as Wayne the hill is very well defined on its southern slope, as it is throughout its whole extent (except at its extreme eastern end) on its northern. West of Wayne no distinct valley separates it from the mica schists which border it on the south and which here begin to widen out. North of Radnor Station it is less than a thousand feet north of the ancient gneiss, and at Wayne but little more, while twenty miles to the westward, between the two branches of the Brandywine, over two miles of mica schists, etc., intervene.[107] In occasional

[107] In the *Final Report* it is stated : "The South Valley Hill hydromica schist belt from the Delaware-Chester county line west to the Brandywine has a south border fairly defined by a straight range of serpentine outcrops and limestone quarries." As more fully shown elsewhere, a triangle of mica schist, with included gneiss, and carrying garnets, kyanite and staurolite, intervenes. On the Delaware-Chester county line (Devon) no rock is visible between the serpentine and the hydromica, but to the westward as well as to the eastward the schists and gneisses intervene, increasing in width westwardly to nearly three-quarters of a mile at the East Branch of

beds there is a highly quartzose variety containing little mica, but still enough to make it distinctly a schist.

These rocks are usually olive-green in color, weathering to yellow and red, and rarely to purple tints.

A curious error in regard to these rocks has been remarkably perpetuated. When Prof. Rogers wrote, they were known as talcose schists, the distinction between talc and damourite, etc., being hardly recognized, but when that distinction was made clear these rocks were shown to be not talcose at all, being destitute, or nearly so, of magnesia.[108] Notwithstanding this they are termed talc schists repeatedly in the volumes of the Second Geological Survey, and chloritic schists and chloritic mica schists by Dr. Frazer.[109]

The following analyses of true chlorite schists and of these hydromica schists by Dr. Genth are instructive:

1. Talcose chlorite slate, Prince's quarry, near Lafayette (Montgomery county, Pa.). C6, 128.

2. Chlorite slate from the same. C6, 130.

3. Chlorite mineral, Rose's quarry. C6, 130.[110]

4. Hydromica schist from road between Gulf Mill and Hitner's marble quarry. C6, 132.

5. Ferruginous hydromica schist between Gulf Mills and King of Prussia. C6, 133.

6. "Hydromica slate 1222 feet from Bird-in-Hand tavern on road Gulf Mills to Bryn Mawr." C6, 133. (This therefore is from in the Gulf.—T. D. R.)

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the Brandywine, where much of the rock is heavy-bedded and hard and very different from the hydromica schists.

[108] Dr. Frazer, *Am. Nat.*, Oct., 1883, p. 1021.

[109] C4, p. 103; *Journal Franklin Inst.*, April, 1884, C4, pp. 284, 292, 297, 304, etc.

[110] A serpentine quarry on the west bank of the Schuylkill just above Lafayette.—T. D. R.

	Chlorite Schist.			Hydromica Schist.		
	1	2	3	4	5	6
Loss by ignition, .	9.07	12.60	12.88	7.52	5.91	6.05
Silicic acid, . . .	41.80	32.78	39.39	43.81	43.10	39.35
Titanic acid, . .	.52			3.78	3.28	1.20
Phosphoric acid, .	trace			.13	trace	.49
Alumina, . . .	10.39	17.53	5.07	27.52	30.86	31.92
Ferrous oxide, . .	7.29	3.90	3.25	trace		9.
Ferric oxide, . .		1.31	4.69	7.30	7.28	2.19
Magnesia, . . .	26.71	31.56	34.34	1.77	1.80	3.08
Lime, ...	3.89		trace	.19		
Soda, ...	.27			.56	.66	1.98
Potash, ...	.06			8.81	6.87	5.26
Lithia, ...				trace		
Ni.O., ...						.06
	100.	99.68	99.62	101.39	99.76	100.58

My observations lead me to the conclusion that throughout nearly the whole of their course, from the Schuylkill on the east to far beyond the Octorara on the west, there is not the slightest difficulty in distinguishing the line between the hydromica and the mica schist on the south of it, except that often the margin is concealed by the decomposition of the rocks, as usual in this region. It is, however, quite as well defined as any of the margins except those of the ancient gneiss and the serpentines.

In the mica schists which are south of the hydromica, talc schists and probably chlorites do occur, as near Copeland Schoolhouse, East Bradford township, Chester county, near Mortonville, and on Buck and Doe run, near the Brandywine in East Fallowfield township, but they are rare and always easy to be distinguished

In the northeast the hydromica schist belt first appears in the Whitemarsh (otherwise Plymouth, otherwise Montgomery Valley, the northeasterly continuation of the Chester Valley) not far from Marble Hall. It continues to Conshohocken as a high hill, bounded on all sides, except the southwest, by limestone, which in its turn is bounded by Cambrian sandstone and it by the ancient gneiss. At Conshohocken the Schuylkill flows through it and it is well defined, extending from the Mattson's Ford road to the Gulf creek, bounded on both sides by limestone and intersected by the Conshohocken diabase dyke.

One of the prominent features of this belt is its remarkable widening west of the Schuylkill. From its beginning to the Schuylkill it is about a thousand feet in breadth. It forms the hill on which Conshohocken is built. West of the river it forms a hill of about the same width and 300 feet to 400 feet high for a mile and a half, where it is cut by the Gulf creek to a level of about 150 feet. This creek, flowing eastwardly through the upper part of Cream Valley and near the southerly edge of the hydromica, here turns abruptly northward through a very steep-sided gap known as "The Gulf," and then turning abruptly eastward flows on, or very near, the northerly line of the hydromica into the Schuylkill. The illustration of this gap was taken by Dr. Charles Schäffer.

FIG. 3.—The Gulf.

A very little west of the line of this gap, two steep, nearly parallel hills of hydromica appear rising out of the limestone plain which bounds it on the north, and widen the belt at once to a mile and a half. It would be interesting to know whether the floor of the intermediate valleys is of limestone, but no rocks are visible in the valleys, and I have been unable to find trustworthy dips except in the southernmost hill. The strike is evidently nearly coincident with the trend of the hills ± S. 60° W. In the Gulf, at the south entrance, near almost vertical limestone of Cream Valley, the dip is N. 30° W. 70°, soon becoming 90° and then S. 25° E. 80° near the north entrance and the limestone of the Chester Valley, making a synclinal if the rock is stratified and dips so steep are trustworthy. This was Mr. Hall's view, while Dr. Frazer thought it anticlinal. The limestone in front of the promontories dips S. 20° E. 70° to 90°, S. 30° E. 75°.[111]

About three miles west of the Schuylkill, the Radnor and King of Prussia road crosses (N. 25° W.) nearly on the dip line. The southerly of the two valleys ends a short distance east of this road, the northerly a short distance west of it, the hills becoming a tableland two miles broad with deep, precipitous gorges on its steep north slope, and more gentle ones on its more moderate south slope, but without a gap for nearly twenty miles. It is here 350 feet to 450 feet above tide.

From the road just mentioned for about a mile the schists still form a hill distinct on the south as well as on the north, but in the vicinity of Wayne the floor of Cream Valley—composed in great part of the mica schists, here very full of garnets, some of large size, with Cambrian sandstone and, probably (a mile east, *certainly*), limestone—rises to 370 feet, and the southerly portion of the hydromica schists is no longer a prominent hill though it still occupies the highest ground, attaining an elevation of over 500 feet above tide.

At Wayne exposures of the two series are close together, but the rocks are entirely distinct one from the other. The hard garnetiferous schist in Fenimore's quarry, north of St. David's Station, dips N. 34° W. 75°; the hydromica schist in the well of the water-works east of the Radnor Street road, distant from the quarry .3 mile N. 40° W., dips S. 25° to 30° E. ± 70°. Both

[111] The Schuylkill Valley Railroad cuts the Conshohocken hill east of the Schuylkill. The hill is apparently wholly of hydromica (except the diabase dyke), yet in this excavation, at the railroad level, immediately northwest of the dyke, was abundant limestone, nearly vertical, apparently underlying decomposed hydromica schist, also nearly vertical. Directly across the river the strike of the hydromica (N. 60° E.), of the limestone (N. 62° E.), and of the trap dyke (N. 65 E.) being approximately the same, and the distance about 1,000 feet, the dyke is separated from the limestone on each side by about 500 feet of hydromica.

these exposures are excellent. The two rocks may be seen between the above exposures within 500 feet of each other, and in the branches of Gulf creek, the mica schist with a rock much resembling the Cambrian sandstone striking N. 70° E., dip uncertain but steep; the hydromica with a dip 60° to 80° S. 30° E. with iron ore and sink-holes adjacent.

Just west of Wayne, the Pennsylvania Railroad crosses Cream Valley by an embankment, at the foot of which the garnetiferous mica schist may be seen, and enters a cut showing abundant fragments of a gneissic rock (probably the Altered Primal of Rogers), the diabase of the Conshohocken dyke, and the typical Cambrian sandstone. The latter was abundant when the cut was made, but it is now hard to find. It was exposed also in an older cut to the eastward through which the railroad formerly ran. At the Eagle road, about a thousand feet northwest of Wayne Station, but immediately northwest of the cut just mentioned, the railroad enters the hydromica, in which it continues over ten miles, the grade rising from 405 feet at Wayne to 546 feet at Malvern with summits probably 50 feet to 75 feet higher. At Frazer the summit of the hill is 560 feet; the railroad has descended to 490 feet, and is near the northerly foot of the hill, limestone appearing on the north within one or two hundred yards. Here the West Chester branch diverges southward, climbs the hill to a height of 584 feet, and crosses it to the ancient gneiss which underlies West Chester. The cuts of the Pennsylvania Railroad from Wayne westward afford abundant exposures. The rock is quite uniform; the following dips were obtained: Just below Valley Forge road (near Devon), strike N. 70° E. 90°; 200 feet west, N. 12° W. 87°; east of Devon Station, S. 5° E. 75°; half a mile above, S. 30° E. 85°; 200 feet above the last, S. 25° E. 85°.

At the northwest end of this cut there is for about a hundred feet the unusual dip of N. 45° W. 65°, followed by a small valley and another cut, strike N. 60° E. 90°; toward the west end of this cut N. 50° W. 60°, being almost a repetition of the former. Just below Berwyn Station, strike N. 45° E. 90°, just above strike N. 50° E. ± 90°.

Along the north foot of the hill the dips are usually S. E. 60° and upwards, agreeing closely with those of the limestone—*e. g.*, southwest of Howellville, Chester county, S. 25° E. 60°; north of Paoli, S. 35° E. 75° to 90°; Frazer, S. 10° E. 65°, S. 25° E. 60°, S. 35° E. 65°; south of Glenloch, S. 30° E. 60° to 90°, S. 25° E. 70° to 80°.

The exposures along the West Chester branch present no special features. The border line between the mica schists and the hydromica is not distinct; the latter east and west of Kirkland Station strikes N. 60° to 75° E. 90°, but a half-mile north of Green Hill Station the mica schists are well exposed close to a small branch of Taylor's or Black Horse run. They dip quite regularly S. 23° E. 60°. The same rock forms bold bluffs further west along Broad run,[112] a small branch of Valley creek. The hydromica is not well exposed in this vicinity, but its border is probably but a little north of the southerly line of West Whiteland township, so that the hydromica has diminished in width to a mile and a half or less.

About a mile and a half further west Valley creek affords a good section, as does also the East Branch of the Brandywine one to two miles beyond (the two converging). On the former the hydromica may be seen with a vertical dip about three-quarters of a mile south of the Pennsylvania Railroad, while at and above McMinn's (now Grubb's) mill the mica schist dips S. 30° E. 60° and S. 25° E. 45°. On the East Branch the latter is very

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[112] It may prevent confusion to state that there are at least three Broad runs in Chester county, the northernmost a small creek rising near Kirkland Station on the railroad from Frazer to West Chester and flowing nearly west into Valley creek (C^4, p. 9); the next a considerable stream rising in the hydromica schists south of Gallagherville and flowing southeast in a course which for four miles is remarkable for its parallelism to the general course of the Brandywine, from which in the four miles it is but little over one mile distant. This course is curved first eastward, then southeastward, the last being nearly the dip. This is the Boardley run of C^4, pp. 40, 70. The southernmost is in the southerly part of New Garden township, close to and nearly parallel with the Delaware State line.

"Extensive exposures of limestone occur along the northern edge of New Garden township in the banks of Broad run" (C^4, p. 59). If this is correct there is a fourth Broad run.

Valley creek is but little more definite, as two of the name head in the Chester Valley on the east and west sides of the divide which crosses the valley near Glenloch in the western part of East Whiteland township, the easterly flowing east and then north through the Valley Forge Gap to the Schuylkill, the westerly flowing west and then south into the East Branch of the Brandywine. It is this into which the Broad run referred to in the text flows.

Besides these there is Valley run, rising south of Caln Meeting-house, flowing eastward through the Chester Valley and through Beaver creek into the East Branch of the Brandywine.

boldly exposed close to Hawley's mill, S. 35 E. 45°, S. 40° E. 40°, S. 40° E. 65°, S. 70° E. 25°; while within 500 feet to the northwest the hydromica, striking about N. 50° E., dips vertically.

About a quarter of a mile above Hawley's mill and one mile above Valley creek, there is a small quarry in very quartzose hydromica on the right bank. The bedding is unusually regular. The rock contains small cubes of pyrite. Its strike is N. 50° E., dip 85° to 90° S. E.

About a mile above this, on the left bank, close to where the road to the east part of Downingtown crosses the creek, is a green hydromica schist N. 75° E., 85° to 90° N. W. This is close to the northwest corner of East Bradford township.

About three-quarters of a mile S. 30° W. of Hawley's mill, on the farm of Wilson Young, is a quarry in which the schist resembles more closely the mica schist than the hydromica, but with a dip of 90°, strike N. 45° E. About 500 feet south of this is an outcrop of dolomite colored green, probably by talc.

About three miles west of the East Branch, along Broad run, and about one and three-quarter miles south of Thorndale, is a high bluff of hydromica schist dipping S. 40° E. 70°. West of this is a distinct but small anticlinal in the hydromica from N. 40° W. 75° to S. 28° E. 55°, while a quarter of a mile north the strike is N. 60° E., the dip 90°. One mile south the mica schists, here heavy-bedded and hard, dip nearly S. ± 15°.

The localities mentioned in the last two paragraphs indicate that the usual nearly vertical dip of the hydromica and the low dip of the mica schists are not without exception.

On the West Branch of the Brandywine the hydromica schists may be seen well exposed south of Coatesville to beyond Modena on the northeast bank, dipping S. 25° E. 60°, S. 10° E. 55°, S. 45° E. 45°, S. 25° E. 50°, S. 30° E. 55°, S. 20° E. 45°, S. 45°, below which are the mica schists. The mica schists occupy the southwest bank from northwest of Modena southeastward, with dips S. 10° E. 55°, S. 35° E. 10° to 20°, S. 10° W. 20°, S. 20° E. 50°, S. 35° W. 20°, S. 80° W. 30°, S. 40° W. 20°. No definite structure could be made from these very irregular dips.

On the highland between lines south of Coatesville and of Pomeroy no trustworthy dips in the hydromica were obtained. The mica schist, however, is exposed, especially along the Strasburg road, and here seems to dip S. ± 45° E. ± 50° with much uniformity (one dip, however, was S. 10° E. 55°), but on the road from the Strasburg road to Modena, at a half-mile west of the former, S. 35° E. 10° to 20°; at five-eighths, S. 10° W. 20°; at three-quarters, S. 20° E. 50°.

The next gap is made by Buck run flowing south from Pomeroy. Here the line is near Newlin Station, north of Garrett's mill. At the mill the mica schists form a precipitous hill and dip S. 20° E. 35°. South of Newlin Station they are S. 50° to 60° E. 20°, one-quarter mile above S. 40° E. 45° on the right bank, S. 25° E. 35° on the left bank near the railroad bridge. On the same side, one-eighth mile above the grist mill near Newlin Station, convoluted mica schist dips S. 40° E. 60°. A quarter of a mile above the dip of S. 25° E. 35° near the railroad bridge, above (northwest of) Newlin, the hydromica appears dipping S. 50° E. 80°; a mile further northwest S. 45° E. 85°, then a half-mile from Pomeroy and not far from the limestone S. 35° E. 60°, S. 30° E. 50°, beyond which the limestone dips S. 20° E. 60°, S. 25° E. 60°.

West of Buck run exposures near the border are few and poor. One in the mica schist on Fawn run is S. 50° E. 30°; near Gum Tree N. 55° W. 35°. North of this, on the Highland road, hydromica schist, here unusually full of altered pyrite, is abundant. In West Fallowfield, near Hudson's grist mill on Officer's run, hydromica schist dips S. 45° E. 45° to 90°, but further west near Steeleville, on the Octorara, the rock fragments are of mica schist.

In Lancaster county the division line appears to be near Chestnut Level, where mica shists dip S. E. 30° to 40°, also near Fern-Glen Post-office, S. 35° E. 40°. On the Susquehanna, above and below Phyt's eddy, very compact heavy-bedded mica schists, dipping S. 30° to 35° E. 40° to 55°, make high cliffs.

If the distinction between the mica schists and the hydromica is a valid one, it is of no little importance to a proper comprehension of the geology of the region. The distinctions which I would draw may be summed as follows:

Mica Schists.	Hydromica Schists.
Structure comparatively coarse.	Structure very fine.
Quartz visibly intermixed and especially interlaminated.	Visible quartz in lenticular masses, very rarely interlaminated.

Mica Schists.	Hydromica Schists.
Feel rough and harsh.	Feel smooth and unctuous.
Lamination often curved and twisted.	Lamination smooth and regular (sometimes waved), except around the lenticular quartz, whose curves it follows.
Quarries into large blocks with parallel bedding or cleavage planes and roughly rectangular sides. Makes a fair rough building stone.[113]	The quartzose variety quarries into comparatively small pieces with more or less rounded surfaces. Almost worthless as a building stone. That free from visible quartz breaks into thin plates, is very soft and of almost no value.
Dips usually southeast and generally less than 40°.	Dips usually 70° and upwards, except on the northern edge adjacent to the limestone and except in its western part.
Feldspar often present macroscopically.	Feldspar rare and found in minute particles only and kaolinized.
Garnets often abundant. Pyrites very rare, disseminated.	No garnets detected. Pyrites in some portions, abundant in cubes altered in great part to limonite. The quartz full of cavities containing ferric oxide.

The dip is the most distinct feature, except in the Coatesville-Modena section and westward. Dr. Frazer seems to have noticed the difference of dip, but to have regarded it as of little significance.

On page 287, describing Willistown, he says: "The northern part of the township is filled with broad conchoidal mica schist containing much chlorite and milk quartz ; . . . . dips vertical or nearly so." He then gives two dips N. 20° W. 80°, S. 15° E. 85°. "On the State road near George Hoskins, S. 35° E. 62°." This last is in the southerly part, in what I think the true mica schists, and illustrates the change of dip.

Describing East Bradford he gives dips apparently going southward: "Strike of these schists is N. 30° E. and the dip vertical. At the mouth of Valley creek the same rocks[114] dip S. 20° E. 40°

[113] The bridge which carries the Strasburg road over the West Branch of the Brandywine was built about 1820 of this stone, quarried in the vicinity, and is surpassed by very few road bridges in Pennsylvania. It has five arches.

[114] In my judgment the rocks having these diverse dips are equally diverse

(C^4, p. 292). . . . . In all cases above mentioned the rocks are chloritic in character." "On the eastern side of the township the character of the rocks is not chloritic, though there can be no doubt of the stratigraphical continuity of the beds "[115] (C^4, p. 293).

Describing West Bradford (pages 295, 296), the same change of dip may be noticed: "85°, 70°, 80°, vertical, 72°, vertical, a little further south . . . . S. 20° E. 40°, S. 40°, S. 20° E. 45°." "There can be little doubt that in these dips we have an anticlinal between the limestone valley of Chester (and the vertical dips immediately south of it) and the limestone belt here with the moderate southeast dips in the same schists just north of it."

My view would be nonconformity and that the schists are not of the same age. The Schuylkill section may prove instructive in this connection, comparing the east side with the west, the intervening distance being about a mile and a half for 3, half a mile for 4, and about a thousand feet for the others.[116]

East Side.	West Side.
S.E. 1. Ancient gneiss.	1. Ancient gneiss.
2. Rogers' Altered Primal.	2. Rogers' Altered Primal.
3. Cambrian sandstone, almost undoubtedly continuous through Barren Hill and Willow Grove with 7.	3. Mica schist, in or northwest of which occurs (to the westward) Cambrian sandstone.
4. Limestone, almost certainly continuous north of Marble Hall and Barren Hill with 6.	4. Limestone, mica schist.
5. Hydromica schist.	5. Hydromica schist.
6. Limestone of the Chester Valley.	6. Limestone of the Chester Valley.
	6½. To the westward mica schist.
7. Cambrian sandstone.	7. Cambrian sandstone.
	7½. To the westward schistose and gneissoid rocks.
8. Ancient gneiss.	8. Ancient gneiss.

in their character, as elsewhere described and nowhere better to be seen than here, the northerly steep dipping being soft, almost ductile, the southerly, gently dipping, being hard harsh quartzose schist.

[115] It is to be regretted that Dr. Frazer has not more fully described these chloritic rocks. Among the hydro mica schists I have seen no chlorites, and yet if I understand him aright, it is in the hydromica schist area that he found them abundantly. Dr. Frazer was one of the first, if not the very first, to call attention to the misnomer of the "talc schists" (*Am. Naturalist*, Oct., 1883) for rocks containing no magnesia.

[116] Except that 7 and 8 are concealed on the Schuylkill by the Red Sandstone, but outcrop both northeast and southwest.

All observed facts seem to agree with the hydromica schists lying in a synclinal (perhaps not simple) over the limestone, and may be recapitulated as follows:

First.—The limestone of the Chester Valley may be followed northeastward around the end of the hydromica and thence southwestward into Cream Valley.

Second.—The limestone in its turn is surrounded, except on the west, by Cambrian sandstone and that by the ancient gneiss.

Third.—The two northwesterly hills of hydromica strike into a limestone valley with nearly vertical dips, the limestone having similar strike and dip. No explanation seems possible but that the two were closely folded together, the hydromica overlying.

Fourth.—As already stated, limestone was exposed north of the trap dyke in Conshohocken in the nose of the hydromica schist hill, about twenty feet below the surface.

In considering the limestones, I have mentioned the fact that these hydromica schists bound the valley in Lancaster as they do in Chester county, and that west of Quarryville they seem to extend northward and the limestone to dip under them.

The Schists and Gneisses.

Excluding the Ancient Gneiss and the Hydromica Schist.

For convenience of detailed description the schists and gneisses may be subdivided as follows from the ancient gneiss as a starting-point, the first, and perhaps the third, occurring on both sides, the others on the southeast only:

1. Rogers' Altered Primal.
2. The Spangled Schists.
3. The Chestnut Hill Schists, including the highly garnetiferous schists and the sandy schists (whetstone schists). Prof. Rogers' second belt.
4. The harder, more plicated schists and gneisses to the eastward of the last. These may again be divided into:
    - *A.* Manayunk schists.
    - *B.* Porphyritic gneiss.
    - *C.* The more feldspathic schists and gneisses with much hornblende schist and gneiss, including the Fairmount-Leiperville-Chester gneiss.
    - *D.* The Frankford gneiss.
5. The schists between the North Chester Valley Hill sandstone and the limestone.
6. The schists, gneisses, etc., north of that sandstone.

The whole series of these rocks between the ancient gneiss of the Buck Ridge and its continuation southwestward, and the Delaware river from Trenton, N. J., to the southerly line of Pennsylvania, and, in western Chester county, over the whole area from the hydromica schists of the South Valley Hill southward, have been termed by Prof. Lesley, following Prof. Rogers, "The Newer Gneiss of the Philadelphia Belt."[117]

He regards them as belonging all to one system of sedimentary rocks, the oldest on the southeastern edge (Gray's Ferry), and as being the remnants of a mountain range of which the mica schists of LaFayette, on the Schuylkill, formed summits of ten thousand or fifteen thousand feet in height.[118]

In saying "The Newer Gneiss seems to occupy the whole field south of the belt of South Valley Hill hydromica slate in Chester . . . . county," I presume Prof. Lesley did not intend to include the ancient gneiss area, over three miles wide in the eastern part of the county and running to a point west of Northbrook, about half-way to the Lancaster county line, the continuation of Buck Ridge.

On the Schuylkill section these rocks were divided by Prof. Rogers into his first and second groups, by Mr. Hall into three, his second, the Manayunk schists and gneisses, including part of Rogers' first, and perhaps part of his second. Mr. Hall's name is convenient to distinguish the schists and gneisses which cover the greater part of the area, and which are so well and typically exposed at and near Manayunk.[119]

The differing views of geologists as to these schists and gneisses have been given, but the researches of Dr. George H. Williams[120] and of Mr. Frederick D. Chester[121] and Mr. C. B. Keyes[122] in the region to the south have thrown much light on the rocks in the adjacent Pennsylvania region.

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[117] *Final Report*, pp. 118, 128; *First Geol. Survey of Pa.*, I, p. 64.

[118] *Ibid.*, I, pp. 118, 119.

[119] These divisions, while serving a useful purpose in discussing the region, must not be regarded as typifying wholly distinct series of rocks, for in most of them strata may be found closely resembling the typical rocks of some of the others. Over large areas, however, the type rocks are very much more abundant than any other kind.

[120] The gabbros and associated hornblende rocks occurring in the neighborhood of Baltimore, Md. (*Bul. U. S. Geol. Survey*, No. 28).

[121] The gabbros and associated rocks in Delaware (*Bul. U. S. Geol. Survey*, No. 59; *Proc. Acad. Nat. Sci.*, Phila., 1884, p. 248).

[122] *Bul. Geol. Soc. Amer.*, 1891, Vol. II, p. 309, etc.

The studies of these geologists seem to establish the fact beyond question that in those areas igneous rocks have by dynamic metamorphism become more and more changed, chiefly by the well-recognized alteration of pyroxene into hornblende, and the development of a distinctly foliated character into what are known in the Philadelphia belt as hornblende schists and gneisses.

With this introduction it will be best to consider first the rocks nearest the ancient gneiss, then the limited areas of the porphyritic gneiss and the Fairmount and Frankford gneisses, leaving to the last the very large area outside of those mentioned.

It should also be noted that in this region it is impracticable, in the present state of our knowledge, to use the terms gneiss and schist in their strict petrographic sense. While there are true and typical schists, and equally characteristic gneisses, yet these pass the one into the other by insensible gradations. The terms therefore will be used more in a general than in a strict petrographic sense.

I. Rogers' Altered Primal.

The typical rock is thus described by Prof. Rogers: "Metamorphosed with characteristic white streaks of imperfectly developed crystallized feldspar and hard hornblendic material, with roundish specks of semi-crystallized feldspar;"[123] "remarkable for the regular parallelism of its lamination and bedding; the laminæ alternately light and dark, being exceedingly thin, many of them usually packing within the thickness of an inch. . . . . In some of the layers certain laminæ are studded with isolated crystallizations of hornblende."[124]

This description is graphic as the rock itself is characteristic. Its breadth is not great, but on both sides of the ancient gneiss, from east of the Schuylkill westward, it seems to be of constant occurrence. The rock is often plicated, sometimes minutely so. It is well exposed at the Schuylkill where it appears to be thicker than elsewhere. As Prof. Rogers notes, the feldspar occasionally occurs in rounded crystalline masses of considerable size and the rock approaches a porphyritic gneiss in aspect, but the feldspar is rather in nodules and not in crystals. Some beds, well shown in the

[123] Vol. I, p. 72.
[124] *Ibid.*, p. 68.

Stacker-Brooks quarry one mile north of Radnor Station, Delaware county, Pa., yield a flagstone. This quarry exposes the rock well, and in it occurred distinct pebbles of the ancient gneiss, the only occurrence in this region of pebbles in these rocks of which I am aware except in similar rock west of the Brandywine. The lamination and plication are shown in a photograph by Dr. Charles Schaeffer.[125] It is here in contact, with the limestone, and on the

FIG. 4.—Plicated gneiss. One mile north of Radnor Station.

southeast side of the latter, but on the northwest side the rock is not essentially different. The limestone appears to be less than forty feet in width.

It is possible that the Conshohocken diabase dyke, which about this point crosses it, or is in juxtaposition, may have caused some change, but at other points in the course of this dyke there seems to have been little or no effect on the adjacent rocks. The rule,

[125] Except the possible occurrence at the Queen Lane Reservoir, Philadelphia, and in the Avondale limestone hereafter noted.

however, is that this harder porphyry-like rock is next to the ancient gneiss, and it frequently forms a guide to the margin, as in southeast Willistown, near Westtown School, and on the Brandywine.

On the southeasterly side of the ancient gneiss it may be seen at the Schuylkill, but best in a quarry on the place of Dr. Williams, southwest of Rosemont; also near Westtown School, southeast of West Chester.

Prof. Rogers regarded this as equivalent to his lower primal slate of the North Valley Hill, but apparently all that can be certainly stated as to its age is that in this region it is the upper stratum of the ancient gneiss, or else the first overlying rock. It is evidently of clastic origin.

I have omitted this rock from the geological map because its narrowness would require it to be greatly exaggerated to be visible at all.

II. The Spangled Schists.

These, while probably but a variety, are well defined and important.[126] They form to the northeastward a narrow but characteristic belt northwest of the Chestnut Hill schists, from which they differ markedly. In Huntingdon Valley they lie southeast of the limestone and on the Neshaminy southeast of the Cambrian sandstone. The characteristic feature of most of the rock—namely, that the mica, instead of being all disseminated, is partly in separate curved imperfect crystals, as if it had been subjected to great compression, the crystals showing brilliant surfaces on exposure—is here well shown. Generally the crystals are quite imperfect, but sometimes nearly perfect. Feldspar, probably orthoclase, while frequently absent is sometimes present in large quantity. To the southwest the curved surfaces of the mica are large, when the term conchoidal mica schists, applied to them by Dr. Frazer, is most appropriate,[127] the rock on a cleavage surface presenting a series of rounded hills and hollows, with the mica particles parallel to the curving sides.

These rocks are usually quite schistose, but sometimes in heavy and solid beds, sometimes very micaceous, sometimes feldspathic, and sometimes hornblendic, but invariably the characteristic min-

[126] *Second Geol. Survey of Pa., Annual Report*, 1886, p. 1592.
[127] C^4, p. 287.

eral, whether mica, feldspar or hornblende, is in more or less distinct crystals through the rock. The feldspar crystals are often large, but usually not distinct in form, resembling rather rounded pebbles, but almost always with single smooth cleavages. In certain varieties these feldspar masses weather out while the ground mass remains intact, forming a rock full of holes, well shown north of the ancient gneiss west of the East Branch of the Brandywine, southwest of Copesville. The mica crystals are sometimes very distinct and abundant, with perfect cleavage, but usually with curved surfaces; more frequently they are indistinct, but a fracture of the rock gives always a succession of rounded elevations and depressions, usually small, but sometimes two or three inches across, with much lustre.

More rarely hornblende appears, not scattered through the rock in minute particles, but distinctly crystallized, sometimes on the cleavage or bedding plane like the tourmalines of the Cambrian sandstone, sometimes, as well shown on the west bank of the Brandywine just below the mouth of the East Branch, in distinct imbedded crystals.

This porphyritic character seems, however, to be not confined to the lowest rocks of the series, as, at least in one instance, the rock above the Cambrian sandstone is of the same character. This is in Cream Valley, one mile nearly north of Radnor Station, and a quarter of a mile west of the Montgomery-Delaware county line.

The northeasternmost point at which these schists are well exposed is close to the Pennypack creek, east of the Bound Brook Railroad, though they appear as far east as the Neshaminy. Near the Pennypack they are more compact and harder than elsewhere and are very dark and argillaceous-looking. At Paul Brook Station, in a well, the same schists were found, much decomposed, full of large garnets. They form the northwest flank of the hill bounding Huntingdon Valley on the south, about an eighth of a mile southeast of the limestone. They dip quite regularly S. 20° to 30 E. 60° to 70°, and are bounded southeast by the Chestnut Hill schists, as usual much plicated and nearly vertical. They contain garnets in some strata, the garnets usually much larger and not nearly so numerous as in the typical Chestnut Hill schists.

They continue flanking the hill to its termination near Jenkintown, southwest of which they again appear southeast of the Cambrian sandstone of Waverly Heights. They may be seen on the westerly slope of Chestnut Hill, on Paper Mill lane, and on the Schuylkill close to the LaFayette serpentine, also at Rosemont, between the serpentine and the ancient gneiss, dipping S. 45° E. 50°. Here the Chestnut Hill schists east of it are not very garnetiferous, but sandy and approaching whetstone. On the Roberts' road, the nearest exposure, the latter dip S. 40° E. 80°; further southeast, S. 57° E. 57°, S. 48° E. 50°, S. 45° E. 62°, S. 50° E. 70°, with some irregular, as E., S. 80° E., S. 70° E.

It is possible that these belong to the spangled series and not to the Chestnut Hill. Typical Chestnut Hill schists occur further east, not well shown, near the Pennsylvania Railroad, owing to deep decomposition, but very clearly both to the north and south.

Southwest of Rosemont the spangled schists are exposed on the Roberts' road, and here one stratum is very feldspathic and crystalline, almost a granite. It has, however, the same relation to the ancient gneiss as the schists at Rosemont.

At Darby creek they are prominent, here lying within 200 feet southeast of the ancient gneiss and northwest of the serpentine. Both the muscovite and the orthoclase are in a more crystalline condition than elsewhere, except perhaps southwest of Rosemont; the different strata vary greatly, the most crystalline muscovite occurring in an argillitic variety of the schist.

Westward of Darby creek exposures are very few, and I am not aware of any outcrop that can be clearly recognized. On the Brandywine, however, a porphyritic gneiss, with hornblende crystals in place of mica, just east of the ancient gneiss probably takes its place.

About two miles west of the forks of the Brandywine, on the State road, near Pocopsin Inn, and between the ancient gneiss and serpentine, it is well exposed, being here very feldspathic. It dips nearly E. 10°, and apparently overlies the serpentine. The ancient gneiss is here not over a quarter of a mile in width, and on the northwest side similar schists occur. A mile to the southwest, the ancient gneiss ends apparently in a large outcrop of serpentine and enstatite (Newlin corundum locality), beyond and on both sides of which is a great area of mica schists. Northwest of the ancient gneiss these extend to the Schuylkill, narrowing greatly.

Because of this narrowing they will be discussed from the Schuylkill westward.

As has been stated, the sequence of the rocks on the west side of the Schuylkill near Conshohocken is: Southeast—ancient gneiss, Rogers' Altered Primal, garnetiferous schists, limestone. Northwest—hydromica schist, but in the midst of the limestone schists appear. The contact on the southeast is concealed. The limestone dips S. 28° E. 74°; about 300 feet northwest limestone again appears, dipping about 70° to 80° N. W. If dips so steep as these are trustworthy we have here an anticlinal of limestone.

A little east of this, on Aramink creek, the contacts of the gneiss, the altered primal and the garnetiferous schist—the latter here, and here only, very closely resembling the typical Chestnut Hill rock—may be seen. The dips are very uniform and agree well with those of the limestone: Gneiss S. 20° E. 73°; altered primal S. 20° E. 85°; schist S. 25° E. 80°, while on the River road there are dips in the schists of S. 61°, S. 60° E. 86°, and immediately southeast of the schists a sandy white rock, breaking into small angular fragments much resembling the Cambrian sandstone, which outcrops on the opposite shore of the river at Spring Mill.[128]

These outcrops are near the mouth of Cream Valley, a very straight narrow valley, referred to on p. 216. At this point the summit of the gneiss hill is over 400 feet above the floor of the valley, while the opposing hill (hydromica schist) is between 200 and 300 feet, the summits being less than a mile apart.

The schists may be found thence westward on the northerly slope of the gneiss hill. On the Gulf road, and westward, serpentine and steatite appear in the schists.[129] On Montgomery avenue, 1.5 miles from the Schuylkill, the Cambrian sandstone appears in or close to them.

About a half-mile west of Montgomery avenue, large masses of these schists, full of large garnets, appear near Gulf Creek on the land of Mr. Joseph E. Gillingham. From this westward they are readily detected at short intervals. Close to the Delaware-Montgomery county line, the typical sandstone was exposed in the bed

[128] A mile and a half distant, the river for that space flowing at the base of the ancient gneiss parallel to the strike and over the line of strike of the limestone and sandstone.

[129] The northerly Radnor belt (*Proc. Acad. Nat. Sci.*, 1878, p. 402).

of an affluent of Gulf creek, with the schists apparently on both sides of it, certainly on the southeast side. About .4 of a mile west of this was the Stacker-Brooks quarry in limestone and schistose gneiss, some layers answering to the description of Rogers' Altered Primal, much alike on both sides of the limestone, except that on the south side some layers of the rock were more slaty and quartzose, while on the north side the porphyritic aspect was more developed. Both sides and the limestone were plicated. About an eighth of a mile nearly due south of this quarry the sandstone was exposed in a lane on the west line of Judge Hare's property.

About .6 mile west of the quarry and south of the Eagle road,[130] west of the Radnor and King of Prussia road, large masses of the schist may be seen containing staurolite in addition to the garnets. The schists were exposed in a well south of this on the property of E. A. Schmidt.

In a quarry on land of Francis Fenimore, a quarter of a mile north of St. David's Station, they are unusually well exposed, dipping N. 25° W. 70°, N. 34° W. 75°, while the hydromica schists on the north are S. 10° E. 90°, S. 20° E. 60° to 80°, S. 25–30° E. 70°. North of Wayne they are poorly exposed, but shown to be at least 400 to 500 feet in breadth, probably more than to the eastward. Here, apparently in these schists, both on Gulf creek and in the cut of the railroad, the typical Cambrian sandstone appears.[131]

[130] The Mattson's Ford road follows the valley from the Schuylkill to the Delaware county line. It then bears more southwestwardly and ascends the ancient gneiss hill, crossing a serpentine outcrop (the Radnor-West-Chester belt, not the northerly belt just mentioned), to Radnor Station, while about .2 m. to the north the Brooke's Mill road continues up the valley ending in the Radnor and King of Prussia road. On this road, about .1 m. north, the Eagle road begins and continues up the valley.

[131] Contrary to Dr. Frazer's opinion, I think there is no difficulty in tracing the border line between the hydromica schist and the mica schists which lie to the southward, that is if I understand him correctly. "Throughout an area widening from the east from one mile near Eagle Station to fourteen miles or more along the Octorara creek, and touching the northern outcrop lines of most of the limestone and serpentine patches which extend along this belt, there occur thin mica schists . . . . some of them are garnetiferous. . . . . Within this triangular area . . . . are irregular included areas of more or less chloritic rock and some argillitic or hydra-mica-schists. It was intended to separate these areas from the general mica-schist region and from each other, but this attempt when reduced to paper had to be abandoned, so impossible to suppose as the results of natural divisions were the boundaries thereby produced." C^4, p. 216.

Eagle Station was at the crossing of the Conestoga turnpike by the Pennsylvania Railroad, about .5 m. east of Devon Station. This point is about .3

This is about four miles from the Schuylkill. Westward they are almost continuous and widen greatly, though usually occupying low ground and therefore much concealed.

In Easttown and Willistown townships, in Chester county, near the headwaters of Crum creek, eleven miles from the Schuylkill, they are poorly exposed in connection with the serpentine. On the road next south of the State road three approximatively parallel outcrops of serpentine may be seen, with two and perhaps three outcrops of trap (diabase) and with the garnetiferous schists in place both to the northwest and southeast, and with garnetiferous schist fragments between the serpentine outcrops. On the road leading to Green Tree, the schists may be seen on both sides of the serpentine, while on the road to Malvern, half a mile westward, they occupy a space of some 2,000 feet between two outcrops of serpentine. Trap, probably the diabase of the Conshohocken dyke, occurs distinctly north of all these serpentine outcrops, and to a less extent among them, but none of the outcrops of any of the rocks, except the serpentines, are favorable for observation.

North of West Chester, the schists have become nearly or quite a mile in width. Here they do not appear between the serpentine and the gneiss, but only north of the serpentine. Near the serpentine they contain garnets and staurolite, and throughout garnetiferous strata are not uncommon. The dip is almost uniformly to the southeast and not steep—*e. g.*, one-half mile west of Green Hill Station, S. 23° E. 60°; on High street, near Wrangle Schoolhouse, S. 20° to 30° E. ± 50°; on the north branch of Broad run, in the southwest corner of West Whiteland township, S. 20° E. 55°, but a little higher up the creek they strike N. 60°

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mile north of the ancient gneiss hill and about 1.5 south of the southerly border of the Chester Valley limestone, the hydromica schists lying on both sides of the railroad, the mica schists not exposed, the ground south of the railroad being low. It is clear, therefore, that Dr. Frazer means to include the soft unctuous hydromica schists, but as these occupy to the westward a comparatively narrow belt, the harder mica schists must be included. This is confirmed by the fact that the latter are frequently garnetiferous, the former rarely if ever so. The distinctions between the chloritic and non-chloritic schists I have been unable to recognize. Except in small quantity among the serpentines, and except a narrow stratum near Mortonville, I doubt whether there is chlorite schist, properly so-called, in the region except as a comparatively rare occurrence as in quartz masses near Gum Tree. The line of demarkation between what I have termed the mica schist and the hydromica is clear, sharp and easily to be recognized wherever the exposures suffice, and such are not few.

E. and are nearly vertical. They are exposed in this vicinity in bold bluffs. A very short distance to the north the soft hydromica schists may be seen dipping vertically.

In this vicinity there appears among the schists a hard compact mica and hornblende gneiss much resembling some of the ancient gneiss, but more schistose. It appears on New street, northeast of West Chester in abundant loose masses, and also in place. Its strike is nearly west-southwest, dip about 90°. This is in West Goshen, about a quarter of a mile east of the East Bradford township line. North of it are loose masses of serpentine, but none of it was seen in place. On the west side of the township line, or perhaps on the line, and west of it, this gneiss seems to form the centre of a hill of about 175 feet in height, quite narrow and about half a mile long. On both its flanks are the schists. A road cutting exposed the westerly nose of this hill, showing a narrow synclinal of the gneiss, including a stratum two feet wide of steatite, overlying which were mica schist and quartz, much plicated. Nearly on the strike of this hill, and about 500 feet southwest, is a lower, less abrupt hill of schists, including two outcrops of limestone (Cope's quarries). They lie about S. 50° W. and S. 65° W. from the gneiss. The limestone and schists in the southerly and best exposed outcrop strike S. 40° W., dip N. 35° to 45° W. 65°. The schists forming the north wall are garnetiferous, spangled and contain interlaminated quartz and also feldspar nodules. The limestone is but about forty feet wide. The south wall is a porphyritic schistose gneiss, but, as Dr. Frazer suggests, probably more recent than the ancient gneiss and made up of fragments of it.[132] The other outcrop, perhaps 200 feet to the north, is insignificant, showing only the south leg of an anticlinal, with traces of the arch. The adjacent rock is not exposed in place, but the soil is full of schist fragments.

To the northwest of Cope's quarry is a hill extending west-southwest to the Brandywine. This, as shown by fragments in the soil and by the exposures on the Brandywine, is of the harder feldspar and hornblende gneiss which forms the high hill east of Cope's. The trap dyke extends along its slope near the summit, but on the Brandywine it is on the southerly side of the small valley which separates this hill from that in which Cope's quarry is. A meas-

[132] C^4, p. 294.

urement of this gneiss about .2 mile northwest of Cope's quarry just north of the trap gave a strike N. 40° E. nearly vertical. Northwest of this gneiss the schists again appear and near Copeland Schoolhouse contain thin layers of talc schist.

Cope's quarry is about a mile northeast of the East Branch of the Brandywine, on which the rocks are unusually well exposed. At the State road crossing, three miles southwest of West Chester, and for some distance above it, the ancient gneiss is seen. The next roads to the north are the Strasburg road, running westward from West Chester over the gneiss, and a short curved road diverging northwestwardly from it and converging to it along Black Horse run, laid out to obtain better gradients. The ancient gneiss is exposed on these roads also. The two unite at the crossing of Black Horse run, not far from Cope's quarry, and ascend the low hill on which the inn stands. This is of varied rock, chiefly a hard but schistose feldspar and compact hornblende gneiss, much of it decomposed. There are decomposed schists with it, probably the hornblende rock altered, and in seams in these a compact talc (?) known as "indurated talc." This rock does not resemble any other of the vicinity, and is probably intrusive, or perhaps the schists with intrusive hornblendic rocks (altered diorite?) altering them. On the east slope of the hill schists strike N. 60° E., dip uncertain. On the west slope, the hard gneiss strikes N. 40° E., dip uncertain. Close to the Brandywine, the Strasburg road makes a détour upstream to avoid a bold cliff on the right bank known as Deborah's rock. The rock forming this cliff strikes N. 50° E., dip about 90°; it is very hard but somewhat schistose mica and hornblende gneiss, and belongs, I believe, to the schistose series and not to the ancient gneiss. At Copesville, where the Strasburg road crosses, the schists are well exposed in high cliffs. They are quite micaceous and contain kyanite and garnet, and more rarely menaccanite with feldspar in porphyroidal masses; some layers are less micaceous. A hard gneiss with considerable masses of feldspar occurs further north. Dips here are S. 50° E. 40°, S. 30° E. 50°, S. 45° E. 45°. Some of the gneiss is studded with isolated crystals of hornblende. These rocks, as pointed out by Dr. Frazer, resemble strongly the rocks near the Delaware northwest of Chester.[133]

[133] C^4, p. 61.

Three-quarters of a mile northwest of Copesville, Valley creek, flowing nearly south, empties into the Brandywine. On it at McMinn's mill, or Grubb's mill (Talcose Post-office), the mica schists dip S. 25° E. 45°, and just above S. 30° E. 60°. Three-quarters of a mile above McMinn's mill, the hydromica schists are met, the strike about southwest, but somewhat irregular, the dip vertical or nearly so.

Returning now to the East Branch of the Brandywine, the mica schists may be observed just above the mouth of Valley creek, dipping southeast about 60°. A mile above is Hawley's mill. On the left bank, high steep cliffs of the mica schists form a prominent feature, on the right bank they are also exposed, though not so prominent. They dip S. 40° E. 40°, S. 40° E. 65°, S. 35° E. 45°, S. 70° E. 25°. Less than three hundred feet above, the hydromica schists appear with their characteristic features, striking about S. 45° W., dip vertical or nearly so.

It should be noted that a line connecting Cope's limestone quarry with the range of quarries among which are the Poorhouse quarry and the Embreeville quarry would pass a little north of Copesville. In C^4, p. 58, it is stated that there are signs of limestone on the East Branch of the Brandywine a little north of Copesville. I could find no outcrop; the contours, however, very distinctly indicate the continuance of the limestone, the creek itself following its strike for a half-mile at nearly 90° from its general course and a well-marked valley occupying the line west of the Brandywine. On the south side of this valley a road has been constructed diverging northwardly from the Strasburg road close to the Brandywine and entering it again a mile beyond Marshallton, to avoid a very high hill of the schists over which the old road passes. On the Strasburg road schists only can be seen (except trap) poorly exposed, dipping south-southeast, but on the newer road mica schists are well exposed, dipping S. 30° E. 50°. On this road, a little over a half-mile from the Brandywine, is the limestone quarry of George March. No contacts are visible, but south of the quarry and within 100 feet are quantities of schist fragments, two very large, which may be in place. Its strike is N. 40° E. A quarter of a mile north of the quarry there is an exposure in a lane on Ingram's property; the rocks are quite varied here, some layers being micaceous, some highly feldspathic, and some hornblendic. They strike from N. 80° E. to E. and dip 60° and upwards southeast, or toward the limestone. A quarter of a mile west of this is an abandoned limestone quarry (Moses Woodward's), south of which are schists poorly exposed. Three-quarters of a mile westward is the road to Gallagherville, near the junction of the newer road with the Strasburg road. Here in the schists there is a considerable outcrop of coarse pegmatite. The adjacent schists dip steeply to the northwest, and a variety with large garnets is precisely the rock of Fenimore's quarry, north of St. David's, Radnor township. Close by is another abandoned limestone quarry (Moses Bailey's), south of which is garnetiferous mica schist, imbedded in which was found a pebble-like mass of an older rock, probably ancient gneiss. This schist strikes N. 50° E. and is nearly vertical; a quarter of a mile south the schists dip S. E. ± 70°.

Half a mile southwest is the Poorhouse limestone quarry, by far the largest of the series. Here all the indications are that the schists both underlie and overlie the limestone. The dip being very low, 0° to 15° S. E., an overturn is incredible. North of the quarry decomposed gneiss and schists with quartzite bands dip S. 40° E. 45°, becoming steeper to 65° southeastwardly, while mica schists overlie conformably.

If we take a section line, west of Copesville, that is about midway between the East Branch and Broad run, we find the ancient gneiss well exposed on the West Branch of the Brandywine at Seeds Bridge, southwest of which it forms Brag Hill. On the westerly border of East Bradford, about three-quarters of a mile N. 15° W. of Seeds Bridge, is a plicated sandy schist with hornblende and mica gneiss, dipping about N. 45° W. 10° to 50°, and a quarter of a mile further a porphyritic, argillitic schist, in much of which the feldspar crystals or masses have weathered out, leaving numerous cavities. It forms a small hill, and strikes N. 50° to 70° E. vertical. West of this is a hill of the distinctly spangled schists, here containing much feldspar, hence a gneiss, dipping N. 45° W. 15°. Northward the schists continue, and in them, south of the Strasburg road, is trap which extends eastward probably two miles, and in line with that northwest of West Chester, near Black Horse run. It is probably the diabase of the Conshohocken dyke. North of Marshallton, the schists dip S. 45° E. 60° on the southerly border of the limestone valley, north of which on this section-line no good exposures were seen, but to the eastward are the gneissoid schists north of March's quarry.

We come next to the most interesting section of this belt, viz., that north and south of Northbrook.

Beginning south of the ancient gneiss, here very narrow, we find going northward, the distances given being those of the outcrops noted:

Approximate Distance.	*Dip.*	
	10° E.	Spangled mica schist and granulite close east of and apparently overlying serpentine, State road, west of Pocopsin Inn. (Southeast of this other schists cover most of the region to the gabbro of Delaware.)
± 300′	S. 70° E. 30°.	Schists and gneiss, some highly feldspathic, some not; with talc and serpentine. This was the most satisfactory dip and about an average of a considerable exposure, but for a short distance the dip increased to 90° and was then 70° N. W.; this was south of the gentle southeasterly dips.
1,900′	N. 15° W. 75°.	Ancient gneiss, near northerly foot of hill.
2,600′	S. 40° E. 40°. Steep northwest irregular.	Ancient gneiss on the Brandywine east of Northbrook; two dips close together.
2,600′	N. 20° W. 25°. N. 70° W. 67°.	Schists on right bank of the Brandywine west of Northbrook, and to the westward enstatite and serpentine.
3,000′	± 0° to 45° ± N. W.	Schists on left bank west of Northbrook, very irregular.
1.5 m.	N. 45° W. 15°.	Spangled mica schists with much feldspar northeast of Trimbleville.

Approximate Distance.	*Dip.*			
1.75 m.	S. 45° E.	± 70°. 90°.	East and west of Broad run, south of the road next south of Strasburg road and close south of limestone.
2.5 m.	S. ± 45° E.	0°. 20°.	Limestone and mica schist overlying Poorhouse quarry.
2.6 m.	S. 40° E.	45°. 70°.	Schists north of Poorhouse quarry.
3.25 m.	S.	15°.	Heavy bedded schists on Broad run, a half-mile northeast of Romansville.
4. m.	S. 30° E. S. 40° E.	90°. 70°.	Hydromica schist on Broad run, one mile north of Romansville.
6.25 m.	S. ± 60° E.	± 70°.	Limestone of the Chester Valley.

We have here apparently the schist resting upon both flanks of the ancient gneiss, with comparatively gentle dips from it and very close to its westward termination, no trace of it being visible one mile to the westward, the schists on both sides seeming to unite. Unfortunately, westward there are no good exposures, though abundant decomposing schist fragments are visible.

It would seem, therefore, that these rocks must be the first overlying the ancient gneiss. If such is the fact, and the same schist overlies both flanks, then it is impossible that these should be more recent than the more easterly mica schists, and equally impossible that there can be a profound fault between them and the ancient gneiss. From the occurrence in them of the limestone and of the sandstone, it seems most probable they are of Cambrian age. In this section there seems to be no trace of the subdivisions seen along the Schuylkill. On the contrary, while the mica schists and gneisses characterize the region, the former are most abundant, varying somewhat, mostly from more micaceous to more quartzose varieties, but not in distinct belts or areas, and almost free from other minerals.

Before considering these schists in their westerly and southerly continuation it will be best to discuss schists of somewhat similar character on the southeast of the ancient gneiss area.

III. The Chestnut Hill Schists.

Second Group of Prof. Rogers.

These lie between the spangled schists and the Manayunk schists, and have been so thoroughly discussed by Prof. Rogers, Mr. Hall and others that but a brief notice of them is necessary. They are thus described by Mr. Hall: "Characterized by the serpentines;[134] soapstone; silvery micaceous garnetiferous schists; light-colored thin-bedded sandy gneiss with disseminated light-colored mica in minute flakes."[135]

One of the most definite characteristics is thus well described by Prof. Rogers: "The rock breaking into long narrow chunks, comparatively smooth on their sides, but excessively ragged on their ends; a style of fracture strongly resembling that of half-rotted fibrous wood."[136] They are frequently very garnetiferous, much more so than any of the others.

In the *Final Report*, Vol. I, p. 125, it is stated that this group ends in a point at Jenkintown, eight miles east of the Schuylkill.[137]

While the peculiar wood-like schist, whether garnetiferous or not, is very well marked and characteristic, some areas of the belt as laid down by both Prof. Rogers and Mr. Hall contain rocks very hard to distinguish from those of Mr. Hall's Manayunk group. Mr. Hall states that no dividing line can be drawn. West of the Schuylkill he suggests Mill creek as the dividing line, but the gneisses immediately northwest of this stream are the hard gneisses of the Manayunk belt. The Wissahickon, the Schuylkill, and especially the Schuylkill Valley Railroad cuts give good sections, but no dividing line. Further southwestward the very garnetiferous

[134] Mr. Hall thinks the serpentines, with perhaps a few insignificant exceptions, confined to those rocks or overlying them in synclinal basins. C^5, p. 13 *et seq.* I have given elsewhere my reasons for doubting this (*Proc. Acad. Nat. Sci.*, 1890, p. 95 *et seq.*).

[135] C^6, p. 71.

[136] *Geol. of Pa.*, I, p. 71.

[137] This does not accord with my observations. It is well exposed in a quarry on the Pennypack creek south of Huntingdon valley, the spangled schist occurring as usual on its northwest side, dipping S. 30° E. 70°, while the Chestnut Hill schists are much plicated and apparently nearly vertical. This locality is four miles east-northeast of Jenkintown. The spangled schist is plainly visible on the Neshaminy southeast of Oakford Post-office, six miles further. There is at this point no evidence whether or not the Chestnut Hill or Manayunk schists flank them—there are no rock exposures.

This seems also not to accord with the theory that all these rocks are sheared by a fault diagonal to the strike (*Final Report*, I, p. 125).

variety, so abundant from Cobb's creek northward, gives place to a highly quartzose non-garnetiferous schist, a whetstone. In this section the rock, where entirely decomposed, may be traced by abundant masses of white quartz, weathering yellow. This may be seen in place in the schists on the Gulf road southeast of the Roberts' road, Bryn Mawr. Curiously the apparent southwesterly termination of this area of these schists, which is near Marple Schoolhouse, near the road from Newtown Square to Palmer's mills, is marked by an unusually great outcrop of the quartz.

In these schists kyanite and staurolite are not uncommon, while garnets constitute sometimes a considerable portion of the rock.

IV. The Porphyritic Gneiss.

About four miles from the ancient gneiss, measured along the Schuylkill, which from Spring Mill flows nearly on the line of dip, is the belt of porphyritic gneiss, a hard rock the limit of tide-water before the Fairmount dam was built. The channel was obstructed by the rock forming a rapids known as the Falls of Schuylkill, a name which that part of Philadelphia still retains. It is, at the Schuylkill, not over a quarter of a mile in breadth, and is not visible northeast of Laurel Hill, but it widens rapidly westward, extending at the Lancaster turnpike, 2.5 miles from the river, from the crossing of the Pennsylvania Railroad below Overbrook to Wynnewood, a distance of 2.25 miles, or 1.7 miles across the strike. It is well exposed on Cobb's creek, less so on Darby creek. It can be seen in quarries in the vicinity of Morton, but it apparently does not reach Crum creek.

Just on the northwestern edge of the porphyritic gneiss at the Schuylkill, that is about .2 mile above the Park bridge at the Falls, is a quarry, not recently wrought, in a rock showing the variety of, and rapid changes in, the gneiss of this region. Not over two or three hundred feet in linear extent and less on the strike, the following varieties occur:

Nearly white, fine-grained, chiefly oligoclase and quartz, with a little biotite and tourmaline;[138]
Quartzose biotite schist, nearly black;
Muscovite gneiss, fine-grained, light gray;
Hornblende gneiss, some of the hornblende passing into epidote;

[138] Determined by Mr. Goldsmith.

A gneiss nearly black in color, containing much black mica, probably biotite, passing into a black mica schist;

Pegmatite, chiefly of a reddish flesh-colored feldspar, with tourmaline.

This porphyritic gneiss has much to suggest an igneous origin; much of it is a true augen-gneiss. Its best exposure is that made by Cobb's creek, which flows through it by a deep valley. If igneous, we ought here to find in its width of two miles some unaltered rock and probably an increase in gneissic or schistose structure from the centre toward the edges, but we do not. On the contrary, it seems to alternate with mica schists containing staurolite, garnet and kyanite, or to include one or more areas of them, and the hardest and most crystalline rock is near the edges—*e. g.*, northwest of Sixtieth and Market streets, Philadelphia, and on Cobb's creek 500 feet south of the Haverford road, where that road going southeast turns east and leaves the creek. It has a fine-grained mica feldspar base in which are numerous evenly distributed crystals of feldspar, apparently orthoclase, always twinned, and usually, but not invariably, with their axes parallel. These crystals are firmly attached to the base, so that crystal forms are not seen, only sections upon fracture. They are from an eighth of an inch or less up to two inches in length.

The granite of this belt differs in aspect from that of the rest of the region. It occurs in large quantity. It is a coarse pegmatite, chiefly a flesh-red feldspar, sometimes more than flesh red, with a chalky-white feldspar and with very little quartz and mica, the latter sometimes in thin films and sometimes in small separate crystals. There is also true graphic granite, and some that resembles more a breccia of quartz and feldspar. In the cut of Lansdowne avenue, Philadelphia, it appears to be in dykes cutting the gneiss, or to be filling sharply defined veins. Toward Darby creek in this belt occurs much hornblende rock not containing the feldspar crystals. Microscopic examination by Dr. Bascom shows this to be a gabbro diorite. With this exception the rock is remarkably uniform over its whole area, the variation being almost wholly in the size of the feldspar crystals. The finer varieties make a very good building stone, and even the coarser are used.

This rock appears not to have been seen by the geologists of the Second Survey.[139] It seems to resemble very closely the augen-

[139] C^6, p. 27.

gneiss near Bedford, N. Y., described by Dr. Luquer and Dr. Ries.[140]

The Fairmount Gneiss.

This name has been applied to the rather fine-grained muscovite-microclin-gneiss which forms the hill at Fairmount, Philadelphia, exposed only there and on the opposite bank of the Schuylkill, and along Crum and Ridley creeks near Chester and in that vicinity. On the west side of the Schuylkill it formed a low anticlinal, dipping under mica schists in both directions. The southeasterly dip may still be seen on the Pennsylvania Railroad; the northwesterly was exposed during the construction of the tunnel carrying the tracks of the New York branch under the main line, near Thirty-sixth street. The gneiss is here of very limited extent. On Crum and Ridley creeks what appears to be the same rock is well exposed, and has been largely quarried. Here the dip (cleavage?) is steep.[141]

This rock yields the most valued building stone of the region. The quarries on Ridley and Crum creeks are still yielding large quantities of fine building and curb stone, while that of the Fairmount quarries, until the advance of the city closed them, was much sought for.[142]

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140 *Am. Geologist*. October, 1896, XVIII, p. 239.

141 Mr. Hall (C^5, pp. 2 and 59, etc.), thinks the dip to be gentle and to the northwest and to be indicated by what are known to the quarrymen as beds.

142 It is strange to find in the summary of the *Second Geol. Survey* a sweeping condemnation of this gneiss: "The Philadelphia lower subdivision . . . . " from "Gray's Ferry to the mouth of the Wissahickon. . . . . very few solid beds can be found and the surface stone is worthless. Even where quarries have been opened, the undecayed stone can only be used for the roughest building purposes . . . . . But among the gray micaceous gneiss beds and mica slate beds occur numerous beds of hard hornblende-gneiss, which is a good quarry stone and stands well" (p. 122).

In the following important structures the Fairmount gneiss was used for face stone and it would have been very much more largely used but for the fact that its outcrop was in part taken into Fairmount Park, in part by the Pennsylvania Railroad, and the remainder built upon.

The Church of the Redeemer, Bryn Mawr; Bryn Mawr Station; Ardmore Station; the residence of Mrs. Wheeler, Bryn Mawr and that of Mr. James R. Whitney; that of Mr. John C. Wilson, northwest corner Thirty-fifth and Powelton avenue; that of Mr. Field, southeast corner Thirty-sixth and Powelton avenue; that of George W. Blabon, Twenty-second and Tioga streets; St. Martin's Church, Radnor, Pa.

These and many others were constructed of the Fairmount stone and show no signs of decay.

The stone from the quarries on Crum and Ridley creeks has been used for nearly a century. The size of the quarries shows the immense quantity of stone removed. By far the largest proportion of this was used for face stone and curbing.

From the quarries on Crum and Ridley creeks was obtained the stone for the old Market Street Bridge, the new Baltimore & Ohio Railroad bridge across the Schuylkill in Fairmount Park, the bridge of the Trenton Cut-off Railroad over the Schuylkill below Norristown, and many other important structures, none of which show signs of deterioration.

The fine stone arched bridge of the Reading Railroad over the Schuylkill at the Falls was constructed over a half-century ago of the porphyritic gneiss, quarried near by, and is in perfect condition to-day.

Comparatively little of the hornblende gneiss has been used, except for road material, and except that of the Frankford and Rittenhouse lane (McKinney's) quarries, in which some hornblende occurs, though hardly in sufficient quantity to make it a hornblende gneiss.

The Frankford Gneiss.

This rock has the abnormal strike of nearly east and west. Its chief exposures are at Frankford, at Wayne Junction, Germantown, and at McKinney's quarry on the Wissahickon. It is a highly feldspathic gneiss containing but little mica (chiefly biotite, var. lepidomelane) and hornblende, very hard yet readily wrought, forming a valuable building stone.

At a time when all the rocks of the region were deemed undoubtedly sedimentary, the late Prof. H. Carvill Lewis asserted his belief that this was an altered intrusive dyke.[143]

The quarries at Frankford and McKinney's are noted mineral localities.[144]

The Manayunk Gneisses and Schists.

There remain to be described the mica schists and gneisses which cover the remainder of the area between the ancient gneiss and the Delaware, which are not distinctly separable into belts or areas. They are of somewhat varied character, but are typified by Mr. Hall's Manayunk belt, so called from the excellent exposures near that part of Philadelphia. He describes it as containing gray schistose gneiss with garnets, beds of hornblende slate and fine-grained sandy gneiss.[145]

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[143] *Nature*, October 8, 1885, p. 560.
[144] *Proc. Acad. Nat. Sci.*, April 26, 1892, pp. 178, 179.
[145] C^6, p. 2.

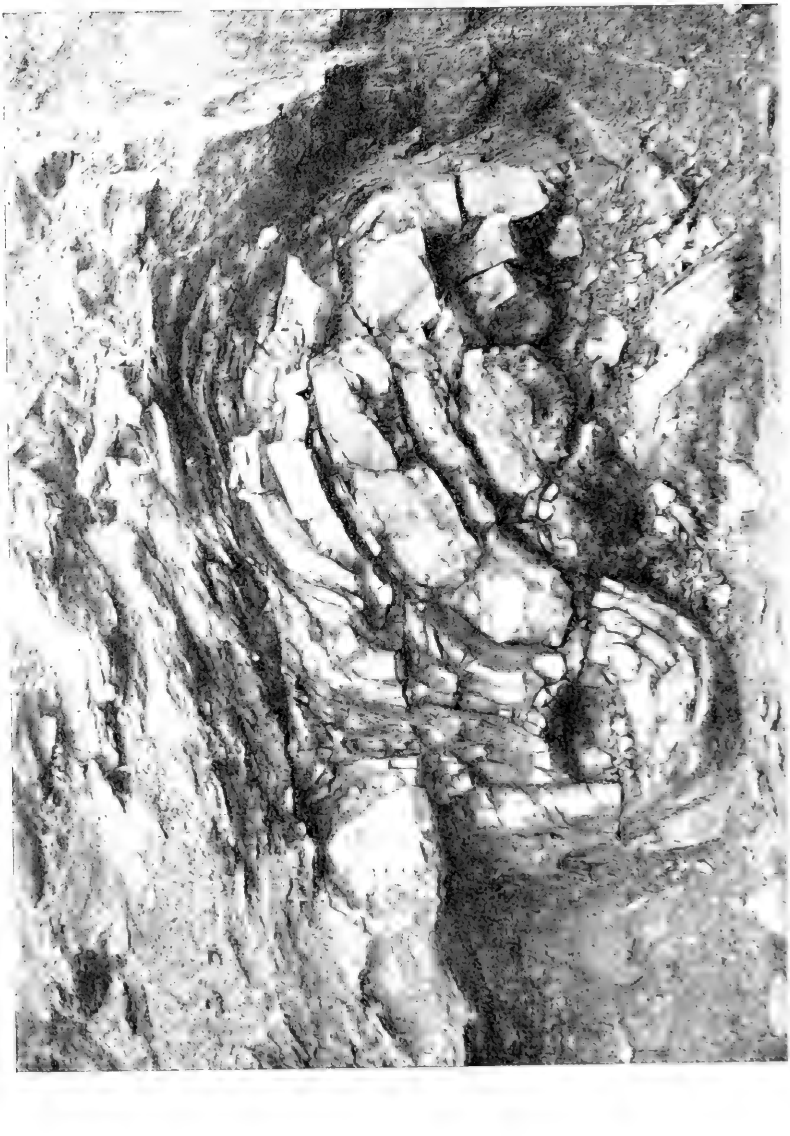

FIG. 5.—Gneiss, Roxborough Avenue.

They contain few garnets compared with the Chestnut Hill series; toward the eastward, hornblende schists are more abundant, likewise feldspar. A prevailing feature is the sharp folding of the rock, the plications being numerous and great. Fig. 5 is from a photograph taken by Dr. Schäffer on Roxborough avenue near the Wissahickon, Philadelphia.

As stated by Mr. Hall and by Prof. Lesley the subdivisions, so clear on the Schuylkill, cannot be recognized much further southwestward. Indeed, the typical Manayunk rocks so prominent on the Schuylkill are scarcely to be found three miles west of it.

Near the mouth of a small creek flowing into the Schuylkill near Strawberry Mansion, Fairmount Park, is a rock apparently identical with one found by Dr. George H. Williams and described by him as follows: "In specimens collected on Sligo Branch;[146] the surface of this rock was covered with small nodules, which upon examination proved to be made up almost entirely of quartz and sillimanite, a mineral combination strongly suggestive of the contact metamorphism of included fragments."[147]

In an excavation in the mica schist made for water-pipe near the Queen Lane reservoir, in Germantown, Philadelphia, two masses of quartz were observed looking like elongated pebbles. They are oval in section, one measuring 5 x 3 x 10 in., but one end was broken off. The original length was probably a foot; the other was much larger. They are composed of a hornstone-like quartz, jointed so that they fell to pieces on extraction, the joints thinly coated with probably hyaline quartz with dendrites. They were imbedded in a very soft mica schist.

Before discussing the rocks of western Delaware county and southern Chester county, it will be well to consider the topography and drainage systems of the region.

The Schuylkill flowing with a nearly south course across the Chester Valley limestone and the hydromica schist strikes the ancient gneiss hill, and for a mile and a half flows along its base a little north of east. Then, breaking through by a steep-sided gap, it flows with a nearly straight southeast course until the porphyritic gneiss is reached at the Falls. This hard rock does not divert it, but immediately after crossing the gneiss the river flows

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[146] Probably Fairfax county, Va.
[147] *U. S. Geol. Survey*, Fifteenth Ann. Rep., p. 665.

nearly south for a mile and a half through schists and gneisses of varying texture and hardness to Columbia Bridge. Here on the left bank is very hard hornblende gneiss (altered diorite?), with some pegmatite; this again does not divert it, but immediately after, it takes a southeast course until it has passed Fairmount, then southerly, with curves, to its mouth. Southeast of Buck Ridge its drainage area on its right bank is very limited for so large a stream, not exceeding four miles in width at any point, and being as narrow as one and a half miles.

Darby creek and its branches drain the next area to the southeastward between nearly southeast parallel lines about six miles apart, the creek rising on the southerly edge of the hydromica schist and flowing through the ancient gneiss, here nearly three miles wide, and then through the schists. The stream bed is high and the erosion much less than at the Schuylkill.

Next is Crum, then Ridley creek. In their lower courses the drainage areas of these creeks are parallel to that of Darby creek and very narrow, the creeks themselves being but about two miles apart and their combined drainage areas not much over four miles wide. Their northwestern branches, however, spread out to the westward and along the northerly edge of the ancient gneiss and cover a lineal distance of six miles.

The next, Chester creek, is roughly parallel to Ridley creek, but its headwaters also spread out to the westward so that its general course is about east-southeast, while its west branch drains a large area to the southwest. The parallelism mentioned is not perfect, for all the streams converge, and all, except the Schuylkill, enter the Delaware within three miles. All these streams, except the Schuylkill, rise either in the ancient gneiss or along the base of the hydromica and are comparatively small, but owing to their rapid descent, suggestive of geologically modern origin, subject to sudden floods.

The next stream, the Brandywine, is second in importance to the Schuylkill. It rises in the Welsh Mountains in the extreme northwest corner of Chester county. It has two large and important branches. These rise close together and flow southeastwardly across the strike of the rocks and through deep valleys, one to six miles apart, for a distance of about eighteen miles to the southeast edge of the ancient gneiss, where the east branch turns southwest and joins the west branch six miles from the Delaware State line, to which point its general bearing is a little east of south, but with a serpentine course.

By another important branch, Buck-and-Doe run, and its branches, Buck run and Doe run, the whole of central western Chester county is drained, leaving a comparatively small southern and southwestern area to be drained by nearly south flowing streams, Red Clay and White Clay creeks, except the extreme southwest by Big Elk creek.

The Octorara flowing along the west line of Chester county drains but a small area on its left bank.

Darby Creek Section.

The Darby creek section shows southeast of the ancient gneiss, the spangled schist, here gneissic and quite porphyritic, then the serpentine of the LaFayette belt, then Chestnut Hill schists with a preponderance of sandy schist and some hornblende schist, following which are plicated mica schists and gneisses, usually quite hard, and the porphyritic gneiss. Kyanite and staurolite occur near the Philadelphia city line and to the southeastward, but the Fairmount gneiss does not appear.

On this section, from the West Chester and Philadelphia road southeastward pegmatite is frequently found, but usually the contacts are concealed. On the above road, about .2 mile east of Darby creek, two sheets or veins of pegmatite occur, apparently conformable with the enclosing schists. They are almost wholly feldspar. The eastern dips N. 35° W. 40°, and is from eighteen inches to two feet wide. Three feet east of it, and apparently conformable, is a sheet of feldspar with much bluish quartz. Two hundred feet westward is a sheet of the pegmatite, dipping irregularly but gently to the northwest. In these beryl and tourmaline occur sparingly.

The section afforded by Crum creek presents new features. At Darby creek the ancient gneiss is over three miles wide; at Crum creek this area, which here is wider, is divided by a small valley heading in the gneiss on the Philadelphia and West Chester road one mile west of Newtown Square. Here there are obscure traces of schists, close to the well-known serpentine and enstatite of Castle Rock. The arm of ancient gneiss to the southeastward has a width of one mile. The schists, serpentine and enstatite are probably not over 500 feet wide at the creek, if so much. On the southeastern edge of the gneiss are outcrops of serpentine, not immediately on the creek, but to the northeast (Blue Hill). South of Walter Green's the Chestnut Hill schists seem to end in a point, and more compact and heavily bedded schists and gneisses to take their place. In these occur a line of serpentine outcrops, but whereas at Walter Green's and Blue Hill serpentine proper is in very great excess, in these it is subordinate, the chief rock being impure talc schist and antholite (?), the latter being quarried for use as asbestos.

Southeast of this is a wide area of the schists, mostly hard and micaceous but embracing some outcrops of hornblende schist.

On the Media Railroad, southwest of Swarthmore College, but east of Crum creek, is a rock consisting almost wholly of hornblende and very slightly schistose, which is probably an altered diorite. A similar rock was found in the tunnel of the Baltimore & Ohio Railroad west of Darby creek.

The same hornblende rock can be traced nearly north and south from the outcrop at Swarthmore, the most southern outcrop being on the right bank of the creek about a quarter of a mile south of the bridge at Avondale.

On the left bank of the creek, just below the Media Railroad bridge near Swarthmore College, and just east of the hornblende, the mica schists are exposed in great masses, some of which contain andalusite (sillimanite ?) in imperfect crystals, perhaps due to contact metamorphism. About a mile distant, in masses of quartz found loose in a wood, were remarkably perfect andalusite crystals, some doubly terminated. This mineral is reported also from Leiperville, a village on the Philadelphia and Chester road near Crum creek. I have a specimen so labeled, which came from an old collection and which differs decidedly from that from near Swarthmore, but I have been unable to learn the exact locality. Minerals from the Avondale quarries and from those on Ridley creek have been widely distributed labeled as from Leiperville, which is therefore a somewhat elastic term.

A mile below Swarthmore are large quarries in gneiss resembling that of Fairmount, but with the schistose structure more fully and regularly developed and with joints more regular and less numerous, making a valuable building stone. The largest quarry is that of Leiper & Lewis, which has been wrought for over fifty years. Many thousand cubic yards of stone have been removed, much of which has been used in important structures. The excellence of the stone was recognized so early that one of the very first railroads built in the United States connects these quarries with tidewater a few miles below.

In these quarries pegmatite beds, veins or sheets occur, carrying many of the minerals occurring near Fairmount. Particularly fine beryls and garnets have been obtained.

Ridley Creek Section.

The section afforded by Ridley creek is so close to that of Crum, that it is very similar. Where Ridley creek crosses the schist valley in the ancient gneiss, the western branch flowing along this valley joins the main stream, which then follows the schist valley in an easterly direction for nearly a mile before resuming its southeasterly course. From this point west-southwestward the schist valley becomes more prominent and wider, with a very straight course. With but few interruptions it may be traced far into Chester county, its floor, occupied by the Street road, being composed of Cambrian sandstone and limestone with the schists.

Near the right bank of Ridley creek and northwest of the schist valley is the Willistown (Chester county) serpentine, almost certainly a continuation of that at Castle Rock.

Leaving the schist valley, here probably less than .2 mile wide, the creek flows for over two miles through the southerly branch of the ancient gneiss to Sycamore Mills, where the edge of the gneiss forms prominent and high hills on both sides of the creek, and serpentine appears.[148]

[148] It is but fair to say that Mr. Hall, in the map accompanying C^5, interprets this region very differently. Instead of a very narrow valley of schists beginning a mile west of Newtown Square and widening gradually to 500′ at Ridley creek, bounded north and south by the ancient gneiss, he continues the Bryn Mawr schists northwardly up Ithan creek and Darby creek to Camp run, showing more than a mile of schists north of the Roberts road at Darby creek and nearly as much north of the serpentine of Moro Phillips' chrome mine, thence westward, including Central Square and Newtown Square. Southwest of Newtown Square an area of the gneiss is shown rapidly widening westward and cutting off the schists on the right bank of Ridley Creek. At Castle Rock and thence east to Newtown Square the schists are represented as over a mile in width.

But in this area are hundreds of bold outcrops of the typical gneiss ex-

Southeast of the Sycamore Mills are the Blue Hill and Dismal run outcrops of the serpentine, the continuation of the Walter Green outcrop in Marple, then mica schists among which are scattered outcrops of enstatite, antholite, serpentine and a coarse binary granite, including the celebrated Mineral Hill. Much of this area is of the schists in which the serpentine rocks appear, accompanied by a granite or aplite, sometimes free from mica, and often composed almost entirely of oligoclase in crystals and crystalline masses as much as three inches in diameter, with a small percentage of quartz. This appears to be in dykes or sheets as if intrusive in the schists. Two localities in particular illustrate this, one at the easterly end of Crump's serpentine quarry, west of Media, where the granitoid rock had every appearance of a true dyke;[149] the other, on the left bank of Chrome run, three or four hundred feet above the railroad near Williamson Station, shows a mass of hornblende rock striking about northwest, while within two feet of it is the granitic rock striking nearly at right angles. An excavation here would be interesting.

Southeast of Media there are the same schists as on Crum creek. Approaching Chester we find the more feldspathic gneiss resembling that of Fairmount. Two of the largest quarries of the region lie on the left bank north of the Philadelphia and Chester road, Leiper's and Deshong's, but the best stone has been removed to a depth too great for profitable working. At the northwest end of Deshong's quarry is a fine exposure of pegmatite.

Chester Creek Section.

Chester creek rises on the southerly edge of the hydromica, flows southeasterly across the mica schists, the serpentine, and the ancient

actly like that elsewhere so represented—*e. g.*, on the Radnor and Chester road, all along Darby creek, a quarry on the right bank of the creek north of the Roberts road, the cut of the Philadelphia and Delaware County Railroad, about a tenth of a mile northwest of the serpentine and of Fawkes run; between Newtown and Central Square, dipping S. 30° E. 30° to 60° and S. 50° E. 65°; on the road from Newtown Square to Castle Rock, S. 25° E. 75° at the forks and S. 20°, E. 60° close north of the serpentine east of Castle Rock. My view is, as elsewhere expressed, that west of Newtown Square the ancient gneiss tableland is divided by a narrow valley of the schists, the southerly portion narrowing rapidly and ending east of Chester creek, while Mr. Hall continues it south-southwest, making it unite with and include the gabbro area of Chichester and Lower Chichester.

[149] The quarry has been abandoned many years and the falling in of the sides has nearly obliterated this.

gneiss, and enters the mica schist valley spoken of close to Westtown school, near which the valley can be well seen and the hills of ancient gneiss bounding it. Southwest of Westtown school the southerly arm of ancient gneiss ends, and schists and schistose gneisses only are found. Many of these, however, are of a decidedly harder character than most of those along Ridley creek and to the northeast. They do not, however, differ from the harder strata of the northeasterly gneisses, and in places between the two creeks, as along the railroad west of Media, the hard gneiss may be seen in narrow layers between the strata of soft mica schists. They do, however, differ most markedly from the much harder and little schistose rocks of the ancient gneiss to the north and east.[150]

In the north the best exposures are afforded by the West Chester (*via* Media) branch of the Pennsylvania Railroad, which from West Chester follows the west branch of Chester creek and then the main stream to Wawa. The ancient gneiss can be recognized clearly for some distance beyond the two-mile post from West Chester. About .1 mile beyond it the gneiss dips N. 25° W. 10°, and 150 feet further N. 30° W. 15°. This is about .15 mile west-northwest of Oakbourne Station. The cut just above the station shows a feldspathic gneiss much decomposed, dipping N. 50° W. 60°. Below the station is a feldspathic gneiss, dipping about N. W. 45°, and 100 feet beyond a similar rock, more decomposed, with plicated beds, dipping N. 45° W. 70°. This is about 100 feet north-northwest of the three-mile post. One-tenth mile beyond the post is a cut in a feldspathic gneiss, weathering almost black upon the surface, somewhat schistose, dipping S. 55° E. 50°, and about .1 mile further a small quarry in similar but more micaceous gneiss, showing a small distinct anticlinal N. 30° W. 55°, S. 60° E. 50°, with a downward pitch to the northeast. The border between the ancient and newer gneiss I believe to be somewhere near the three-mile post. The slopes are much more gentle until Cheney Station is reached; this being the floor of the schist valley referred

[150] Mr. Hall, however, regards them as the same as the ancient gneiss and as occupying very irregular areas in Concord, Middletown, Aston, Bethel and Upper and Lower Chichester; but, according to my observations, except in portions of the last three townships, the rocks are identical in the areas differently colored and are very unlike those in the area to the north colored for Laurentian. Into Bethel and Upper and Lower Chichester and probably further the gabbro area of Delaware extends (F. D. Chester, *Bul. of the U. S. Geol. Survey*, No. 59).

to as heading west of Newtown Square, the Street road crossing the creek at Westtown Station about half-way between Oakbourne and Cheney. Six-tenths mile above Cheney on the right bank of the creek the schists are exposed. At Cheney the hill bounding the Street road valley on the southeast crosses the creek, as does also the very irregular county line (Delaware-Chester). The rocks exposed seem to be almost exclusively large loose masses of a hard gneiss, mostly hornblendic. They do not resemble those of the ancient gneiss to the north, nor those of the same (topographic) hill to the northeast. Blue quartz is absent, the boulder decomposition likewise. They do resemble the hornblende rocks of Columbia Bridge, Swarthmore, Darby, etc., and are not improbably altered diorites. About .5 mile below Cheney and above Locksley Station is a small cut showing a feature exhibited also to the westward near Concord Station (Baltimore Central Railroad) on the west branch of Chester creek. This is a decomposing rock, weathering alternately into laminated very soft schistose layers one inch to eight inches wide, and layers of small, hard, angular blocks of very hard rock one inch to four inches wide. Of the latter sixteen were observed in a space of eight feet. The schistose portion appears to have been a schistose gneiss; the harder masses, the interior of which appears to be undecomposed, were examined for me by Mr. Goldsmith, who classed it as a diorite. Dr. Bascom classes it as a gneissoid gabbro diorite. Northwest of Concord Station the same alteration is visible, but on a larger scale. The hard rock here was determined by Dr. Bascom to be a gabbro diorite. One dyke (?) of it is about four feet in width. The intermediate strata have all the appearance of decomposed gneiss and mica schist. Near the west branch of Chester creek, about a mile nearly north of Concordville, Dr. Charles Schäffer discovered a single large mass of a gneissoid gabbro with a reticulated structure. It consisted of feldspar, quartz and garnet, arranged in narrow straight veins (?) often several inches long, some parallel, others crossing it at various angles, and often several in an inch with no general parallelism. In the triangles and rhomboids thus formed is a black rock, chiefly hornblende and garnet. A short distance above Locksley Station is a gneiss S. 80° E. 50°, then a highly ferruginous rock, followed by a stratum resembling trap and a gneiss, weathering black, S. 60° E. ± 10°. About .1 mile below Locksley is a large quarry in a garnetiferous gneiss, dipping 30° to 70° S.E. In the railroad cut just below the same gneiss dips 0° to 20° S.E.

Above Glen Mills similar rocks, but rather more micaceous, are exposed with southeast dips of 20° to 30°. Below Glen Mills is a large quarry in similar rock, dipping S.E. ± 70°, and another near Wawa.

Near Glen Mills are outcrops of serpentine on the right bank, and also about three-quarters of a mile northeast; adjoining the latter is a considerable outcrop of coarse pegmatite (Sharpless' quarry) which has been quarried for its feldspar and mica.

Below Wawa and near Lenni on the left bank are extensive outcrops of serpentine with much coarse feldspar rock, probably oligoclase, containing very little quartz, and almost no mica or hornblende, being evidently the continuation of the similar rocks west of Media.

Schists and gneisses not essentially different from those above continue down the creek, but in many places they are deeply decayed. In these decayed schists amethysts are found, some of much beauty, also a quartzite filled with small crystals of tourmaline. Near Morgan's Station (Dutton's mill), Dr. J. T. M. Cardeza found a loose mass, apparently a sandstone, containing elongated quartz pebbles. This was near the amethyst and tourmaline localities.

On the right bank, near Morgan Station, mica schist with alternations of hornblende schist dips S. 20° W. 70°. Here, in pegmatite, Mr. Glanding Dailey recently discovered the rare mineral monazite, its only known occurrence in the region. A little to the westward was found, loose in the soil, very small but brilliant transparent ruby-red crystals of rutile on colorless quartz crystals.

On the left bank, near Bridgewater Station, is a large quarry in rock resembling that of Lenni and Glen Riddle, but containing more mica, with dips S. 60° W. 60° to 90°, S. 65° W. 65°, while on the right bank a coarse pegmatite has been quarried for its feldspar and mica. Near Upland a feldspathic gneiss was quarried, and also between it and Chester. The beds of gneiss of the Avondale quarries and of Deshong's and Leiper's, on Ridley creek, do not appear on Chester creek. The ground is lower and they are probably covered.

Between the main stream of Chester creek and the Brandywine is a region of high ground with few good exposures, but some points of interest. In the longitude of West Chester the northerly branch of the ancient gneiss narrows rapidly and in Westtown and East Bradford townships, its southern border appears to describe approximately an arc of about two miles radius with a centre near the railroad station in West Chester, serpentine outcrops being not far from the margin. The Street road valley continues, but not so distinctly as to the eastward. In it we find the Cambrian sandstone and limestone, apparently the outliers of the large areas west of the Brandywine. The easternmost exposure of the sandstone is in the road running southwardly from Oakbourne Station, about a quarter of a mile south of the Street road, on the farm of John Wyeth.

The exposure is poor, but the rock unmistakable and clearly in place. Nearly a mile to the westward the Wilmington road crosses the Street road. On the former sandy schists dip gently southeast for over a mile, and among them, about a half-mile north of Dilworthtown, the sandstone appears in quantity, but its outcrop in place is concealed. The schists north of it dip 15° to 0° S.E., south of it 15° to 30° S.E. The outcrop must be narrow. About a quarter of a mile west-southwest from this locality, on the farm of Minshall Sharpless, the sandstone is well exposed in a small quarry, the rock dipping N. 35° W. ± 80°. Southwest of this about .2 mile, on the road from Dilworthtown to Birmingham Meeting-house, and about .2 mile west-northwest of Dilworthtown, is a considerable outcrop near the forks of the road, fragments only being visible. Following the right-hand fork north-northwest about .7 mile a small limestone quarry with a dip S. 40° E. 50° is found on a branch of Radley run. This is near the western border of Thornbury township, about .6 mile south-southeast of Brinton's quarry and about a quarter of a mile nearly east of Birmingham Meeting-house. South of it are abundant schist fragments, with one outcrop in place S. 30° E. 30°, with abundant evidence of decomposed mica and hornblende schist. Inasmuch as along the Street road, the north line of Thornbury township, schists dip ± 15° S.E., it would appear probable that the structure is monoclinal.

The Brandywine section from the ancient gneiss at the forks three miles southwest of West Chester is as follows, the general course of the creek being about S. 30° E., or nearly on the line of the dip:

Distance.		*Dip.*	
0.	miles.	S. 60° E. 45°.	*North of East Branch:* Ancient gneiss.
1.	"	S. 15° E. 20°.	Schistose, porphyritic gneiss.
1.	"	S. 40° E. 40°.	*Lenape:* Porphyritic with crystalline muscovite, and mica schist.
1.7	"	S. 60° E. 50°. N. 40° W. 20°. ± S.E. 90°. Prevailing dip S.E.	Hard feldspathic gneiss with considerable mica and a little mica schist, the gneiss schistose and porphyritic with waves and folds, but no minute plications.
2.	"	S. 35° E. 55°.	*Street road:* Sandy mica schists not exposed at the creek, but to the eastward, and more largely to the westward, where they enclose Cambrian sandstone and limestone.
2.7	"	S. 30° E. 30°.	*Half a mile above Brinton's bridge:* Hard plicated gneiss and hornblende gneiss, gabbro and pyroxenite.
3.3	"	S. 25° E. 25°.	*Harvey's limestone quarry, N. W. wall:* Hard gneiss with mica schist.
		± S. E. ± 45°.	*Harvey's quarry:* Limestone.
		S. 20° E. 45°.	*Harvey's quarry, S.E. wall:* Hard gneiss.
4.1	"	S. 30° E. 30°.	Hard gneiss, left bank.
4.15	"	S. 10° E. 65°.	Schist and gneiss, some porphyritic.
4.2	"	S. 20° E. 70° to 90°.	Same, some coarse porphyritic with decomposing feldspathic micaceous rocks.
4.25	"	± S.E. ± 45°.	Gabbro (?), left bank.
4.3	"	S. 40° E. 45°.	Heavy-bedded feldspar and hornblende gneiss.
4.5	"	S. 20° E. 85°. S. 30° E. 70°. N. 30° W. 40°.	Hard plicated gneiss, left bank.
4.7	"	N. 30° W. 20°.	
4.6	"	S. 40° E. 45°.	Gneiss.
4.7	"		*Chadd's Ford Junction:* No good exposure. To the westward a marked valley with limestone and sandstone.

Distance.		*Dip.*		
4.8	miles.	S. 70° E.	70°.	Garnetiferous schist.
4.9	"	S. 55° E.	45°.	Very schistose gneiss.
5.	"	S. 60° E.	35°.	Schistose gneiss.
5.4	"	S.	70°.	Schistose gneiss.
		S. 20° E.	70°.	Schistose gneiss decomposed.
5.9	"	S. 40° E.	60°.	Mica schist and gneiss.
5.9	"	S. 30° E.	50°.	Hard hornblende schist and mica schist. Altered gabbro (?).
6.1	"			*Brookfield Station:* Like the last, but with included masses of feldspar.
6.5	"	S. 10° E.	70°. 80°.	Hard mica schist. Loose masses of quartz and mica as if decomposed pegmatite.
6.6	"			*Cossart Station.*
7.	"			Delaware line.[151]
7.5	"	S. 50° E.	50°.	Very hard, heavy-bedded mica schist.
8.7	"			*Granogue Station.*
9.4	"	N. 50° W.	50°.	Mica schist and gneiss in the middle of a cut, hornblende schist at both ends. The schist and gneiss contain red garnets.
9.2	"	N°. 40 W.	80°.	Hard heavy-bedded hornblende schist and mica schist.
10.6	"			*Guyancourt Station.*
10.7	"			Mica schist gneiss and pegmatite.
11.1	"			Thin-bedded mica schist.
11.2	"	N.	40°.	Hard mica schist and gneiss.
11.5	"			*Winterthur Station.*
11.6	"			Hard mica schist and gneiss with a little pegmatite.
12.5	"			Gabbro.

Below Chadd's Ford the curvatures of the creek are so numerous and great that the distances on the dip line are probably not seventy-five per cent. of those given, and between Winterthur and Cossart not much over fifty per cent.

THE SCHISTS AND GNEISSES WEST OF THE BRANDYWINE.

This region is mostly high, the slopes not rugged except toward the Brandywine, and usually decomposition has altered the surface

[151] Between Cossart and Granogue the creek and the railroad bend in the form of the letter S and cross the State line three times.

rocks to a considerable depth. On the northern margin near the ancient gneiss and also at a few scattered and insignificant outcrops further south serpentine appears. In the midst and to the south the Cambrian sandstone, with adjacent limestone, forms lines of outcrop; two being about seven miles in length. Almost invariably the dips are to the southeast, and not steep.

While the principal streams flow from north to south, there are three east-and-west valleys. Of these the southerly two are limestone valleys, and of these the northerly is the continuation of the valley mentioned as heading near Newtown Square and followed by the Street road, a valley of limestone with adjacent sandstone, the bounding hills being of schist and gneiss. The southerly is a similar valley, occupied by the Baltimore Central Railroad. The northernmost of the three is that occupied by Pocopsin creek. Like the others it is very straight, but limestone occurs at but one insignificant locality, a quarter of a mile north of the axis of the valley.

South of Northbrook a section through about the middle of Pocopsin township, nearly on the east line of East Marlborough, and through the middle of Kennett would show, south of the ancient gneiss, here not over .4 mile wide: (1) serpentine (Pocopsin Inn); (2) mica schists with gentle southeast dips, some loose masses of talc schist, sufficiently abundant to indicate an outcrop, and limestone (the talc and limestone on the Larkin farm, about .5 mile south-southeast of Pocopsin Inn); (3) mica schist, abundant in loose masses but without measurable outcrops; (4) serpentine (one mile nearly south of Pocopsin Inn); (5) the valley of Pocopsin creek, on which, nearly a mile to the eastward, mica schists dip S. 20° E. 40°; (6) a mile without exposures except of soil derived apparently from mica schist; (7) garnetiferous mica schists dipping S. 30° E. 40° on the Doe run road, .6 mile west-northwest of the Red Lion Inn, followed closely by decomposed sandy schists, and these by (8) the typical Cambrian sandstone, dipping S. 25° E. 15° to S. 28° E. 50°, with sandy mica schists immediately underlying, dipping S. 20° E. 25° (this sandstone to the westward borders the Street road limestone on the north). A mile to the south is the northerly line of Kennett township, and in this distance soil only was found. A quarter of a mile south of the line, at Marshall's, now Still's mill, on the east branch of the east branch of Red Clay creek; (9) a very hard hornblende rock of trap-like aspect, dips (?) S. 25° E. 55°. This may be traced a mile or more to the eastward, and is probably an altered diorite. Associated with it are masses of pegmatite. The exposures of the latter are but of fragments. South of the gneiss is (10) a decomposed gneiss, with much rusty quartz, and south of it (11) Cambrian sandstone with quartzite and very sandy micaceous rock, dipping S. to S. 10° W. 30°. This is just south of Red Clay creek, where it turns from a nearly south to a west-southwest direction, and about .3 mile east-northeast of the limestone of the Sharpless quarry. South of the sandstone are (12) decomposed hornblende and feldspar gneisses, dipping apparently nearly 0°, with few exposures. The most prominent rock is a very hard, tough hornblende gneiss, usually visible in large loose masses only, but largely exposed in place on the east branch of Red Clay creek at Pierce's paper mill, a little west of this section line, about .75 mile southeast of Kennett Square Station. At this point a single specimen of cancrinite, now in the collection of the Academy of Natural Sciences, was found many years ago by Mr. Jefferis and Dr. Isaac Lea. So far as can be observed this hornblende rock appears in narrow outcrops which cannot be ranged in a single line, though a nearly east-and-west line will pass through several of them.

These rocks suggest an altered diorite. They contain plagioclastic feldspar, sometimes finely aventurine, also titanite and chabazite. While this gneiss appears to be the most prominent rock, it is probably in very much less quantity than a more feldspathic gneiss, subject to more speedy decomposition.

This hard gneiss, another outcrop further south, and that at Still's mill were regarded by Prof. Rogers as rising in anticlinals through the schists,[152] by Dr. Frazer as a gneiss older than the schists,[153] and by Prof. Lesley as three separated areas of the old azoic gneiss.[154]

Similar rocks can, however, be traced among the mica schists into the great gabbro area of Delaware so well described by Prof. Chester, who cites one locality on the Brandywine just below

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[152] I, p. 77.
[153] C[4], 315, 316.
[154] *Final Report*, I, p. 79.

Jessup & Moore's paper mill at which foliated hornblende rock, much resembling that of Kennett, may be seen between "perfectly massive gabbro without the least sign of any distinct line of separation between the two structurally different rocks."[155]

This is certainly a most interesting locality, confirming very positively the views of Mr. Chester, who, I believe, was among the first to urge a plutonic origin for these rocks,[156] though Prof. Lewis still more forcibly published the same views, extending them to other less massive rocks.[157]

A section about three miles west of the last, or nearly north and south of Embreeville, shows the absence of the ancient gneiss, which has ended west of Northbrook, and hence a great width of the schists and gneisses, from the hydromica on the north to and beyond the Delaware line, a distance of some eleven miles. To the northward we find hydromica schist, cut by the Downingtown trap dyke, near the headwaters of Broad Run, West Bradford township. A half-mile south of Cottage schoolhouse, and .75 mile north of Romansville, these schists, dipping S. 70° E. 70°, form a high bluff. This seems to be near their southern limit, which is characterized by a high ridge extending east-northeast toward the Brandywine. South of the ridge is a prominent valley, perhaps indicating the margin. This valley, somewhat interrupted it is true, may be followed from Romansville to Hawley's mill on the Brandywine, where, as already stated, the two series may be seen close together with diverse dips. In this valley there is a very small outcrop of dolomite, colored green by talc or chlorite, on the farm of Young's estate, .75 mile west of the Brandywine.

On Broad run, a quarter of a mile south of this valley, the hard spangled schists appear prominently, dipping about S. 15°. A half-mile south of this, on the Strasburg road, are soft mica schists, with some very feldspathic schistose gneisses, nearly vertical. About a quarter of a mile south of this we reach the line of limestone outcrops already referred to, extending from Cope's quarry, east of the East Branch, to Embreeville, on the West Branch of the Brandywine, and probably to Doe run. These, as

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155 F. D. Chester, *Bull. U. S. Geol. Survey*, No. 59, p. 43.
156 *Proc. Acad. Nat. Sci.*, 1884, p. 248.
157 H. C. Lewis, *Proc. British Asso.* in *Nature*, October 8, 1885, p. 560.

elsewhere more fully stated, seem to be overlaid and underlaid by schists and gneisses, in which is the typical Cambrian sandstone (Hayes' quarry, one mile west of the Poorhouse quarry). About an eighth of a mile north of the Poorhouse quarry, decomposing schistose gneisses dip S. 40° E. 45°, hence under the limestone. The schists over the limestone are from very nearly 0°, perhaps 5° S.E., to S. 50° E. 15°. South of the quarry are plicated schistose rocks containing feldspar and mica porphyritically enclosed. The dips vary from 0° to probably 40° S.E., while one clear dip near Glen Hall bridge had the unusual direction of N. 70° W. 10° to 40°. One mile southeast of the Poorhouse quarry and .5 mile east-northeast of Glen Hall is an outcrop of steatite and serpentine on the Lamborn farm, just north of a ridge of garnetiferous schist, the latter dipping S. 30° E. 20° to 30°. The localities south of the Poorhouse, also Hayes' quarry, are in Newlin township, the latter very close to the West Bradford line. Between the Poorhouse quarry and Embreeville is a low plain about .75 mile by 1.5 miles. It is not improbable that the existence of this plain is due to the limestone.

While at the Poorhouse quarry the immediately underlying schists are concealed, at Embreeville they are well and clearly exposed by a cut of the Wilmington & Northern Railroad, not over a hundred yards north of the limestone quarry. They are spangled and garnetiferous schists, dipping quite regularly S. 50° to 55° E. 30° to 45°. At the west end of the cut is a quarry in a decomposing, very white feldspar, the relation of which to the schists is not clear. So far as it appears it is a conformable stratum under or in the garnetiferous schists.

The feldspar has been mined for use in the making of pottery. It is a "soda orthoclase, with a slight admixture of lime feldspar and considerable free quartz."[158]

The limestone dips in nearly the same direction as the schists, S. 45° to 50° E. 60°. About a hundred yards southeast of the limestone, schists and gneisses with one granitoid stratum, with tourmaline, dip S. 50° E. 55°. South of this are hills of hard mica schists, dipping about 45° S.E., rising probably 250 feet above

[158] Prof. Thomas C. Hopkins, "Feldspars and Kaolins of Eastern Pennsylvania," *Journal of the Franklin Institute*, Vol. CXLVIII, p. 13, July, 1899.

the Brandywine, and exposing, a little north of the summit, much white and much rusty quartz. The white quartz contains small crystals of back tourmaline, and seems to form a distinct stratum, striking about N. 20° E., observable, however, only in loose masses on the surface.

The summit of the hill and its eastern slope show fragments of mica schist only, with much quartz, the surface of which is stained yellow.

About one mile to the eastward of this hill is the extensive outcrop of enstatite serpentine, coarse pegmatite and trap, the well-known Newlin corundum locality, noted for its diaspore, beryl, tourmaline and other minerals besides the corundum. This is less than half a mile from the apparent western ending of the ancient gneiss. The schists close to the ancient gneiss appear to dip away from it. Thus .2 mile west of Northbrook N. 70° W. 67°, N. 20° W. 25, a little further south nearly W. ± 45°, a half-mile further south ± W. ± 30°. A half-mile to the west of the last the southeast dip seems to be resumed.

A mile and a quarter south of Embreeville the north line of East Marlborough is crossed, and mica schist and coarse pegmatite occur poorly exposed. Then follows a half-mile of schist soil, with much loose quartz, but no rock in place, until the Doe run road is reached.

On the Doe run road, west of Unionville, the soil is of decomposed schist. About a half-mile west, a narrow belt of hard gneiss, with spangled schist, crosses the road. The hard gneiss is only about ten feet wide; its strike is N. 20° E., dip 90°. The spangled schist a little east of it dips 15° S.W. A half-mile further west the road passes through a cut of garnetiferous mica schists, dipping S. 30° to 50° E. 40° to 60°, just beyond which and to the northward is Logan's limestone quarry, the limestone dipping S. 40° to 45° E. 40° to 50° under the garnetiferous schists. A little over a hundred yards west of the limestone is an outcrop of the sandstone dipping S. 75° E. 30°.

South of the Unionville-Doe run road, exposures were not found, but one mile southeast there is a quarry on Milton Thornbury's farm at the head of the east branch of Red Clay creek, showing a micaceous gneiss S. 60° E. 15°, with a vein of quartz dipping S. 85° W. 70°.

Three-quarters of a mile south of this quarry is the Street road, which here, according to Breou's map, runs S. 85° W. parallel to the south line of East Marlborough township; on this road sandy mica schists, with typical Cambrian sandstone, dipping S. 5 E. 15° to 20°, may be seen. South of this is the Street road limestone belt. At Taylor's quarry, about a mile and a quarter west-southwest of Taggart's cross-roads (Willowdale Post-office), the contact of the limestone with overlying mica schists (locally known as firestone and used for lining limekilns), is well shown. The mica schist dips S. 30° E. 20°, the limestone about the same or more gently. In Pusey's north quarry, which is about a thousand feet S. 50° W. from Taylor's, the same schists appear to the southeast, and to the northwest mica schist, dipping N. 35° W. 70°. In the northeast corner the limestone dips N. 25° W. 15°, while on the south side it is S. 25° E. 50°, a clear anticlinal, if these dips may be trusted, but the plications in the limestones of this region are so numerous that they probably cannot. The rocks immediately adjacent to the limestone on the northeast and southwest are not alike.

About 500 feet southeast of the Taylor quarry, mica schist and gneiss dip S. 50° E. 50° with plications, and about a mile south-southeast on Red Clay creek, close to the north line of Kennett township, there is a quarry on the left bank in a very hard close-grained mica schist, S. 50° E. 45°, while just below on the right bank is one in a hard biotite gneiss S. 40°. South of this is the mica schist hill on which the village of Kennett Square stands, known to the westward as the Toughkenamon hill. This seems to be chiefly of mica schist, some highly micaceous, some very sandy and approaching closely the typical Cambrian sandstone, some quite garnetiferous. The sandy varieties are best shown on the road running north from Kennett, also north of the State road and on the latter close to the west branch of Red Clay creek, .75 mile west of Kennett Square, and on the left bank of the creek, west of the State road (the main street of Kennett Square).

Kennett Square Station is at the southern edge of the village, and about ninety feet below the State road. The railroad occupies the valley in which limestone occurs, both to the east and to the west. South of this is the hard, rather coarse hornblende gneiss before spoken of, well exposed at Pierce's paper mill, .75 mile southeast of the station, as stated in the preceding section.

South of these hard gneisses the schists occupy most of the area, and near the Delaware border there is another line of limestone outcrops which extends from Jackson's quarry, Hockessin, Delaware, through Brown's quarry to the Nevins' quarries, with schistose and garnetiferous gneiss certainly overlying and apparently underlying the limestone.

South of the Nevins' quarries are mica schists, poorly exposed, covering a large area in northwestern Delaware. In these, between two and three miles south of the line of the Nevins' quarries and the Brown quarry, are the Eastburn limestone quarries, apparently with schists above and below the limestone, and perhaps interstratified, as the three quarries with southeast dips are apparently separated by schists and lie in a northwest-southeast line. The south quarry shows plications, but a general southeast dip. One satisfactory measurement was S. 40° E. 25°, but the northwest side of the quarry is a wall of mica schists dipping N. 65° W. 65°, but not over 200 feet northwest of this is the second, and probably largest, quarry; no rock showing but the limestone dipping S. 40° to 50° E. 20°.

Before discussing the next section it may be expedient to trace to the westward the northern edge of the mica schists, which was previously traced from the Schuylkill to Broad run one mile north of Romansville, West Bradford township, Chester county. About three miles to the westward, on the West Branch of the Brandywine, the northerly border of the mica schists is well defined, the creek itself seeming to flow nearly on the line east of Modena, the hydromica schist on the left or north bank dipping nearly south about 45°, while the hard mica schists on the right bank dip quite irregularly S. 80° W. 30°, S. 20° E. 50°, S. 10° W. 20°, S. 40° W. 20°, S. 35° W. 30°. On the right bank of the creek .2 mile north of Mortonville a quarry has been opened in a hard mica schist, in which the quartz grains are elongated. West of this the Strasburg road seems to be in the mica schists to a point northeast of Ercildoun.

Buck run affords excellent exposures. The hydromica appears about .25 mile northwest of Newlin Station dipping S. 50° E. 80°, while .15 mile above the station the mica schists dip S. 25° to 50° E. 20° to 45°. West of this the hydromica schists extend along the Highland road, while a mile to the south of that road the mica schists form low cliffs on the left (northwest) bank of Fawn run, south of Harmony schoolhouse.

In West Fallowfield township the line is between Cochranville and Hudson's grist mill on Officer's run, near the Gap and Newport turnpike, and on the Octorara in the vicinity of Steeleville.

Through East Fallowfield, Highland and West Fallowfield townships, the mica schists adjoining the hydromica, where not decomposed, are heavy-bedded, largely of the spangled or conchoidal variety, dipping usually to the southeast less than 50°, best shown along the West Branch of the Brandywine, where they form some high and steep cliffs.

South of this border of hard rocks are more quartzose and sandy schists often containing garnets, from which the harder schists are nearly free.

A section about four miles west of Embreeville, that is nearly south of Coatesville, passing through East Fallowfield, West Marlborough, London Grove, Franklin and London Britain, and the valleys of Buck run, Doe run and the east branch of White Clay creek, shows many alternations of the schists and gneisses. To the north is the hydromica schist; following it, well exposed on Fawn run and Buck run, are the heavy-bedded mica schists with irregular dips and then the Doe run valley.

In West Bradford, Newlin and East Fallowfield are outcrops of the only distinct chlorite schist I have observed in Chester county. Except its intense green color it resembles the more evenly bedded mica schists, but can be quarried in flat slabs or flagstones used chiefly for paving walks, etc. The best-known outcrop is Fulton's quarry on the Speakman farm in Newlin township, about .4 mile north of Harvey's bridge on the Brandywine, and about .6 mile nearly west of the Hayes sandstone quarry. It also outcrops on the Strasburg road about a quarter of a mile east-northeast of Mortonville, and also on the road from Mortonville to Doe run. It dips S. 30° E. 20° at Fulton's quarry and appears to be the same at the other outcrops, though less favorable for measurement. Mr. Walter J. Baldwin informs me that it occurs in West Bradford a little over a half-mile southeast of Romansville, and also south-southwest, the former its easternmost exposure, the latter on the farm of R. M. Jefferis, where it has been quarried, and that there is another quarry, Young's, in Newlin township a little west of

Fulton's. Its margins are concealed, so that no exact measurement was possible, but apparently it is not a hundred feet thick.

The Doe run region differs markedly from the rest of the area, though the high hill seems to be of the same gneisses and schists. It was considered more fully when discussing the limestones. One view of it is that its limestones are the continuation of the Cope-Guest line merely interrupted for a very short distance by an anticlinal of sandstone and schists, that the schists which overlie the limestone overspread the whole area west of Doe run. The former is probably the fact, the latter more doubtful as some of the rocks underlying the limestones may be traced into this western area in which no limestone has been discovered. It is certain, however, that hydromica schists like those which bound the Chester Valley on the south do not overspread the area as represented on the map in C^4, and in the text, page 105, *et seq.*

This western area requires further and careful study. I have not examined it as closely as the more easterly part, but so far as observed the rocks are mica schists, often garnetiferous with but little gneiss, and no hydromica schist such as forms the northerly part of the South Valley hill. The rocks are much decomposed, good exposures being few and far between, and even outcrops comparatively rare.

A few may be mentioned: East of Gum Tree, Highland township, mica schist and garnetiferous mica schist, N. 55° W. 55°.

East of Rosenvick, in the same township, mica schist with staurolite; a dip opposite Michael McLoughlin's is N. 60° W. 20°.

On the line between Penn and Londonderry townships, north of Townsend's mill, hornblende schist poorly exposed.

On the middle branch of White Clay creek, south of Townsend's mill, a very dark mica schist.

On the road to Oxford, about a mile and a half west of Jennerville, Penn township, a cut in garnetiferous mica schist, S. 65° E. 45°.

In Upper Oxford township, on the same road near Lincoln University, a cut in mica schist near a branch of Big Elk creek.

In Lower Oxford township, a half-mile north a little west of Elk View Station, on a mill race, very hard garnetiferous mica schist; dip uncertain.

Near the headwaters of the west branch of Doe run, near the northwest corner of Londonderry township, on the farm of Susan Cochran is a rock differing from any other of the region. It is a very quartzose biotite schist, the layers being very well defined and often twenty or thirty to the inch, and these layers excessively plicated. Across these layers are mica partings dividing the rock into masses with roughly parallel sides. There appears to be but a single outcrop covering perhaps a quarter of an acre.

South of the Doe run valley is a hill traversed east and west by the State road. Mica schist with much loose quartz seems to be the only rock. Three-quarters of a mile south is the Street road. Along this mica schists dipping 30° to 45° S. 30° to 40° W. are exposed with trap, while both east and west of the southwest dips are southeast dips. A little west of Cook's grist mill a schistose gneiss dips S. 30° E. 50°, and near by a very sandy schist about S. ± 40° E. 15°. This is about a half-mile north of Chatham. At Chatham we reach the westerly extension of the London Grove outcrop of Cambrian sandstone, dipping S. 25° E. 55°. South of this no exposures were seen except at the limestone quarries ranging through the central part of London Grove township. The schist outcrops are so associated with those of limestone that they have been discussed with them. In brief, there are rather high hills of garnetiferous schists, with pegmatite and sandstone, all dips being southeast and gentle, some of the schists being apparently below the limestone and some very clearly above it. Similar rocks and gneisses continue to the Delaware gabbro area, being hard and forming bold bluffs near Laudenberg, and surrounding, or at least on both north and south sides of, another limestone area. Usually these are not well exposed, but along Red Clay creek they form precipitous banks resembling those near Landenberg, dipping quite regularly S. 60°–70° E. 60°–70°, the rocks being undecomposed and hard, but to the westward they are decomposed and soft.

V. The Schists and Gneisses Lying between the Sandstone of the North Valley Hill and the Limestone.

These have been so referred to in discussing the adjacent rocks that they require little more than mention here. The fact then is that we have, between the well-marked Cambrian of the North Valley Hill and the limestone, sandy mica schists, rarely carrying feldspar and tourmaline, indistinguishable in their appearance and lithological characteristics from some of the schists of the Philadephia and Manayunk groups; especially do they resemble the sandy schists of the Chestnut Hill group, and those on the Schuylkill below Laurel Hill, and in the cuts of the Schuylkill Valley Railroad southeast of West Laurel Hill.

VI. The Schists and Gneisses North of the Sandstone.

At Valley Forge, northwest of the sandstone, as has been stated, are slaty and schistose rocks, northwest of which is a conglomerate of blue quartz pebbles, resembling very closely the lower Cambrian conglomerate so well exposed near Willow Grove and to the southwestward.

Only six miles to the westward is the Pickering creek gap. We find here the easternmost of a series of outcrops of hard, usually schistose gneisses which prevail thence westward far into Lancaster county, bounded northwestward, in their easterly part, by the northerly ancient gneiss, and their westerly by the hill of Cambrian sandstone which stretches from west of the Gap in Lancaster county to Wagontown, Chester county. These vary much in their constitution as shown in Williams' quarry near Aldham, Charlestown township, where they dip S. 50° to 60° E. 60° to 65°, and in the adjacent railroad cut S. 80° E. 23° with great regularity and are cut by a dyke eighty feet wide of trap. This gneiss is very evenly bedded. It is sometimes hornblendic and sometimes highly feldspathic, indeed almost entirely a white feldspar; sometimes the feldspar is flesh-colored. This feldspathic variety contains small quantities of epidote.

I have termed it provisionally the Chester county gneiss.

Westward similar rocks are shown in all the gaps in the hill. Some of the feldspathic varieties have weathered into kaolin, but as a rule they are hard and undecomposed. A common variety to the westward resembles a pegmatite but has a brecciated aspect; beds of vitreous quartz occur and are quarried. It appears to widen westward and to occupy much of the space between the sandstone of the North Valley Hill and that of Copper Mine Ridge in western Chester and eastern Lancaster counties.

The Serpentines.

As to none of the rocks of this region has there been a greater diversity of opinion than as to the serpentines, including in these the magnesian silicates, usually hydrous, of which serpentine is the type. Mr. Hall, after very careful study in Philadelphia, Montgomery and Delaware counties, concluded that all the serpentines of the region were of the same geological horizon, and that one of the most recent.[159] Dr. Frazer recognized the two different positions in which they occur, and states that the hypothesis that the serpentine is a layer of magnesian schist altered in place, while the most satisfactory in many respects, does not account for all that may be observed with regard to it.[160] Dr. Genth[161] showed that most of the serpentine was derived from the alteration of peridotite or bronzite.

Prof. Lesley thought them due, in part at least, to a metamorphism of the "talc mica" (hydromica) schist formation, due to the trap dyke which occasionally is close to the serpentine. My own views have already been published,[162] but in Prof. Lesley's *Final Report* (p. 107) are not correctly stated: "And this agrees pretty well with all Mr. Rand's observations of the serpentines of Delaware and Chester counties, which he shows pretty clearly to be interbedded among the ancient gneisses of that region."

It was my aim[163] to distinguish the hard, nearly black serpentines, derived chiefly from enstatite or bronzite, which I believe do occur either in or on the margin of the ancient gneiss, from those that are clearly in the mica schists and at some distance from the gneiss. These are usually of a lighter color, with less serpentine proper and with talc, steatite and antholite, which are rare in the former, and are probably altered peridotites in large part. The serpentine north of Easton, by far the best exposed of any in the region, appears at first sight to be interbedded in the ancient gneiss, though I am convinced that the theory of Dr. Frederick B. Peck,[164] that it is due to the alteration of igneous rocks, and per-

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[159] C^5, pp. 13 and 14.

[160] C^4, p. 218.

[161] *Second Geol. Survey of Pa.*, B., I, pp. 62, 113; *Amer. Jour.*, Sec. (2), XXXIII, 199.

[162] *Second Geol. Survey of Pa.*, Assoc. Report, 1886, IV, p. 1611; *Proc. Acad. Nat. Sci. of Phila.*, 1896, p. 21, 1890, p. 76, *et seq.*

[163] *Second Geol. Survey of Pa.*, 1886, IV, p. 1611.

"If these steatite and serpentine belts" (the Philadelphia steatite and the LaFayette serpentine) "be compared, their unlikeness seems to point to a different origin . . . . . The serpentine belt has undoubtedly resulted from the alteration of enstatite."

[164] Private communication to the author.

haps also of adjacent gneiss along a zone of faulting and shearing, is in all probability the true one. I desire frankly to admit my mistake in regard to the supposed pseudomorphs after staurolite in the steatite quarry belt. The late Dr. Williams examined my specimens and identified them as pseudomorphs after olivine, and with this Dr. Bascom's observations of sections agree;[165] so that

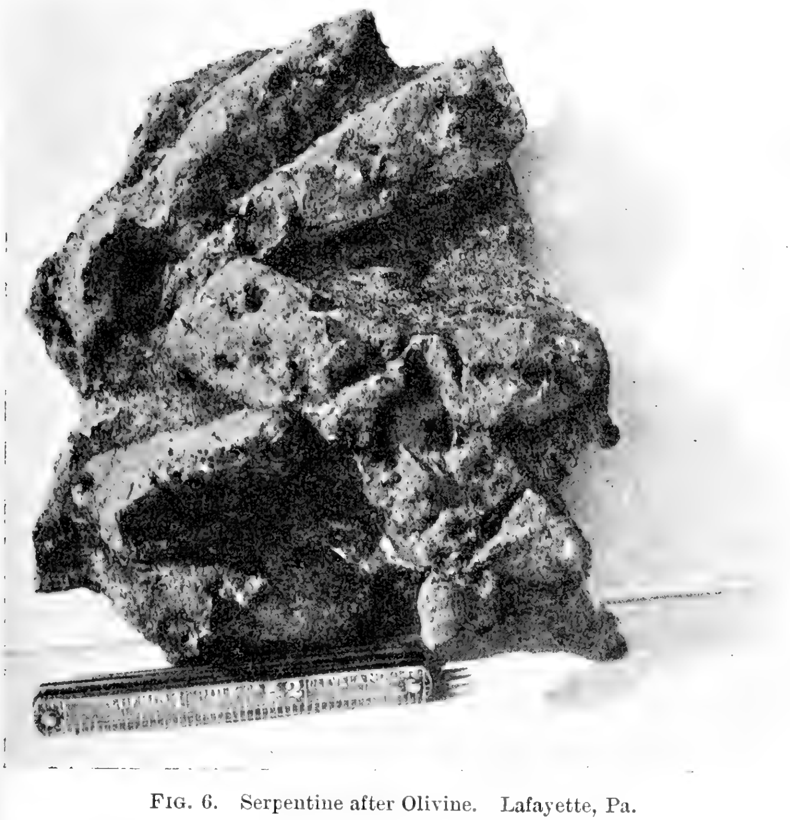

FIG. 6. Serpentine after Olivine. Lafayette, Pa.

there seems no doubt that all the serpentines in southeast Pennsylvania are altered igneous rocks, either pyroxenites or peridotites. Fig. 6 is from a photograph by Dr. Schäffer of a specimen from Prince's soapstone quarry.

[165] *Proc. Acad. Nat Sci.*, Phila., 1896, p. 219.

Mr. Hall, after examining the *northerly* Radnor belt, modified his views, for he wrote (*Annual Report*, 1886, IV, p. 1617): "In all probability there are two groups of serpentines."

The change of pyroxenite into serpentine[166] is followed at many localities by the change of the serpentine into quartz, usually in cellular masses and sometimes in stalactites. Fig. 7 is of a specimen from the Philadelphia and West Chester road, a mile east of Newtown Square, photographed by Dr. Schäffer.

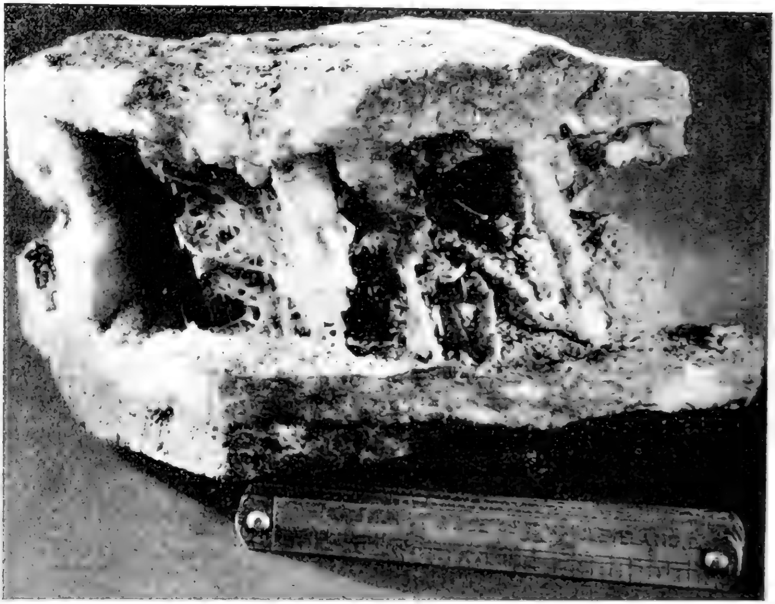

FIG. 7. Quartz after Serpentine. One mile east of Newtown Square.

To this recapitulation may be added some notes of observations made since those papers were written.

The Outcrops in Chester County West and South of the Great Belt North of West Chester.

1. *Cope's Serpentine.* This is on the land of Caleb Cope, about a mile northwest of West Chester, and is referred to in C[4], p. 89, in a quotation from Rogers as Cobb's serpentine. I described this,

[166] *Second Geol. Survey of Pa.*, Annual Report, 1886, p. 1614.

in one of the papers referred to, as occupying a narrow stratum in a synclinal of mica schists overlying a rock, apparently of the ancient gneiss, though not so characteristic as to be beyond doubt, and lying a very short distance north of undoubted ancient gneiss.

Further examination has satisfied me that the rock underlying the steatite is not as supposed, but merely a portion of the belt of hard gneiss which lies north of the serpentine further east, and which outcrops on the Brandywine above Cope's bridge, referred to by Mr. Hall as resembling the rocks of southern Delaware county.[167] It seems to be but a local variation of the schistose gneiss, and is comparatively small in quantity.

Another occurrence of steatite, but of still less quantity, was observed about a half-mile north of Cope's, and the same distance east of Copeland schoolhouse, where a narrow belt of talc schist was embedded in the mica schist. These seem to have no relation to the great serpentine belt.

2. *Black Horse Serpentine.* About 1.7 miles west of West Chester the Strasburg road, having descended the gneiss hill on which that city lies, crosses Black Horse run about a half-mile southwest of the Cope locality and ascends a low hill on the summit of which stands the Black Horse Inn, an old landmark. This is referred to (C^4. p. 89) as follows: "A still more trivial locality of steatite is at the Black Horse tavern on the road to Taylor's ford.[168] It is on the same general line with the previously mentioned localities of magnesian rocks."

The rocks here are fairly exposed in the road cutting, and are microscopically heavy-bedded hornblende schist with massive hornblende, much of which has undergone deep decomposition. Under the microscope thin sections show besides the hornblende olivine and hypersthene, indicating a plutonic origin. In the decomposed rock the steatitic mineral occurs in seams, from the thickness of a knife-blade to an inch or more. No serpentine was

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[167] "In the vicinity of Copesville, East Bradford township, the rocks exposed along the east branch of the Brandywine creek are a coarse micaceous gneiss identical with those on the southern edge of Delaware county. Syenite is found in large quantities in the micaceous gneiss at the north of Copesville. Its occurrence is similar to that as found in the vicinity of the White Horse Tavern in Ridley township, Delaware county" (C^4, p. 61).

[168] Probably intended for Copesville or Cope's bridge. I am informed that Taylor's ford is in another part of the county and that this crossing of the Brandywine was not known by that name.

observed nor any steatite except in the thin seams. This outcrop is unlike any other of the region. In parts the hornblende has a massive trap-like character, but other portions seem to be distinctly foliated with strike of N. 40° to 60° E., dip uncertain.

3. *Worth Serpentine.* This locality, noted by Rogers and barely mentioned by a quotation from Rogers (in C^4, p. 89), is of interest, inasmuch as the relation of the rocks so very closely coincides with what may be observed in Delaware county, the ancient gneiss axis being absolutely continuous. Like the Radnor serpentine, it forms a prominent hill, striking ± S. 40° W., dying down steeply westward at a small affluent of the East Branch of the Brandywine. The locality is on the Worth farm, about one mile S. 30° W. of Copesville, or Cope's bridge. To the south of it the gneiss is prominent, though not visible in place close to it. On the north a considerable dyke of trap, probably the diabase of the Conshohocken dyke, appears within 300 feet, and then the gneisses and mica schists dipping southeast or toward the serpentine. The visible outcrop is not over 1000 feet in length; it is visibly 300 feet to 400 feet broad. It is distinctly foliated and dips N. 30 to 40° W. 30° to 65°.

A curious occurrence here is a stratum of serpentine of no unusual appearance, but containing disseminated magnetite in such abundance as to exhibit strong polarity.

About a mile and a half southwest of the Worth serpentine the West Branch of the Brandywine and the Wilmington & Northern Railroad, which here follows its right bank, give numerous and good exposures of the gneiss on the southeast and of the schists on the northwest, but no serpentine is visible. A mile further southwest, near Northbrook, the serpentine again appears, and at this point on *both* sides of the gneiss, which is here only a quarter of a mile wide but forming a high hill. The outcrop of serpentine —or rather outcrops, for there appear to be two on the northwest side of the gneiss—have not, I think, been previously described.

They are inconspicuous and lie respectively S. 50° W. five-eighths, and S. 60° W. one-half mile from Northbrook, on a road running south-southwest, nearly parallel with and a little west of the Newlin-Pocopsin township line, from the Brandywine just west of Northbrook to the State road. Enstatite or bronzite accompanies the serpentine. About a quarter of a mile north of these a greenish mica schist dips ±45° nearly due west. At Northbrook a road runs nearly south to the State road at Pocopsin Inn, a point about a half-mile northeast of these outcrops. Near this road the gneiss is exposed in place in the bed of a brook on the northeast. Southeast of it and close to the summit and to the State road signs of serpentine again appear, together with the feldspar porphyritic rock which appears at so many serpentine localities. The occurrence is so remarkable that I copy in full from my notebook:

South of Northbrook, heavy-bedded gneiss in bed of brook N. 15° W. 75°.

South of this, ascending a steep hill, no rock in place but abundant gneiss fragments for .2 mile. Then, at about 300 feet north of the State road at Pocopsin Inn, loose honeycomb quartz was seen, then as follows:

10′. Serpentine in gutter of road, not well exposed, but apparently in place;
20′. Concealed;
20′. Mica schists, decomposed, poorly exposed;
40′. Schistose gneiss, highly feldspathic and full of nodules of feldspar (probably orthoclase) mostly one-eighth to one-half inch in diameter, but some two inches, the rock much decomposed, dip ± 20° S.E. It varies from nearly mica schist to almost pure feldspar;
3′. Feldspar (?) decomposed into nodules, with a stratum ± 3 inches of a soapy schist;
50′. Mica schists with interbedded schistose gneiss, not porphyritic. Overlying this (topographically) is apparently the same rock decomposed, and, within three feet of the undecomposed, talc schist in loose masses;
50′. Mica schists, dip steeper southeast and then vertical, then ± 70° N.W.

These were observed on the westerly and higher side of the road, where the exposures were best. On the easterly side was talc schist, about ten inches wide, clearly intercalated in the mica schist and enclosing feldspar, decomposing apparently into the talcose material.

From this to the State road was concealed, but on the State road a quarter of a mile further west the serpentine makes a well-known and conspicuous outcrop, and here the porphyritic schistose gneiss or granulite, with spangled schists, appears east of the serpentine and dips E. 10°.

West of this on the State road, close to a road leading northwest to Glen Hall, is an insignificant outcrop, to the west and north of which schists poorly exposed dip northwestwardly probably under 30°.

Going northwest on this latter road, and looking eastward, the westerly end of Brag Hill (gneiss) may be seen as a promontory. Close to the road running nearly west from Northbrook to the corundum mines, the schists form the summit of a high hill, on the strike of Brag Hill, and in this to the westward serpentine with enstatite or bronzite appears, with much aplite, granite and pegmatite, with some trap, covering an area over a mile in length and of uncertain width, probably between a quarter and half a mile wide. It is in this that the large quantities of corundum and accompanying minerals have been found for which Newlin is famous; large quantities of feldspar are now being obtained from surface openings.

This is the westernmost exposure of serpentine adjacent to the ancient gneiss, and it will be observed that as the gneiss disappears beneath the schists, the flanking serpentine seems to unite in this large outcrop directly in the strike of the gneiss.

We ought here to find evidence of the structure, but the dips in the schist are obscure. It is sure, however, that we have the continuous ancient gneiss from near Trenton to this point, and that on both sides of it for a distance of nearly twenty-five miles we have outcrops of serpentine of closely similar character, not continuous throughout, but often so for miles, and in all cases where outcrops can be observed very close to the edge of the gneiss. At times between the gneiss and the serpentine there can be found a thin outcrop of the spangled schists or gneiss, and especially the feldspathic porphyritic variety. Beyond the serpentine, on both sides, are the garnetiferous and spangled schists in large quantity, which, or the feldspar porphyritic varieties, appear to divide the serpentine whenever, as southeast of Malvern, at Sconneltown, and at Strode's mill, it appears in double outcrops.

Following the southeasterly margin of the ancient gneiss east-northeasterly from the serpentine at Pocopsin Inn, we find the next outcrop at Sconneltown, about two miles southwest of West Chester, where the adjacent rocks are similar—the hard ancient gneiss on the northwest, the softer schists and very feldspathic gneiss on the southeast.

About a half-mile nearly southeast of the Sconneltown outcrop are those at Strode's mill. These are two, close together. The ancient gneiss is apparent within less than a quarter of a mile north of the larger outcrop on the right bank of Plum run, but the road from Sconneltown to Strode's mill does not expose the hard gneiss, but only soft schistose gneiss, some highly feldspathic. These have a dip of about 35° S.E. Within ten feet southeast of the serpentine is a small outcrop of the massive hornblende rock which appears at several outcrops of the serpentine. About .1 mile further southeast are schistose, very feldspathic gneisses with a coarse granite of reddish feldspar and quartz S. 70° to 75° E. 50°, then another outcrop of serpentine, followed by coarse gneiss dipping 30° to 50° N.W., beyond which schistose gneiss, feldspathic and hornblendic (but to all appearance not the ancient gneiss), dips S. 10° W. 20°, forming Osbourne's Hill, in which years ago a mine was opened for manganic oxide derived from the decomposition of a massive manganesian garnet.

About a mile further southeast is Brinton's quarry, which will be discussed hereafter as its serpentine appears not to belong to the range of outcrops under consideration.

From Strode's mill the border of the ancient gneiss passes nearly east-northeast, but along it no serpentine appears for some six miles. At this point, the southwest corner of Willistown township, is a well-known and extensive outcrop, where the Street road diverges from the Philadelphia and West Chester road. The ancient gneiss is to the northwest, but apparently separated from the serpentine by spangled schist containing garnets and pebbles (?) of quartz and feldspar.

About two miles to the eastward is the well-known "Castle Rock" of massive enstatite or bronzite, forming a precipitous cliff on the right (west) bank of Crum creek, while on the left is serpentine and much honeycomb quartz from its decomposition. East of this serpentine, which covers but a small area, is a narrow outcrop of the gneiss, followed by another outcrop of serpentine poorly exposed near the top of the hill, 1.5 miles west of Newtown Square, beyond which the gneiss again appears. Except of the gneiss, all the prominent outcrops are on the south side of the Philadelphia and West Chester road. The gneiss is exposed in the road and on both sides of it. It is in this vicinity, but perhaps not far east of Willistown Inn, that the gneiss appears to project toward the west-southwest a prong which forms a high ridge south of the valley through which the Street road runs, and the floor of which is of schistose rocks. On Crum creek, which flows southeast, this prong is nearly two miles wide, and on its southeast border are the Blue Hill and Marple outcrops of serpentine, which can be traced northeast to a probable connection with the LaFayette belt.[169] South of the serpentine outcrops mentioned are a number of exposures in both Delaware and Chester counties. These are mostly small, scattered and, with few exceptions, insignificant compared with those to the northward. Those east of Chester creek have been fully described.[170] Those in Delaware county west of Chester creek are shown on Mr. Hall's map, C^5. All of them appear to be in the schists and schistose gneisses, and they are of rock, usually light-colored and much softer than that near the ancient gneiss, talc and antholite being often more abundant than true serpentine, like the southerly outcrops to the westward. Some show merely a small area of honeycomb quartz. On but few of them have quarries been opened. Probably the largest exposure is on the Smith's bridge road, .1 mile east of Elam. Here some quarrying has been done in a light-colored serpentine, very much jointed and showing abundance of slickensides, on the Husband farm; east-northeast of it .2 is hornblende schist.

Bullock's quarry, in Birmingham township, Delaware county, one mile west-northwest of Elam, shown on the map C^5 as serpentine, was not in serpentine but in limestone.

In southeastern Chester county somewhat similar outcrops occur. Of these the most important is that in which Brinton's quarry[171] has been opened in a pale-green serpentine, so uniform in texture and free from quartz that it is sawed into shape for building purposes by a toothed circular saw nearly as rapidly as if it were

[169] *Proc. Acad. Nat. Sci.*, 1885, p. 407.
[170] *Ibid.*, March 25, 1890, p. 100, etc.
[171] C^4, pp. 63, 298, 299; C^5, Plates xiii and xiv. Probably more serpentine for building purposes has been obtained from this quarry than from any other in the United States.

wood. After sawing probably two square feet of surface in about three minutes, the teeth of the saw were quite cool to the touch. The rock is much jointed, so that there is a great deal of waste, but much valuable stone is procured. A feature of the outcrop is a huge mass of feldspathic rock, looking like a dyke. It is mostly plagioclastic feldspar with tourmaline and a little quartz. Occasional beryls occur.

The nearest visible rock southeast of the serpentine is on the Street road about .2 mile from the quarry, a spangled gneiss in thin beds, the partings being nearly plane surfaces.

In 1892 a cut was made southward into the quarry, giving a good exposure of the adjacent rock on the north. Next to the serpentine was a narrow selvage of decomposing chloritic rock, then a highly schistose gneiss, with abundant feldspar in rounded masses, then a vein or dyke of coarse very feldspathic granite, of which the mica, probably originally biotite, is now Jefferisite, then a decomposing schistose gneiss dipping N. 40° W. 65°, or away from the serpentine. East of Brinton's, trivial outcrops are said to occur within a mile.

About two miles northeast of Brinton's and east-southeast of the old Pleasant Grove schoolhouse, fragments of a light-colored serpentine are abundant in the soil. A small quarry for building stone was wrought in this vicinity on the farm of Mr. James S. Rhoads. It is now filled in. All these are almost certainly in direct continuation of the serpentine at Brinton's quarry, which, however, does not appear on Chester creek, less than half a mile to the eastward.

West of the Brandywine and south of the margin of the ancient gneiss are several outcrops. Of these, the most conspicuous is that at Pocopsin Schoolhouse, Pocopsin township, about a mile west-southwest from the Brandywine at Lenape. A hard dark serpentine forms two quite conspicuous hills, surrounded apparently by schistose porphyritic gneiss, and accompanied by a coarse tourmaline-bearing granite. Nothing but the serpentine is well exposed. West of this, a well-marked valley, occupied by Pocopsin creek and by a parallel public road, leading from Lenape to Marlboroughville, trends a little south of west, very nearly parallel with the Street road valley and with the southeasterly boundary of

Pocopsin township. In this valley are two well-marked outcrops of serpentine.

One of these lies southwest of Locust Grove and about 2.2 miles west-southwest of Pocopsin Schoolhouse upon a small branch of Pocopsin creek, quite near its mouth, and has an apparent irregular southeast dip. One measured was S. 45° E. ± 80°. The outcrop is small, but a quarry was opened on it. The serpentine is much jointed and rather light in color. No other rock is exposed near by. A little less than a mile to the eastward is a quarry in mica schist S. 20° E. 40°.

The other lies 1.25 miles further west-southwest, and about a half-mile nearly south of Marlborough Meeting-house in East Marlborough township, very near the head of Pocopsin creek. It is interesting because contact is shown with the garnetiferous mica schist on the northwest, dipping S. 30° W. 30°. The schist near the contact seems to have been changed in part into serpentine, and the strike changes suddenly from southeast to east-southeast. The serpentine is of a dull yellowish green and has been quarried to a small extent.

The two localities are on a line about a mile south of the Pocopsin Inn serpentine, which is near the margin of the ancient gneiss. About half-way between is an outcrop of talc schist, north of limestone on the L. M. Larkin farm, near the Pocopsin-Newlin township line and about a mile south of Northbrook Station, Wilmington & Northern Railroad In the adjacent soil are abundant fragments of mica schist and gneiss, with some highly feldspathic gneiss and some decomposing hornblende rock.

About a mile and a quarter northwest of Northbrook Station, hence northwest of the ancient gneiss, on the Lamborn farm, is an outcrop of serpentine and steatite, the latter used by the Indians for the manufacture of pots. The outcrop is not large. South of it is a ridge of garnetiferous mica schist dipping S. 30° E. 20° to 30°, so that we have here a very remarkable repetition of the rocks of Radnor and Lower Merion.

	Chester county.		*Delaware county.*	
N.	Limestone Schists,	Poorhouse quarry.	Limestone Schists,	Stacker's quarry.
	Steatite Schists,	Lamborn's.	Steatite Schists,	Judge Hare's.
	Serpentine,	Northbrook.	Serpentine,	Radnor Station.
	Ancient gneiss,	South of Northbrook.	Ancient gneiss,	South of Radnor Station.
	Serpentine Schists,	Pocopsin Inn.	Serpentine Schists,	Rosemont to Lafayette, Bryn Mawr.
S.	Serpentine,	Pocopsin creek.	Serpentine and steatite,	Soapstone quarry belt.

This may be only accidental coincidence, but it is curious.

There is an outcrop of talc schist and steatite very close to the west line of West Bradford township on Buck and Doe run, about a quarter of a mile from its mouth and about a mile south of Mortonville. There is mica schist on both sides; dips of N. 20° E. 45° and N. 85° E. 50° were observed.

Very recently Mr. Walter J. Baldwin pointed out to me an outcrop of serpentine apparently within the hydromica schist, or on its southern edge. It is on the Steele farm, near the west line of West Bradford township and a mile and a half northwest of Romansville, on the second road north of the Strasburg road and the first road south of the Highland road. It is light green in color, weathering nearly white. Most of it is intersected by numerous irregular joint planes along which decomposition has begun. The masses not so intersected are very tough. It forms the nose of a hill on the south side of the road, and is visible about 1000 feet east and west and 400 feet north and south, the hill striking about S. 70° W. No adjacent rock is exposed, the nearest being the hydromica schist.

In the southwestern corner of Chester county, extending thence into Lancaster county on the west and into Maryland on the south and southwest, is a series of very extensive outcrops, perhaps the best known of any in the State, as in them were Woods' chrome mine, Lowe's mine, the line pit, etc., the extensive sand chrome washings and the mines of magnesite, deweyite, etc., which supplied Powers & Weightman, as a source of magnesia for many years, and also Bye's serpentine quarry in Harford county, Md.

The latter was opened on a very uniform compact serpentine, about five miles from Conowingo on the Susquehanna. It is translucent, and from a pale to deep green, taking a high polish and making a beautiful ornamental stone, but the quarry was not successful, probably owing to the great waste caused by the numerous joint planes.

An analysis by Dr. F. A. Genth, quoted in a circular of the company, is as follows:

Silicic acid,	40.06
Alumina,	1.37
Chromic oxide,	.20
Niccolous oxide,	.71
Ferrous oxide,	3.43
Manganous oxide,	.09
Magnesia,	39.02
Water,	12.10
Magnetic iron,	3.02

S. G., 2.668; hardness, 4.

For many years these serpentine areas furnished all the chromium compounds used in the United States except very small quantities mined in Delaware county. The region has, consequently, been more carefully studied than the others, and I can add nothing of importance to what has been published.[172]

An outcrop of serpentine wholly within the ancient gneiss, and the only one so located, unless possibly that east of Radnor Station, which, if within, is very near the border, was discovered in the spring of 1899 by Miss Ogilvie, a student under Dr. Bascom at Bryn Mawr College. It is located near the Red Rose Inn, north of the Spring Mill road, and about two miles east-northeast of Villa Nova Station, a little west of the old Gulf road, and near the source of Aramink creek. This would be probably three-quarters of a mile from the northerly edge and a half-mile from the southerly edge of the ancient gneiss. The rock has been quarried for road purposes; no contacts are visible. The serpentine is quite uniform, of a dull yellow-green color and not hard.

Whatever doubt there has been as to the origin of the serpentines, petrographic studies seem to prove that almost, if not quite all, are derived from the alteration of a basic igneous rock, peri-

[172] William Glenn, *Trans. Am. Inst. M. E.*, XXV, 481; Dr. Frazer, C^4, pp. 341–345; Dr. Frazer, C^3, p. 89, etc., 170, etc., 190, etc.; Prof. Fred. D. Chester: "All the rocks of this belt can be traced back to an original pyroxenic magma erupted through the azoic schists which surround the belt" (*Second Geol. Survey of Pa.*, Annual Report, 1887, p. 105).

dotite, amphibolite or pyroxenite, except in the comparatively few occurrences in limestone. In several of the outcrops in this region the unaltered mother-rock may be found in all stages of alteration, and this macroscopically. This may be seen at Rose's quarry, opposite LaFayette on the Schuylkill, and to the westward, and on the same belt near Darby creek and in Marple; near the corundum mines in Newlin, Chester county, and at Radnor. At most localities the original rock seems to have been an orthorhombic pyroxene —enstatite or bronzite. In the neighborhood of Glen Riddle, southwest of Media, some of the serpentine is after actinolite.

There are some facts in relation to the serpentines in this region which have received no adequate explanation:

1. The occurrence of the dark pyroxenite serpentine on both sides and close to or within the ancient gneiss from the Schuylkill westward, but not eastward. If due to the alteration of an intrusive igneous rock, its occurrence along a definite horizon is remarkable. If a sheet, it should be more closely continuous.[173]

2. The occurrence of parallel belts of peridotite serpentine seprated by schistose rocks from the pyroxenite serpentine on both sides of the ancient gneiss.

3. The occurrence at many serpentine localities of an acid rock, chiefly of triclinic feldspar, in the form of veins or dykes. Can it be explained by magmatic differentiation ?

4. The occurrence at many localities of a massive amphibolite on the southeasterly side of the serpentine outcrops, at Willistown, near Newtown Square, Strode's mill, the soapstone quarry near LaFayette and the outcrops in southwest Chester county, resembling in this the dunyte beds of North Carolina.[174]

Besides the chromium, which is common in the enstatite serpentine, nickel has been found in very small quantities as sulphide, millerite and hydrous silicate, genthite, at the soapstone quarry, near LaFayette, and as genthite and also in wad and in pimelite northwest of Radnor Station.

Since the above was written I have found on the serpentine south of Newtown Square, Delaware county, a very dark-brown, almost black rock, apparently wholly unaltered and which appears to be

[173] Cf. *Proc. Acad. Nat. Sci.*, Phila., 1890, pp. 114, 118, etc.

[174] Dr. Julien, *Proc. Boston Soc. Nat. History*, Vol. XX, p. 11, Dec. 6, 1882.

hypersthenite;[175] some of the crystalline masses composing it are nearly an inch across.

Pegmatite.

In the schists and gneisses, particularly in the southeastern part of the area, are more or less irregular masses of pegmatite, usually composed of microlin, albite, quartz and muscovite, the minerals ocurring in abundance relatively as named, with biotite, tourmaline and garnet in small quantity, and more rarely beryl, autunite and other uranium minerals.

Some of these masses seem to occupy fissures in the gneiss with well-defined walls; others to be lenticular masses wholly surrounded by the gneiss, while others seem to grade imperceptibly into the gneiss. The first may be seen at Deshong's quarry on Ridley creek, northeast of Chester, where a large mass is exposed showing sharp but very irregular contacts with the gneiss. In this quarry, as indeed in all the quarries of that vicinity, pegmatite was comparatively abundant, but usually in isolated masses, many of them quite small. It occurred also in the Fairmount quarries, at Frankford, and indeed at almost every place near Philadelphia and Chester at which quarrying has been done extensively. It occurs in large quantity in the porphyritic gneiss, composed almost wholly of a reddish and a chalky white feldspar, with very little quartz and still less mica, with tourmaline rarely and none of the rare minerals.

In the more schistose rocks to the northwestward it is comparatively rare, though a large mass was quarried immediately southeast of the ancient gneiss near LaFayette, Montgomery county, almost wholly feldspar.

Southwest of Philadelphia it occurs at a number of localities, at some of which it has been mined extensively, mostly for use by manufacturers of china, etc. Most of these are open cuts, but at the largest, near Elam, southwest of Brandywine Summit, there are extensive underground workings. Most of these have been described by Prof. Thomas C. Hopkins.[176]

There are some localities in addition to those referred to by Prof. Hopkins that may be mentioned:

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175 Dr. Bascom in a private communication identifies it as hypersthene.
176 *Journal Franklin Institute*, July, 1899, Vol. CXLVIII, No. 1.

1. Chandler's Hollow. This was quarried about 1860–70, and yielded besides feldspar much muscovite, most of which was filled with markings of magnetite, making fine specimens, but ruining the mica for commerce. This was not far south of the Brandywine Summit mines, southwest of Elam.

2. Craig's Pits, about a mile and a quarter southwest of Chadd's Ford. This is an open cut into the side of a hill; the feldspar seems to be an irregular lenticular mass or vein with considerable muscovite. The feldspar seems of good quality and a very large amount has been quarried.

3. Butler's Pits, one-half mile south-southeast of Fairville Station. These are in level ground, and have been excavated to and below water level. From the size of the opening an immense quantity of feldspar must have been taken out, but when visited in 1897 work had ceased.

4. Swayne's Quarry. This is about half a mile south of Butler's. The pegmatite seems to be an irregular chimney-like mass, which has been followed to a depth of nearly one hundred feet. At this place the feldspar was subordinate to the muscovite, which when the mine was in full operation was obtained in crystals, some measuring eighteen inches across and being over a foot in length.

Much of it had the magnetite markings, but a large amount of valuable mica was obtained.

West of Avondale as well as north of it are several outcrops of pegmatite, one of which, immediately east of and in contact with the limestone of the Avondale lime and stone quarry, was wrought to some extent, but not largely. It seems to be a well-defined vein or bed, striking nearly northwest and southeast. At nearly or quite all of these the chief feldspar is microclin.

Adjacent to the serpentine areas are often outcrops of feldspar, generally, if not always, triclinic. Two only of these are now wrought, those in Newlin township near Unionville, and at Sylmar in West Nottingham. Some of the other outcrops have yielded cabinet specimens, but have not been tried commercially. That a mile west of Media has yielded fine sunstone and moonstone, beryl and columbite, some of the moonstone and beryl furnishing gems. That near Dismal run furnished a nearly transparent variety, as did also that at Brinton's quarry, Westtown, Chester county, and Blue Hill, Upper Providence, Delaware county, which furnished also the baryta-feldspar cassinite.

The feldspar from Sylmar resembles that obtained at the famous Dixon's quarries (and Way's quarry) in New Castle county, Delaware, but is remarkably tough and not easily cleaved, so that before crushing and grinding for market it has to be roasted.

Besides the locality mentioned by Prof. Hopkins near Boothwyn Station (Bunting's quarry, Bethel township, Delaware county), there are many outcrops in that township and the adjoining one, Chichester, which have been explored to a slight extent for their well-defined crystals of feldspar, garnet and beryl. One remarkable one south of Boothwyn was very slightly exposed in low ground on a small affluent of Naaman's creek.

It consisted almost entirely of microclin and quartz, but almost all the microclin was well crystallized, the crystals with rather rough surfaces, but sometimes complete and doubly terminated. They varied in length from an inch to a foot and were usually about twice as long as broad. Quartz occurred in the feldspar in the usual graphic granite form and also filled the interstices between the feldspar crystals. One specimen was nearly an octahedron in shape, with deep grooves parallel to a basal plane. This would seem consistent with the theory that the feldspar crystallized first, the quartz occupying the space remaining; but from the same place I have, imbedded in the microclin, a crystal of quartz of its own hexagonal form.

A little west of Boothwyn was a narrow vein or dyke about two feet wide in decomposed schists, composed of quartz and feldspar, in which were found fine crystals of garnet; this had perfectly straight well-defined smooth walls, striking N. 35° E. nearly vertical.

The feldspars of this region are worthy of careful and systematic study.

At a number of localities the pegmatite has decomposed and become wholly kaolin. Many of the pegmatite outcrops show much kaolin, but at none of the kaolin outcrops have I seen undecomposed pegmatite. There is, however, much intermixed quartz and mica, but both almost always in very small masses, little more than sand.

There is, however, no appearance of water sorting, the quartz, mica and kaolin being evenly intermixed. It would appear, therefore, as if the pegmatite which gave rise to the kaolin was a much finer grained rock than that quarried for its feldspar.

Prof. Hopkins, in the paper already referred to, has described the kaolin deposits. There is one curious fact to which I would call attention—the occurrence of limestone with nearly every kaolin deposit, viz., near Glen Loch (Chester Valley), Kaolin (Broad Valley), near Avondale, Hockessin, Elam, and also at Peach's kaolin mines in Delaware, south of Hockessin. At all these six localities limestone occurs close to the kaolin. The Wagontown locality may be an exception, but inasmuch as the Cambrian sandstone which underlies the limestone occurs just north of Wagontown, the probability is that it is not an exception, simply that the limestone is not exposed.

Trap Dykes.

There are in Pennsylvania, southeast of the vicinity of the Red Rocks, two well-defined trap dykes, besides a number of exposures of igneous rocks not yet reducible to a system.

Fig. 8.—Columnar Diabase. The Gulf, Montgomery Co., Pa.

The easternmost of these is the well-known Conshohocken trap dyke, specially studied by Prof. H. Carvill Lewis, and thought by him to have a linear extension of some eighty miles, though usually less than a hundred feet in breadth. Its best exposures are at Conshohocken and at Gulf creek. At West Conshohocken there was exposed an offset cutting the hydromica schists to the eastward of the main mass. It was only two or three feet in breadth. No change in the adjacent schist was observed.

The columnar structure is best shown at Spring Mill and at the Gulf, as well shown in Fig. 8, from a photograph taken by Dr. Charles Schäffer. A remarkable feature is the absence of any noticeable change in the rocks cut by it. Its strike is very nearly that of the limestone, mica schist and hydromica schist, but it passes through all of them. Near Flourtown it is in the limestone of the Plymouth Valley. It then crosses acutely from the north to the south side of the hydromica schist hill, and in the cut of the Schuylkill Valley Railroad at Conshohocken is in the southeasterly limestone (that of Cream Valley). Directly across the river, in West Conshohocken, it is again in the schist.[177]

Near the Delaware county line it crosses the limestone, being north of it at the Gulf, and south of its course north of St. David's Station, where it is in or on the margin of the garnetiferous mica schist, and this seems to be its position also at Wayne, where it is exposed in the railroad cut northwest of the schist and southeast of Cambrian sandstone. West of Wayne the outcrops are not continuous, but when found are in the comparatively low ground between the ancient gneiss hill on the southeast and the hydromica hill on the northwest. In Willistown township, Chester county, immediately west of the Easttown line, it appears on the road next south of the State road, and apparently exists in three separate branches, one north of the serpentine, the next in it and the next south of garnetiferous mica schist. All are within a thousand feet. The dyke crosses the State road close to the easterly line of East Goshen, and thence westward appears to be on the north border of the serpentine, though north of Goshenville it cuts it. Northwest of the Gen. Greene Hotel the serpentine appears to end in a rounded hill and the trap is concealed. South-

[177] The exposure on the east side of the river indicated that the limestone underlies the schist at that point, both having, however, nearly the same dip as if folded or rather crumpled together.

west of this the trap may be traced, but no serpentine until the east line of West Goshen is crossed. About a mile west of this line, and near the Pennsylvania Railroad, the serpentine again appears in great quantity, with the trap on the northerly side. Thence westward the trap skirts the north side of the serpentine ridge to its termination near Hoopes' mill. On the road passing the mill, the continuation of New street, West Chester, exposures are poor, but loose masses of serpentine are north of trap masses; this is near the westerly line of West Goshen. In East Bradford, which adjoins, the trap is prominent on the side of the hill north of Cope's limestone quarry and south of Copeland Schoolhouse. A half-mile to the westward is the East Branch of the Brandywine, on which just north of Cope's bridge loose masses are abundant, but the outcrop here appears to be somewhat south of the strike of the easterly outcrops. West of Cope's bridge it is conspicuous along the Strasburg road toward Marshallton, West Bradford. Southeast and southwest of Marshallton it is exposed nearly in line with the outcrops on the Strasburg road, but also northwest of the serpentine at Worth's in East Bradford, about a mile southeast of Marshallton, considerably south of the outcrops on the Strasburg road. West of this is the valley of Broad run, but I am not aware of any exposures until the Newlin serpentine is reached. This is about two miles west-southwest of the outcrops near Marshallton. Going west-southwest the first exposure is on a small affluent of the West Branch of the Brandywine about three-quarters of a mile west of Northbrook. Close southwest of this are two roads about a quarter of a mile apart leading nearly south from Glen Hall to the State road. On the easterly are serpentine, pegmatite and mica schists, while on the westerly is a large outcrop of trap, in loose masses only. Between these roads is the locality famous for its large beryls, giving name to the elevation, Beryl Hill.

West of Beryl Hill is Corundum Hill. On its easterly flank and near the summit there is much trap, but only in loose fragments apparently within the serpentine.

About a mile and a half nearly southwest of Corundum Hill, and about a half-mile southwest of Unionville, there are outcrops along the State road a little northwest of the diverging from it of the Little Street road.

Thus far the outcrops are probably of the Conshohocken dyke much interrupted and somewhat curved, but the outcrops to the southwest are scattered and not referable to a line. The northeastern one is about two miles nearly west of that last mentioned, and a little west of the E. S. Baily limestone quarry west of Marlborough Inn (Upland). This also is on the State road, and is about a mile west of the east line of West Marlborough. On the same road a mile further west is another outcrop.

About a mile south of the State road is the Street road, on the line between West Marlborough and London Grove townships. Along this road are several outcrops, the easternmost nearly south of the outcrops on the State road last mentioned. The next is a half-mile further west near Woodville, the next three-quarters of a mile further west and a little east of the Pomeroy & Newark Railroad, both on the Street road and on a lane running south from it.

All these outcrops west of Unionville are of loose masses only and none of them are extensive. To the southwest are other similar outcrops, some of which are probably continuations of the dyke next to be described.

THE DOWNINGTOWN DYKE.

This dyke was described[178] as extending in a nearly straight line from a bold outcrop on the Brandywine, over twenty feet high at Downingtown, in a south-southwest direction into Penn township, being largely exposed only occasionally, as on the Brandywine in Downingtown and on the Pennsylvania Railroad a quarter of a mile west of Downingtown Station, where a cut some twenty feet in depth has been made through it, but clearly to be traced by intermediate loose masses. It is here probably 125 feet in width, with limestone visible ten feet east of it and very little further west of it, and strikes about N. 15° E.[179]

[178] Rand, *Proc. Acad. Nat. Sci.*, Philadelphia, 1895, p. 540.

[179] Dr. Frazer, *Proc. Acad. Nat. Sci.*, 1896, p. 206, apparently regards my brief description of this dyke as a reflection upon his work, saying that "he refrained in a great many instances from connecting together scattered localities where trap fragments occurred, on the assumption that these represented a dyke, because he was often unable to assure himself that these fragments where anywhere near the place of their origin," and, further, "the second dyke which begins in Downingtown is probably the same to which the following reference is made (C^4, p. 274); at several points on the

Recently Mr. Walter J. Baldwin, formerly of Romansville, and now Professor in the Manual Training High School of Brooklyn called my attention to the fact that the dyke does not end with the outcrop on the Brandywine, and took me to a series of outcrops extending in a north-northeast direction for a distance of three miles up and over the summit of the North Valley Hill, the trap being in a nearly straight narrow line and in quantity. For this distance there seems no reasonable doubt of the continuity of the dyke.

The road to Lionville diverges nearly north from the Lancaster turnpike at a point about .7 mile east-northeast of Downingtown railroad station. After going north a little over a half-mile, it turns north-northeast. Near this bend the dyke may be seen crossing the bend—*i.e.*, crossing the road twice and bearing a little more northwardly than the road. A quarter of a mile or less beyond this curve, a road goes northward through the woods. The dyke crosses this road, a little north of the road to Lionville. Further north there is an east-and-west road, on or very near the north line of East Caln township. On this road, about a quarter of a mile east of the woods road, it is again apparent on the land of Jacob Lewis, and Mr. Baldwin informed me that it occurs also on the intermediate land of Clara Fox. Beyond this I did not follow it, but Mr. Baldwin states that he has traced it across Uwchlan township, south of the graphite mines near Byers' Station, across West Vincent, crossing the two branches of Birch run a little west of Birchrunville, crossing French creek at Cook's ford in East Vincent township, and close to Brownback's Church on the Ridge road in East Coventry, the Schuylkill at Frick's lock below Sanatoga Station, and through Sanatoga Park to the

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road leading south from the Downingtown railroad station occur fragments of trap."

In the paper referred to the writer intended and made no criticism of any one, but it seems to him that to identify "fragments of trap" on the road south of Downingtown Station with a dyke more than a hundred feet wide, quarried to a depth of many feet, west-northwest and southwest and not south of Downingtown, is possible only upon the assumption that Dr. Frazer never saw the exposures. No geologist can be expected to see everything. It will be many years before it will be difficult for new facts to be discovered.

The writer would also contend that in a non-glaciated region numerous trap masses in a straight line with a large and unmistakable dyke, all being of a uniform coarse diabase, are evidence of connection though possibly not of the absolute continuity of a dyke.

large outcrop at Pruss' Hill, Montgomery county. If the dyke is continuous, of which there seems little doubt, it is triassic diabase, an offshoot from the great outbursts through the Red Rocks near Pottstown, and must be more than thirty-four miles long. Near Downingtown, concentric or boulder decomposition is well shown in the sides of the railroad cut.

Southwest of Downingtown the dyke is exposed at intervals toward and at Mortonville, also on Buck run and northwest and southwest of Doe run village, thence almost continuously and very largely to the south bend of the Pomeroy & Newark Railroad. Thus far there seems no reasonable doubt that all the outcrops should be referred to one dyke. The next two are probably, but not certainly, of the same; one of them is on the line between London Grove and Londonderry townships, very near the northwest corner of Penn, and about two miles west of Chatham. It is small, as also is the next, a mile south-southwest on the road from West Grove to Daleville, .1 mile east of Townsend's mill, but these probably belong to the same.

The next two are about five miles west-southwest on branches of Big Elk creek, respectively a half and three-quarters of a mile southwest of Lincoln University.

The rock at all these outcrops is a diabase. That of the Conshohocken dyke, uniformly fine-grained in texture, has been described by Dr. Bascom.[180] That of the Downingtown dyke is much coarser in grain, and very much alike at all the outcrops. That near Baily's quarry is of much finer grain, finer even than that of the Conshohocken dyke, as is also that east of Townsend's mill, while that west of Chatham and also that at the Street road and Pomeroy & Newark Railroad is intermediate.

That of the easterly outcrop on Big Elk creek seems to have much less feldspar than the others, while that of the westerly shows a coarse variety and also one very fine-grained.

Inasmuch as the coarseness or fineness may be due simply to slower or more rapid cooling it cannot be regarded as an important feature. Indeed, as a rule we should expect to find a coarser grain in the middle portions of a dyke and finer towards the edges, as indeed is the case at Downingtown, but the persistency of the character in the Conshohocken and Downingtown dykes is remarkable.

[180] Dr. F. Bascom, *Proc. Acad. Nat. Sci.*, Philadelphia, 1896, p. 220.

In the ancient gneiss are numerous dykes of trap, usually small and not to be traced any distance. Some were very clearly exposed in Johnson's quarry at Wayne. Here the trap, a fine-grained diabase, was from an inch to a foot in breadth, and could be seen to fork, to include masses of the gneiss, etc. Some of the dykes are hornblende schist, and are suggested by Dr. Bascom[181] to be altered diorites. Dykes of norite also occur, one near Van Artsdalen's quarry in Bucks county,[182] and one on the property of Miss Brown near the crossing of the Lancaster turnpike by the Radnor and Chester road, about .3 mile south of Radnor Station, identified by Dr. Bascom. Thin sections shown by her before the Mineralogical and Geological Section of the Academy of Natural Sciences show very beautifully the reaction rims of garnet around the crystals of pyroxene. About a third of a mile northwest of Radnor Station occurs a diabase (determined by Dr. Bascom) in the ancient gneiss, of coarse texture and having a reddish tint. Besides those mentioned there may be named the following prominent outcrops:

Railroad cut east of Radnor Station.

Erben's, Ithan creek, northwest of the Radnor and Chester road, Radnor.

Ellison's, Ithan creek, north of the Roberts' road.

Montgomery avenue, east of the Spring Mill road, Lower Merion.

State road, west of Pocopsin Inn, East Marlborough township, Chester county.

All these are apparently diabase, or diorites altered into hornblende schist.

In northern Chester county, besides the great outcrops of diabase in the north, there are scattered outcrops which remain for further examination. The more important may be mentioned:

1. Williams' quarry, near Aldham, Charlestown township, Chester county,[183] a gabbro in a very distinct dyke about 100 feet wide with porphyritic feldspar crystals.

2. A porphyry, near Barneston, Chester county.

3. South of Honeybrook, two outcrops, the northerly weathering

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[181] Private communication to the author.

[182] Dr. J. F. Kemp, *Trans. N. S. Acad. Sci.*, Vol. XII, p. 71, February, 1893.

[183] *Proc. Acad. Nat. Sci.*, Philadelphia, 1895, p. 540.

white and looking like chalk flints, instead of the usual rusty yellow.

4. Beaumont's quarry, near Glen More.

5. J. H. Schrack's, West Caln, altered diorite, about three-quarters of a mile north of West Caln Meeting-house.

Other Igneous Rocks.

When we shall have a careful microscopic study of sections of the rocks of this region doubtless many rocks now doubtful will be found to be igneous or derived from igneous rocks, but at present a few only can be identified.

Prominent among these is the gabbro which, entering the State from Delaware, itself, with its accompanying hornblende rocks, spreads over much of the southeastern part of Delaware county, and apparently sends tongues into the mica schist and gneiss areas. Surface decomposition renders accurate mapping almost impossible. Some exposures, as near Concordville and Locksley Station, Delaware county, look as if comparatively thin dykes or sheets had been intruded into gneisses, after which both had been folded and crumpled.

The gabbro proper is well exposed at Claymont, Del., just over the line. A variety consisting almost wholly of a triclinic feldspar forms a part at least of Cedar Hill, in Bethel township, near the northwest corner of Chichester. In this region pegmatites are abundant but not well exposed.

There are exposures of a trap-like rock in Middletown township, Delaware county, about a mile northwest of Lima. The large loose masses forming the outcrop extend N. 60° W. nearly a half-mile.

A still smaller outcrop occurs in Edgemont township, one mile northwest of Cheyney Station, about two feet wide, and striking near north and south in hornblende and feldspathic gneiss.

Conclusion.

In the whole region southeast of the Red Rocks three localities only are known to have yielded fossils in rocks in place. The North Valley Hill sandstone in some places, notably west of Valley Forge, shows abundance of *Scolithus*. The same fossil was found by Dr. Frazer at Avondale, Chester county.

Fossiliferous pebbles occur in the Delaware river gravels, also on the northeast slopes of Barren Hill, where *Scolithus* was found abundantly in large pebbles of the Cambrian sandstone, the source of which is obscure. They were exposed by the digging out of material for the Roxborough reservoir.

There should be mentioned also the fossils found in Shainline's quarry south of Henderson Station, referred to on page 204. In 1899 Mr. Lewis Woolman discovered in the limestone of this quarry what appear to be fossils resembling some of those in the orbicular quartzite. They were exposed by the weathering of the rock. Mr. Woolman thinks them suggestive of the flat-coiled forms such as *Raphistoma*, etc., rather than the elevated spiral forms like *Murchisonia*.[184]

The important locality is that described by C. D. Walcott, *Amer. Jour. Science*, XLVII, January, 1894.

It is north-northeast of Gap, Lancaster county, Pa., where in a sandy stratum in the limestone fragments of *Olenellus* and a species of *Obolella* were found. These identify the limestone of the Pequea Valley, a part of the great Lancaster county limestone region, with the Cambrian. As there seems no reason to doubt the identity of the limestone of the Lancaster and Chester Valleys, this would seem, as stated by Mr. Walcott, to identify the Chester Valley limestone as Cambrian, and the underlying sandstone as Lower Cambrian.

Accepting, then, that the sandstone of the North (Chester) Valley Hill is lower Cambrian, are we justified in assigning the scattered outcrops of similar rock to the same? It must be admitted that lithological evidence is untrustworthy, but in this case we have a peculiar rock, not only in the constituents, but also in its aggregation, and also in the fact that its characteristic tourmalines are always stretched and broken. The possibility that such rock should occur abundantly at two different horizons is remote.

Not only is there the lithological evidence, but also the stratigraphical, that the peculiar sandstone is almost always overlaid and underlaid by schists, and that above the upper schist almost invaria-

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184 Personal communication to the author.

bly a limestone is found. I think, therefore, there is little doubt that all the limestone and tourmaline-bearing sandstone may be considered of Cambrian age.[185]

The schists and gneisses present a more difficult question, which may be subdivided:

1. the age of the hydromica schists of the South (Chester) Valley Hill—in other words, are they above or below the limestone ?

Dr. Frazer believed the schists to have been uplifted by a fault running along the south side of the valley, and that the southerly limestone was probably once continuous over the South Valley Hill.[186]

This hypothesis necessitates making the hydromica schists continuous with the very different rocks of the North Valley Hill, at times only a little over a quarter of a mile off, each having a thickness of certainly much over a half-mile, which constituted one of the gravest objections to Prof. Rogers' theory that the valley was a synclinal and the north and south hills of the same age, the sandstone of the north hill represented by small sandstone outcrops on the northerly foot of, the south hill, the lower primal slates by the hydromica schists. This view has not been held by any later geologist and need not be discussed further.

Mr. Hall, demonstrating the synclinal structure of these schists at their northeastern end, where they very clearly lie in a basin of the limestone, which in its turn is surrounded north, east and south by the sandstone, and it by the ancient gneiss, argued that its continuation westward must be a synclinal overlying the limestone; the underlying synclinal of the limestone, however, is shown in his sections in C^6 to extend to the left bank of the Schuylkill only, on the right bank and also a mile to the westward to be cut off by a fault, the syenite underlying the limestone and in depth abutting against the hydromica schists at the fault line. Had Mr. Hall found the sandstone south of the limestone at Gulf Mills, I believe his sections G^1 and H would have conformed at this point to his section G.

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[185] There is confirmation in Dr. Frazer's interesting discovery of *Scolithus* in the sandstone adjacent to the limestone in London Grove township south of Avondale. C^4, p. 324.

[186] C^4, p. 303.

Prof. Lesley, agreeing with Mr. Hall as to the structure east of the Schuylkill, agrees in part with Dr. Frazer that at or west of the Schuylkill a great fault raises rocks *underlying* the rocks of the North Valley Hill belt above the surface to form the South Valley Hill.[187]

If this fault really exists and is of magnitude so great and so extensive east and west, it is strange there is not clearer evidence of it. Would it be possible, if it exists, for the dips in the limestone and the hydromica to agree as well as they do? Thus Dr. Frazer gives (p. 269) "along the south border of the Salisbury township limestone belt . . . . S. 10° E. 70° gneiss" (layers in limestone, p. 268), "S. 10° E. 40°; mica schist S. 53°, S. 15° E. 85°. . . . . The dips in the eastern part of the township are S. 10° E. 80°, S. 10° E. 60°, S. 30° E. 60°, S. 60° to 80°, etc."

"East Caln . . . . the dips in the belt of mica schists which passes south of the limestone vary in strike from E. 10° N. to E. 30° N. and from 80° to vertical. Some of the dips in the limestone are as follows: S. 10° E. 85°, S. 10° E. 60°; strike E. 10° N. vertical (= dip S. 10° E. 90°)," pp. 273, 274.

"West Whiteland . . . . schists ± S. 10° E. 80° . . . . limestone . . . . shows very constantly throughout its entire extent dips of S. 10° E. 70° to 85°," pp. 274, 275.

"East Whiteland . . . . Indian King road" (which is on the hydromica hill) . . . . "the dips at first all lie between or near S. 10° E. and S. 30° E. ± 80°." An exception is noted: "Along the main track of the Pennsylvania Railroad numerous dips in the same strata agree at about S. 10° E. 75°."

Dr. Frazer then gives dips in the limestone S. 15° E. 85°, S. 15° E. 80°, S. 15° E. 75°, S. 15° E. 85°, S. 20° E. 78° (pp. 275, 276).

These dips with others are tabulated in C^4 (pp. 119 *et seq.*). If a fault exists it should be brought out by these tables, but they seem to show greater accordance than is common through this region, particularly on pp. 121, 122. Sixteen pairs of southeast dips being tabulated, seven agree, two show western convergence, seven eastward convergence. The table of dips is remarkably accordant. Abbreviated it is:

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[187] *Final Report*, I, 174.

	In the Schists.	In the Limestone.
Northward, 73° and less, . .	3	2
85° to 90°, . .	4	4
Southward, 80° to 85°, . .	8	9
70° to 80°, . .	7	7
60° to 70°, . .	1	6
50° to 60°, . .	4	2
	27	30

The arguments in favor of the fault seem to locate it at the north foot of the South Valley Hill.[188] By Prof. Lesley's theory it must be sufficiently profound to uplift the schists from a position beneath the North Valley Hill rocks, and by that of Dr. Frazer to uplift some two miles of schists. What becomes of it eastward and westward ? Near King of Prussia the straight southerly line of the limestone ends, the hydromica curves gently southeast, forming two promontories, the limestone following, forming, as it were, a bay extending more than a mile south of a line in prolongation of the north foot of the hill in Chester county.

At McFarland's mills, where the Gulf creek flows northward through the hydromica schist hill, the margin resumes its east-northeast direction to the Schuylkill, still bordering as before the hydromica schist hill, which has narrowed to less than half a mile. A fault, to satisfy the conditions, would be of incredible shape.[189]

Mr. Hall's view that the hydromica schists are synclinal over the limestone was controverted by Prof. Lesley:[190]

188 "The existence of such a fault would make it easier to comprehend the very extraordinary straightness of the south edge" (C^4, p. 113).

"Valley limestone, ... terminating eastward at Willow Grove in Montgomery county and westward at Quarryville in Lancaster county. Its extreme length is fifty-five miles in an almost perfectly straight line N. 18° E." (C^4, p. 112).

Mr. Hall's map C^6 shows clearly that east of the King of Prussia the line is very far from straight. Particularly is this true of the portion just west of the Schuylkill.

189 Rand, *Proc. Acad. Nat. Sci.*, Phila., 1892, p. 445.

190 C^4, 115 *et seq.*, who sums up the arguments pro and con briefly as follows:

In its favor—1. The acknowledged synclinal structure in Montgomery county.

2. The apparent necessity for considering it synclinal at Quarryville.

3. If synclinal "we can comprehend the existence of outlying troughs of limestone still further south."

4. The fact (?) that the limestones at the foot of the south hill are non-magnesian.

Against it—"Merely transferring the difficulty a few miles south, viz.: to the southern edge of the talc mica schist belt."

The *first* argument in its favor is so cogent as to be irresistible in the absence of a most remarkable and almost impossible fault.

The *second* is of force if we admit that the limestone cannot thin out, but as we find it does become exceedingly thin in some places compared with others adjacent, why may it not thin out and disappear under the hydromica, which would then rest upon the newer schists and gneisses?

The *third* is not of great force. The southerly outcrops can be reconciled with any of the theories.

As elsewhere stated, Dr. Frazer thinks them an argument in favor of his theory.

The *fourth*, in view of the fact that the composition of the limestone varies so greatly, would require many more analyses to establish its basis, and certainly the arguments in C^4, pp. 103 and 117, are fallacious, for the "talc mica" contains little or no magnesia and cannot properly be called "intensely magnesian."

The argument against it seems rather to be in its favor, for it admits a line of limestone outcrops consistent with Mr. Hall's theory, giving them, however, no weight because they do not compare (in extent it is to be presumed) with those of the valley.

A glance at Mr. Hall's map in C^6 shows very plainly the admitted synclinal of the limestone northeast of the Schuylkill, the northerly leg two miles in width, the southerly less than one thousand feet. Even the latter, I think, is excessive. This is roughly as ten to one. Now as the Chester Valley limestone narrows to a quarter of a mile and perhaps less, the corresponding width of the southern leg would be but 132 feet, a width that is certainly much exceeded at the Poorhouse and Guest quarries. The narrower the outcrop, too, the greater the probability of concealment by the erosion of the limestone and the falling in of the adjacent rocks.

But not only do we find the limestone, but also accompanying it the sandstone, in scattered outcrops and very thin, it is true, but with its peculiar and definite characteristics.

It is true we meet with one difficulty: to the eastward the sandstone is southeast of the limestone and close to it; to the westward, to the northwest of it with an area of schists between. Exposures are not good and no explanation at present appears.

It will be noticed that in southwest Chester county that the sandstone, while at somewhat varying distances from the limestone, is much closer to it if regarded as underlying. If so regarded we have here five successive outcrops of limestone underlaid by sandstone within five miles, all dipping nearly alike. The explanation of this must be by abler hands than mine. Repetition by close folding is not likely with dips so regular and gentle; of faults there is no evidence.

2. The Age of the Mica Schists.

A. Can they be clearly distinguished from the hydromica schists?

As already stated, there is no difficulty in tracing a line with gentle curves northwest of which are hydromica schists only, while to the southeast are the mica schists. That the hydromica schists widen westward and attain a width of twelve or thirteen miles on the Octorara[191] is not the fact, unless no distinction be made between the soft smooth nacreous and unctuous schists of the South Valley Hill and the hard rough mica schists well exposed on all the creeks from east of the Brandywine to west of the Octorara. The following table of dips in the two rocks is instructive:

Locality of Mica Schist.	*Dip Mica Schist.*	*Dip Hydromica Schist.*	*Locality Hydromica.*	*Distance Apart of Measured Outcrops, Miles.*
West Conshohocken,	S. 28° E. 74° S. 20° E. ±90°	S. 15° E. 85°	West Conshohocken,	0.2
Near Water Works, Eagle Road, Radnor,	S. 23° E. 70°	S. 10° E. ±90°	Creek South of same,	0.1
W. of Greene Hill Station, W. Goshen,	S. 23° E. 60°	S. 10° E. ±90°	S. of Kirkland Station.	0.8
Wrangle S. H., W. Goshen,	S. ±25° E. 50°	S. 40° E. ±90°	1 mile N. W. of Wrangle S H.	1.0
McMinn's Mill, E. Bradford,	S. 25° E. 45° S. 30° E. 60°	±90°	Half mile N. of McMinn's,	0.5
Hawley's Mill,	S. 35° E. 45° S. 70° E. 25° S. 45° E. 40° S. 45° E. 65°	S. 40° E. 85° 90°	North of Hawley's Mill,	0.1
Broad Run,	S. 15°	S. 40° E. 70°	Broad Run,	1.
West Branch near Modena,	S. 20° E. 50° S. 10° W. 20°	S. 30° E. 55°	Opposite side of creek,	0.2
Buck Run N. of Newlin Sta.,	S. 25° E. 35°	S. 50° E. 80°	Buck Run N. of Newlin Sta.	0.1

[191] C[4], p. 14.

B. The Relation of the Mica Schists to the Sandstone. We find mica schists both above the Cambrian sandstone, between it and the limestone, and also above the limestone, so that we have at least three horizons. Those below the sandstone are best seen near London Grove, Chester county; those above it, at the south foot of the North Valley Hill from Caln Meeting-house westward to the Octorara; those above the limestone at the Poorhouse quarry, Chester county, and at the quarries of the Avondale Lime and Stone Co., west of Avondale, Chester county, Pa. Those near the sandstone are sandy, not very micaceous and not garnetiferous, these above the limestone much more micaceous, frequently quite garnetiferous, in both cases conformable almost without doubt; but there is much variety, and between visible outcrops of the sandstone and limestone are large areas apparently wholly of mica schists, which are usually to be seen only as abundant fragments in the soil, but occasionally in extensive outcrops, and which cannot with certainty be placed above or below the limestone. These frequently contain garnets and occasionally staurolite and kyanite.

While in some cases these minerals may be due to contact metamorphism, as, for instance, in the vicinity of the soapstone quarry on the Schuylkill, in most of the region plutonic rocks are absent from the garnetiferous schists. In Cream Valley and westward the garnet and staurolite-bearing schists are near the Conshohocken diabase dyke, but where its contacts can be observed, as on the Schuylkill, in West Conshohocken and at the Gulf, the adjacent hydromica schist and limestone appear to be unchanged. The exposures suffice only to prove that much of the mica schist is of the age of the sandstone or more recent. In Chester county, at least, there appears to be no evidence whatever that any of the mica schists are older than the lower Cambrian. The same is true of the schists northwest of the ancient gneiss (Cream Valley and westward).

The schists of the valley between the forks of the ancient gneiss in Newtown, Edgemont, Willistown, Westtown etc., can be traced continuously into the sandstone and limestone region of Chester county without essential change. Similar schists are found on the southerly side as well as the northerly of the gneiss. On the southerly side they are very sandy, resembling those adjacent to the sandstone, but further south and especially eastward they are highly garnetiferous, like those of Chester county associated with the limestones. The schists may be traced northeastward until at Glenside and in Huntingdon Valley, Montgomery county, we find them apparently overlying the sandstone and limestone.[192] Mr. Hall placed the sandstone and limestone in the upper Cambrian or lower Silurian and contended that these schists cannot be below the Hudson river group,[193] but the limestone being recognized as Cambrian, there seems no reason to doubt the adjacent schists being of that age.[194]

3. Are the hard gneisses of southern Delaware and Chester county of the same age as those of the Buck Ridge, or more recent?

My reasons for thinking they are more recent are:

A. The lithological difference which has already been discussed. This would have been of little weight in districts widely separated, but here we have a hill of gneiss of similar lithological character fifty miles long and at times five miles broad, and with another belt of similar rock stratigraphically connected to the northeastward, while the gneisses and gabbros of southern Delaware county, only one to three miles distant southward, are lithologically very different and maintain this difference throughout their whole extent.

B. These gneisses can be traced eastwardly among the schists, the gneisses diminishing, the schist increasing, until they are reduced to narrow beds interbedded (or interlaminated) in the schists.

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[192] Charles E. Hall, C^6, p. 62.

[193] C^6, p. 9.

[194] Dr. Frazer, in an argument against Mr. Hall's views (*Proc. Am. Philos. Soc.*, December 15, 1882, p. 517), says: "There are small tongues and isolated patches of Laurentian rocks occurring in the midst of these southern schists. One comes into Chester county from the east in Easttown and Tredyffrin townships and another occupies a small area near West Chester. These patches are bordered on all their sides by these schists with no intervening rocks. The bordering rocks therefore cannot belong to a group above the Potsdam and the Lower Silurian limestone."

This does not agree with my observations. The ancient gneiss does come into Chester county from the east as stated, but it is about five miles wide at its entrance into Chester county, and the tongue which underlies West Chester is from one to three miles wide and extends west of the Brandywine, continuous and frequently exposed. I have been over the area carefully and have been able to find no isolated patches surrounded by schists. It is true, however, that between the ancient gneiss and the schists the sandstone and limestone do not occur, but they do occur in the schists close to the contact line.

4. What light can be thrown upon the age of the schists and gneisses embraced in Prof. Rogers' first and second groups at the Schuylkill and extending thence northeastward and southwestward ?

The advance of geological science has taught that schistosity, formerly thought to be evidence of stratification, may be due simply to dynamic and metamorphic agencies, and that one frequent result of such alteration, when not carried to an extreme, is the formation, from a more massive rock, of augengneiss or gneiss containing eyes or lenses of quartz, feldspar or other mineral having a more or less drawn-out appearance. This is very common in this region.

The remarks of Mr. Charles R. Keyes[195] in regard to the Maryland Piedmont plateau are most pertinent: "From all appearances the gneiss area was originally largely granitic, but through the agency of the enormous orographic pressure has been squeezed into its present gneissic condition."

If we concede that this granite was penetrated by dykes or sheets of basic rocks, the abundant hornblende schists may be readily accounted for. In the ancient gneiss some of the dykes are now hornblende schist, though retaining their clear dyke form with sharp contacts. The exposures in or near Concord seem to indicate that such intrusions exist.

But we certainly have in the region clastics, besides the Cambrian sandstone proper. It and the schists accompanying it and conformable with it, together with the limestone and the schists overlying it, are certainly of sedimentary origin. But in Brooks' quarry, Radnor, the rocks between the sandstone and the limestone are distinctly gneissic and apparently porphyritic, though many layers are schistose. Here pebbles of the ancient gneiss clearly attest the action of water. These are among the rocks which can be traced westward and southward around the ancient gneiss, and then eastward across the Brandywine and into Delaware county.

But the sandy mica schists and garnetiferous schists, accompanied by the sandstone as far as the southwesterly border of Delaware county, can themselves be traced almost continuously further eastward, the breaks of continuity being not great, until they come

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[195] *Bull. Geol. Soc. Am.*, II, 321.

again into contact with the typical sandstone and the limestone in Montgomery county.

But there are also hard gneissic rocks, both hornblendic and feldspathic, almost always more or less schistose and dipping with the adjacent schists.

Would not the conditions be satisfied by a theory that after the deposition of the sediments they were deeply buried, penetrated by intrusions of granite and basic eruptives, subjected to intense dynamic action, of which the record is left in the plications and close foldings, sheared and faulted, until almost all trace of the original rocks is lost, and a general schistose structure more or less parallel to the strike of the ancient gneiss was developed ?

A change in the direction of the compressing force would account for the remarkable change of dip observed east and west of the vicinity of Darby creek.

MARCH 6.

MR. CHARLES MORRIS in the Chair.

Fifteen persons present.

Papers under the following titles were presented for publication:

"Contributions to the Life-History of Plants. No. XIV." By Thomas Meehan.

"The Biddulphoid Forms of North American Diatomaceæ," by Charles S. Boyer, A.M.

The deaths of F. L. Harvey, a member, and of Hans Bruno Geinitz and William A. Hammond, M.D., correspondents, were announced.

JOHN W. HARSHBERGER, PH.D., made a communication on the history of botany in Philadelphia. (No abstract.)

Dr. Pilsbry withdrew a paper entitled "Notes on some Southern Mexican Shells," presented for publication December 26, 1899.

MARCH 13.

The President, SAMUEL G. DIXON, M.D., in the Chair.

Eighteen persons present.

A paper entitled "Notes on Ameiurus prosthistius," by Henry W. Fowler, was presented for publication.

MARCH 20.

MR. CHARLES MORRIS in the Chair.

Eighteen persons present.

The death of Stephen P. M. Tasker, a member, was announced.

MR. FRANK J. KEELEY made a communication on the motion of diatoms. (No abstract.)

MARCH 27.

The President, SAMUEL G. DIXON, M.D., in the Chair.

Twenty-one persons present.

Papers under the following titles were presented for publication:

"Preliminary Notes on the Rate of Growth and on the Development of Instincts in Spiders," by Annie Bell Sargent.

"New South American Land Snails," by Henry A. Pilsbry.

"Subterranean Waters," by Charles Morris.

A resolution was adopted approving of a modification of the deed of trust of the HAYDEN GEOLOGICAL MEMORIAL FUND, whereby a gold medal will hereafter be awarded every three years, instead of, as heretofore, a bronze medal and the surplus interest of the fund annually.

John W. Harshberger, Ph.D., and John H. Converse were elected members.

The following were ordered to be printed:

CONTRIBUTIONS TO THE LIFE-HISTORY OF PLANTS. No. XIV.

BY THOMAS MEEHAN.

I. Fungi as Agents in Cross-fertilization.

My studies have convinced me that in the main all plants that do not depend on insects for fertilization never fail to produce seeds abundantly. The fact that any individual plant is prolific indicates self-fertilization. Compositæ, as a rule, seed abundantly. Hermaphrodite disk flowers rarely miss perfecting seed; and covering them by gauze to protect from insect visitors shows the full potency of own-pollen. Even when the ray florets are pistillate, the chances of receiving pollen from their own disk flowers are great, and this is not cross-fertilization. In short, the rule in Compositæ is that they are arranged for self-fertilization.

In Gray's *Synoptical Flora* we read, under *Vernonia*: "There are spontaneous hybrids between such very different species as *V. Arkansana* and *V. Baldwinii*, *V. fasciculata* and *V. Baldwinii*, and even between *V. Baldwinii* and *V. Lindheimeri!*" Knowing how apt botanists are to attribute any striking variation to hybridism, ignoring for the time being the well known fact that the innate power of the plant is fully equal to such phenomena, Dr. Gray's statement seems liable to a different interpretation.

In the Meehan nurseries are large quantities of *V. Baldwinii* and *V. Arkansana* growing side by side. Adjoining were a few plants of *V. Jamesii*. Desiring to increase the quantity, the seeds were saved and sown by the foreman in charge of the herbaceous department. Hundreds of these flowered in the summer of 1889. To our surprise there were not a dozen specimens of the genuine *V. Jamesii;* the rest were either intermediate between the two species named, or, where exactly the species, without any evidence that they had ever sprung from the *Jamesii* plants. I could not understand it. It seemed a blow to my deduction about close fertilization in Compositæ.

It so happened that I had been watching for several years past the influence of root-fungus on species of *Liatris*, as well as on *Vernonia Jamesii*, when the original plants were brought from the West. They would grow well the first year, but there would scarcely be one left after three years. The effect on the plants was to induce a more branching habit. Even the spicate species would become paniculate. This was especially so with *Vernonia Jamesii*, though these plants were never wholly destroyed, as the *Liatris* would be. A plant selected for special observation in 1889 showed brownish-red blotches on the stems as they pushed up in spring, which the practiced eye of the gardener would attribute to fungus agency. Later in the season some of these were sent to the eminent mycologist, Mr. J. B. Ellis, of Newfield, N. J. He could detect nothing satisfactory, and advised that specimens should be secured just before frost, when the spore-bearing organs might be formed. There was a gradual enlargement of the stem upward, and indeed the upper portion became almost fasciate, and the branching particularly abundant, just as we often see in some species of *Solidago* or in *Erigeron Canadensis* in the autumn. This was sent to Prof. Byron D. Halsted, of the New Jersey Agricultural Experiment Station at New Brunswick, who also could find no indications of fungus, but simply enlarged tissue such as is usually represented in an insect gall. That it is a development in some unknown way from the operation of the root fungus is clear from the watching of the plant-growth through its whole term.

It was after the discovery of the certain hybridity of the seedlings above described that a careful examination of the flowers of *V. Jamesii* was made. It was found that the normally white anthers had turned brown, and had perfected no pollen. The pistils only were perfect. A small bee, identified for me by Mr. William J. Fox, the well-known entomologist, as *Halictus parallelus*, was an active visitor, its thighs loaded with the clear white pollen from the other species. All this confirms Dr. Gray's suggestion of the hybrid origin of the forms he finds spontaneous; but the probability is that this is not due to any specific arrangement for cross-fertilization, but the consequence of some accidental derangement of the anthers in some one of the species, which gives the opportunity for the reception of pollen by any given plant from some of its neighbors.

II. Morphology of Twin and Triune Peaches.

There are under cultivation double-flowered peaches of several varieties. The stamens have mostly been transmuted to petals, but a few continue polleniferous around the pistil, which remains in its normal perfect form. There is nothing, therefore, to interfere with fruit bearing, and peaches are often found on these double-blossomed trees.

The singular feature of these cases is that the fruits are usually borne in sets of two or three. What we might term the carpellary suture in the peach fruit is on the interior line, with a slightly recurved apex. Any cursory observer might be pardoned for supposing that the peach had returned to the pluricarpellary condition, which we are taught is the original plan. Four out of five of the primary carpels are supposed to be atrophied in the formation of the single-stoned peach.

This note has been prepared because this supposed pluricarpellary condition is so commonly used as an illustration of the development under special conditions of organs usually arrested. The author had conceived this position to be sound, and yet was unable to satisfy himself in regard to any physiological law by which the condition could be brought about. The conversion of stamens to petals is a retrograde movement—a movement that could scarcely aid in the acceleration of development in parts usually dormant.

A new opportunity for observation shows that the condition arises from the union in an early stage of two or three distinct gynœciums, and not from the unusual development of carpels in the one gynœcium. The illustration shows the bases of distinct gynophores

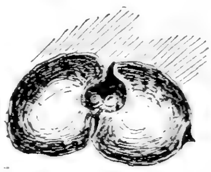

Fig. 1.

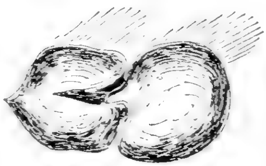

Fig. 2.

(fig. 1), while the full-face view (fig. 2) shows how the suture of one carpel had grown into the carpel of the other by the simple coiling of the spiral faintly outlined at the base in the other drawing.

The double flower in these peaches is the result of the arrestation of normal parts, and this arrestation has extended to the axis on which the flower-buds are borne. These buds have thus been drawn so closely together that they have met in a very early stage of their development, and the carpels of the distinct blossoms become united. It is not the result of a multiplication of normal parts, but a union of distinct individuals.

III. Galtonia candicans—Self-fertilization and Growth-energy.

Noting from the abundance of seed vessels on this plant that it was a self-fertilizer, I set myself to observe it closely with some specially interesting results.

In all plants growth is rhythmic, not continuous. In this case the pauses are of unusual length, while the advances, between the rests, are proportionately rapid. The flower-stalk is strong and very leafy. Some of the leaves are in verticils of three. Then follow two, alternately disposed and widely separated, followed by three arranged in a verticil. This is the rule throughout the whole growth. The time occupied in forming the verticil seemed as long as in constructing the interval, but the foundation for this arrangement occurs in an early stage of development, and could not be positively determined.

In a later stage of approaching anthesis, the rhythmic intervals are still more infrequent. The pedicel curves near the apex, and the flower-bud is drooping. At the curve there is a rest of two weeks, when the flower, which by this time has gone through all its functional purposes, starts on to an ultimate erect position. This renewal of motion in the curve seems to be rapid, but unfortunately a record of the time occupied was omitted. It was, however, discovered that the motion was in the form of a straightening and upward curving of the pedicel, and not by any spiral movement. It may be here observed that the method employed to note these motions and their directions, is by the use of small pins inserted in the stems at or near the points under observation. Most species of plants have their special hours and methods of opening, and it depends on the growth-rhythms whether the various functions operate simultaneously or each set of organs are functional at different times. The corolla occasionally expands before the stamens finish their growth, and not infrequently the pollen is not ejected till some time afterwards. In some, as in *Antirrhinum* and other Scrophulariaceæ, the pollen is ejected in advance of opening. In many kinds of flowers the stigma is not receptive till long after opening, while in other cases this period is reached simultaneously with other functional activity. In the case of *Galtonia* my observations have usually commenced at sunrise, but by that time the perianth has expanded, the two series of stamens have perfected their growth and discharged the pollen on the stigma that the anthers closely cover, the pollen evidently actively at work. Only once was I able to see the pollen in process of ejectment from the anther-cells. These are horny, resembling miniature mussel shells. The pollen was being forced out from the lower portion of the anther-septum, before dehiscence, in the form of small sections of silken thread. Though seeing this remarkable phenomenon but on one occasion, it is probably the normal manner, judging from the fact that the pollen collected on the thighs of the honey bees, that had been at work before the rising of the sun and the beginning of my task, was of a rough and stringy character.

The observations sustain my points : that fertility is mainly dependent on self-fertilization, and that form is governed by varying rhythmic movements of growth-energy.

IV. Evolution in Walnuts and Hickories.

From time to time during past years reports have been received of curious hybrids between the black walnut, *Juglans nigra,* and the butternut, or between the black walnut and the English walnut, *Juglans regia.* Specimens have now come to hand through the courtesy of Mr. H. G. Shelby, of Burlington, Iowa. The popular impression that a hickory (*Carya*) was growing out of the husk (involucre) of the black walnut might well be pardoned, as indeed might those botanists who see hybridization in any serious departure from the normal form.

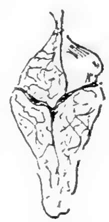

Fig. 1.—Fruit of *Juglans nigra* — outer husk but half developed, developing an interior series of bracts.

The departure can, however, be readily explained under well known morphological laws, and it furnishes us at the same time with some direct evidence in regard to the morphological conception of the structure of the fruit and its envelopes that has hitherto been but theoretical. Though seemingly of a single piece, so uniform in structure that the husk of the walnuts—the black walnut and butternut especially—has to be separated from the nut by heavy blows, morphology teaches us that it is primarily composed of several bracts that have become wholly consolidated, and that it is really the analogue of the involucre of the hazel-nut, or the cup of the acorn. In the specimen before us the husk has been but partially developed, and is seen to be composed of two leaflets. It has the ordinary rough exterior of the walnut husk. From the interior proceeds what appears to be a hickory nut with something of the flattened sharp-ribbed form that characterizes the shell-bark series, *Carya alba*. It is, however, still green and papery, divided into four parts at the apex, reminding one somewhat of the involucre of the bitternut, *Carya amara*. After soaking well the parts in water, we find that these two layers, though apparently united, are easily separable, and the inner layer, of which the four-cleft apex of the abnormal walnut is the continuation, remains as a covering to the true nut-shell. If the husk be removed hastily, we have the ordinary rugose character of the nut, but when it is carefully separated the lower layer remains as a shining brown pellicle, obliterating the usual roughness, and presenting the nut to us as smooth as a nut of an ordinary hickory. The conclusion derived from the study is that the fruit of the walnut is made up from an indefinite number of floral bracts, and that the different species, or even genera of the walnut family, differ from each other mainly in the varying power of consolidating and transforming these bracts.

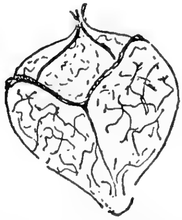

Fig. 2.—Another specimen, less developed.

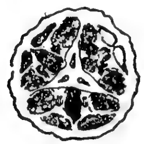

Fig. 3.—Cross section of a nut.

The disturbance reaches the carpels. The section of the nut, showing a tricarpellary structure, is especially interesting.

It is not necessary to call in hybridism to account for the phenomena. They are explainable under the theory of varying degrees of growth-energy as advocated by the author.

V. Evolution by Growth-energy—Ilex opaca and Cornus florida.

In a general view of vegetation, there seems no escape from the hypothesis of evolution. In the study of the individual plant, we know to a certainty that every organ, from the seed-leaves to the various parts of the fruit, is simply modified leaf-blade. This is the foundation of the doctrine of morphology. In this study of the individual we frequently note missing links, as, for instance, a less number of floral organs than we know might have been, the absence of leaves or buds in positions they might have occupied, or suppressions, or, indeed, productions in other instances. When we compare one species, genus or family with another, we may note the same law prevailing. We conclude that acceleration or retardation of growth—the union or the separation of parts involved in the structure of plants—are the chief foundations of the great variety we see.

How this manner of development is brought about is the great question yet unsolved. At times it seems that the whole character of the future individual should be moulded by protoplasmic action in the primordial cell. The most powerful microscope reveals to us nothing of the oak in one cell or of the elm in another, but from the invisible activities of the cell contents the final results are unerringly evolved. All this seems so logical as to account for the whole character of the individual plant. But when we make a broad study of the individuals of a group we know as species, we see so many differences that we have to conclude there must have been intervention somewhere. We see in the Rocky Mountains of Colorado what must have been originally the same species of pine, fir and spruce as are found at lower elevations on the Pacific slope. The only difference is a sturdy dense growth, and a general compactness of all the parts, which enable them the better to resist the cutting winds at a low temperature that are so destructive to the weaker branches of conifers during the winter season. We have no difficulty in deciding that this arrestation of development has been the result of environment—that is to say, the elevation of the land on which their ancestors grew. And yet, for the many ages that the Pacific forms and the Colorado forms have been under such widely different conditions, there is no difference except in this general arrestation of luxuriant growth. Again we are disappointed. Environment does not wholly satisfy us. It may induce slight geographical variations. That is all. Much greater local differences can be shown in which external conditions can have had no part. For instance, in various parts of Florida a large proportion of the holly trees, *Ilex opaca,* have saliciform foliage. Of the many thousands of leaves on a single tree there may not be one that has the margins "undulate, with spiny teeth." Not unfrequently the leaves are from two to three inches long, with here and there one with a spiny tooth to show its relationship. Only for the occasional tooth an expert in classification would with good reason regard it as a distinct species. At any rate, seeing these for the first time as I did, "a remarkable geographical form" is the mental comment. But at length we note as many or more trees with leaves as spiny as any manual of botany would describe them. Geography can have little place here, and we have to conclude, as of other agents in variation, that it cannot be a material power in effecting change.

My thought has been, as my papers to the Academy in past years indicate, that we have to look to growth-energy in connection with the rhythmic nature of the growth-waves for the true solution of the theory of evolution. My purpose in this paper is to illustrate this by a comparison of two species of dogwood, *Cornus florida*, of America, and *Cornus Mas*, of the Old World. The characters of branches and leaves are similar, the leading difference being in the greater production of twiggy branches, the absence of the large white involucre, and the pedunculate fruit that characterizes the European form. When the autumn season of rest has arrived and flower-buds for next spring formed, we find in each instance that two pairs of leaves have been changed to scales covering the embryonic head of flowers. A slight difference now occurs. The growth-energy in *Cornus florida* was expended in elongating the axis below the flower-head, forming a few bracts along its course, and then resting; in *Cornus Mas* it rests at once at the base of the flower, and then proceeds to elongate the pedicels of the flower within the bud. Vertical and horizontal sections of the buds show this clearly. When the rhythmic growth is renewed in spring the energy is directed in the same line. The bud scales enlarge slightly, but continue as small green "involucres" below the flower-buds; the energy is toward the pedicels. The flowers elongate, and we have finally the pedicellate fruits. In *Cornus florida* the energy is sufficient only to cause the expansion of the flowers, and the red fruit finally appears as a conglomerate head, the mass of the force being spent on the four winter scales, which are projected to appear as four large white structures simulating bracts.

We may look to the direction and degree of energy, in connection with rhythmic growth, as the leading factor in evolution. It explains facts otherwise unaccountable. In two plants of dandelion, growing side by side, one may have leaves so deeply laciniate that little but midrib and nerves are seen, while the other have broadly lanceolate leaves, almost entire. To compensate for this, one may have tall strong flower-stems, the other short and weak ones. The growth-force has simply been exerted in different lines, or may have been weak from the start.

Evolution, directed by varying degrees of growth-energy, reconciles many conflicting hypotheses. Granting, what must be true, that the machinery for the production of energy is all constructed by or in connection with the protoplasm in the primary cell; and that this is fed, as the plant grows, by food at its command, results must depend on the strength of this machinery. It must affect the plants variously, and indeed their several parts. The machinery at a given point may suddenly become defective, though not in a vital point; and the energy, obstructed in one direction, is diverted to another channel and we have the "sporting branch," as florists term these changes. These cells in the "sport," with the new energy imparted to them, have the same power of heredity as the original cells. In the willow-leaved hollies, the energy arranged for in the original particles of protoplasm have been kept intact through the whole growth process. Above all it explains what otherwise seems a mystery, the existence of the same species in widely separated localities. There is no necessity for presupposing that all traveled from one central home. If in one locality the powers of the protoplasm in the primary cell of *Ilex opaca* is so nicely balanced that it may give us willow-leaved forms, there is no reason why they may not all do that in time, and the prickly-leaved form gradually die out. A block of hollies hundreds of miles apart might follow a similar course. We may, in fact, picture to ourselves large areas varying in a few generations by very slight changes in the mechanical arrangement of the protoplasmic particles, forming the general energy-producing machinery in the primordial cell.

VI. Cypress Knees—Their Nature and Origin.

While in Florida for a few weeks in the winter season, when ordinary botanical attractions are rare, I took the opportunity of reviewing my conclusions in regard to the nature and origin of the so-called knees of the Cypress tree, *Taxodium distichum*. During two weeks' travel these trees occupied my chief attention. It is no exaggeration to say that thousands of trees in various localities and under different conditions were under close observation. I believe them to be simply root-excrescences, of no more service in the life-economy of the plant, than are the excrescences that often abound on the weeping willow, or on other trees. Indeed, they are not uncommon on the roots of trees. As I saw on this occasion, they abound on the roots of the water oak, *Quercus aquatica*, in this case taking on a hemispherical though often depressed form.

The excrescences were not always present ; indeed, trees free from this condition were in the majority. In one case near Green Cove Springs, I found a group of many hundreds of trees that had been left standing after the great monarchs had been cut away, that had none whatever in the whole group ; nor were there any evidences around the old stumps that there had been any borne by them. In a group of several hundred trees evidently under fifty years old, none were supposed to have any; but on looking carefully over them I found ten that bore them profusely, some of the excrescences protruding over a foot above the ground.

The base of the main trunks of those trees that bear these excrescences are usually hollow, as are the excrescences themselves. In the block that had no excrescences about them the old trunks appeared to have been wholly sound. Though satisfied that there was no ground for the prevalent beliefs that the excrescences were for the purposes of affording air to the roots, for collecting surface food, or were abortive suckers—were, in fact, excrescences of no value to the plant—I failed to understand why they should be hollow, any more than the excrescences in other trees.

Since my return the clue seems to be furnished by a paper in the Eleventh Annual Report (1900) of the Missouri Botanic Garden, just issued. The author, Hermann von Schrenk, deals with "a disease of the *Taxodium* known as peckiness." In this case the wood of the trunk is eaten out in vertical holes, leaving a clear line of demarcation between the part destroyed and the part uninjured. The mycelium of a fungus is always found in connection with it, and is without doubt the cause. No fruiting organs have yet been found, and therefore the name of the fungus cannot be determined. I have examined specimens of these "knees" in the collection of the Academy. A large one is to a great extent hollow, but a portion of the outer wood several inches thick is still left. The "pecky" holes described by Mr. Schrenk are in this wood, and it is quite clear that the cavity is formed by decay induced by the fungus. The smaller one, about eight inches high, had the wood in a gnarled and twisted condition, but so far with no evidence of decay through fungus operations.

The conclusion is that the so-called cypress "knees" are mere excrescences, probably in this case superinduced by fungus action, and that the trees that show no evidences of producing these excrescences are probably free from fungus attacks. It is not to be supposed that every tree in a group, or any considerable number of trees, would be equally infested by the parasite.

NOTE ON AMEIURUS PROSTHISTIUS.

BY HENRY W. FOWLER.

Ameiurus prosthistius Cope.

Amiurus prosthistius Cope, Proc. Acad. Nat. Sci. Phila., 1883, 132.
Ameiurus erebennus Jordan and Evermann, Bull. U. S. Nat. Mus., No. 47, I, 1896, 139 (part).

Upon a recent examination of the typical and other specimens of the present species I have arrived at the conclusion that *Amiurus prosthistius* of Cope is specifically distinct from *Amiurus erebennus* of Jordan.[1] The material at hand, consisting of seventeen specimens from the collection of the late Prof. E. D. Cope, is in excellent preservation and is at present the property of this Academy. As four specimens, Nos. 20,546, 20,547, 20,548 and 20,549, are typical, I have selected No. 20,546 as the type, as it is the first one mentioned in the description, and also from the fact that it had a small label in Prof. Cope's handwriting placed in the branchial aperture which reads, "*Amiurus prosthistius* Cope type." All of the specimens mentioned were collected in the Batsto river, N. J., June 15, 1883, by Prof. Cope. Other specimens collected by him are Nos. 20,927, 20,928, 20,929, 20,930, 20,931, 20,932, 20,933, 20,934 and 20,935 from Pool Tolsoms, and Nos. 20,616, 20,617 and 20,618, also from pools at the head of the Egg Harbor river, N. J.

The form of the body is much as in *Ameiurus natalis* (Le Sueur). Head longer than broad, convexly flattened above, the upper profile line nearly straight to the origin of the D., though the region directly before the D. is swollen on each side. The snout is blunt, obtuse, with the upper lip projecting slightly beyond the lower. The lips are moderately thick, fleshy and generally papillose. Nares situated laterally and anteriorly, the anterior pair about an eye diameter from the posterior pair and near the edge of the snout. The posterior nares are slightly more distant from each other than the anterior pair, but not so distant from each other as

[1] Bull. U. S. Nat. Mus., X, 1877, 85, Pl. xiii, Figs. 19 and 20.

the eyes, and the aperture is larger than that of the anterior pair. The nasal barbels, which originate directly in front of the posterior nares, are not as long as the head, but in younger examples are much longer than in the adults. The maxillary barbels are the longest and reach to the origin of the D. in the young, but do not extend much, if any, beyond the head in the adults. The tips of the outer mental barbels do not reach as far posteriorly as those of the maxillary, though they reach beyond the base of the P. in the young, and to its base in the adults. The inner mental barbels are not as long as the outer at any age. Mouth broad and somewhat semi-lunar, and furnished with bands of teeth of about equal width. In the type a system of minute pores extends along the lower edge of the mandibles, and this is also discernible in other specimens. The gill-membranes are broad, not overlapping, and the angle formed at the isthmus would be equilateral. Gill-rakers short and of moderate number. The eye is lateral and superior, anterior to the centre of the length of the head, and of a very deeply elliptical shape. The posterior and lower margins of the operculum form a small fleshy gill-flap. The occipital process does not reach the interspinal bones, and the bridge of bone is thus incomplete. The origin of the P. is anterior to the posterior opercular margin, and the tip of the spine extends, when depressed, to or beyond the origin of the D. The P. spine with or without several shallow indistinct denticulations on its outer edge near the tip, the inner edge is strongly serrated, and most of the rays of the fin are longer than the spine. Humeral process only slightly rugose and extending slightly beyond the middle of the P. spine. The tip of the P. fin reaches the last D. ray in the vertical and the origin of the A., or very near it, in the young, though in the adults it falls considerably short. The A. encroaches on the V. for at least a third of its length in the young, though very little in the adults. Posterior margin of the base of the Adipose fin nearer to the tip of the caudal than the tip of the D. spine in the adults, but about median in position in the young.

Upper rudimentary caudal rays developed and extending anteriorly at least to below the tip of the Adipose fin. Color of the body blackish-brown, darkest above, belly to the origin of the A. whitish. The terminal portions of the fins are blackish and the bases of the P. and V. lighter. In all of these examples the nasal and maxillary barbels are blackish colored like the prevailing body-color, though the latter are somewhat paler on their terminal portions, and all of the mental barbels are distinctly of the same whitish color as the belly and lower anterior surface of the body. The lower lip is also margined narrowly with brownish. The fin formulæ and measurements are as follows (the latter in millimeters) in the typical specimens:

Radii of D.,	I, 6	I, 6	I, 6	I, 6
" " A. (counting rudiments),	27	27	25	26
" " P.,	I, 8	I, 8	I, 8	I, 8
" " V,	8	8	8	8
Length of D. spine,	15	18	17	20
" " P. spine,	20	22	24	21
Longest D. ray,	26	27	27	27
" P. ray,	24	26	26	27
" V. ray,	21	21	20	25
" A. ray,	23	26	22	28
Head without opercular flap,	44	46	48	53
Depth of body,	38	38	44	42
Between outer edges of P. spines,	35	39	42	43
Humeral process,	13	14	15	15
Postocular part of head,	25	30	28	31
Length of eye,	6	6	6	6
Tip of snout to origin of D.,	65	70	73	86
Interorbital space,	25	25	27	27
Posterior internasal region,	16	16	17	18
Least depth of caudal peduncle,	23	23	21	24
Base of A.,	49	55	53	56
Total length,	208	216	216	230

The fin formulæ and measurements of the remaining specimens (the latter also in millimeters) range as follows:

Radii of D.,	I, 6
" " A. (counting rudiments),	(25?) 26 to 28
" " P.,	I, 8
" " V.,	8
Length of D. spine,	9 to 13
" " P. spine,	11 to 19
Longest D. ray,	12 to 20
" P. ray,	13 to 19

Longest V. ray,		10 to 16
" A. ray,		12 to 19
Head without opercular flap,		16 to 31
Depth of body,	*(circa)*	16 to 27
Between outer edges of P. spine,		15 to 25
Humeral process,		5 to 10
Postocular part of head,		9 to 18
Length of eye,		3 to 5
Tip of snout to origin of D.,		24 to 42
Interorbital space,		9 to 17
Posterior internasal region,		6 to 12
Least depth of caudal peduncle,		9 to 17
Base of A.,		21 to 38
Total length,		83 to 142

As Prof. Cope has contended, this species proves to be closely allied to *Amiurus natalis* (Le Sueur), of which it may be found to be a subspecies, but at present it seems advisable to consider it distinct. *Amiurus erebennus* of Jordan is certainly different, as the caudal of that species is stated as being short and truncated; in the figure it is represented with somewhat acute tips and with the posterior margin a little emarginated; all the barbels are said to be black, the A. with 22 to 24 rays and the occipital process only little free behind. *Ameiurus prosthistius* is easily distinguishable as the shape of the caudal is altogether different, the upper rudimentary rays greatly exceed the development of the lower, the caudal itself is rounded, not at all truncate, emarginate or pointed, the inferior barbels are all whitish like the lower anterior surface of the body, and the A. has as many as 28 rays. In all the smaller examples examined, all possessed at least 26 A. rays, except one of which I am doubtful that has 25?, while the majority had 27.

DESCRIPTIONS OF NEW BEES COLLECTED BY MR. H. H. SMITH IN BRAZIL.—I.

BY T. D. A. COCKERELL.

Genus **AUGOCHLORA** Smith, 1853 (sens. lat.).

Series I. Hind spur of hind tibia of ♀ pectinate (subg. AUGOCHLOROPSIS Ckll., etc.).

A. Larger species, length over 8 mm.

I. Teeth of hind spur of hind tibiæ three, large, more or less broad even to the tips.

(i) Femora and tibiæ ferruginous.

Megalopta idalia Smith, 1853.

♀. Length 12 mm. Head and thorax shining brassy or yellowish green, with faint coppery tints; metathorax, abdomen and legs ferruginous, the apical half of the abdomen above fuscous. Antennæ ferruginous, scape long; ocelli large; face narrow, eyes large, subreniform, *space between the orbital margin and lateral ocellus much less than the diameter of the ocellus;* front with dense, more or less confluent, small punctures; clypeus and supraclypeal area (which is quite convex) with large scattered punctures; lower margin of clypeus and sides of face broadly, and the labrum, pale ferruginous; process of labrum large but low and rounded, a little depressed in the middle; *mandibles dark ferruginous, blackish at their bidentate tips.* Pubescence of thorax wholly pale, scanty and short, like a fine mould; mesothorax with numerous but very shallow punctures of two sizes; scutellum with very minute punctures, and a few larger ones interspersed; basal area of metathorax feebly enclosed, finely roughened, with a few longitudinal ridges at the extreme sides; pubescence of legs wholly pale, tinged with golden; tegulæ pale ferruginous; wings hyaline, slightly yellowish, nervures and stigma pale ferruginous, subcostal nervure black; second submarginal cell very small; second recurrent nervure joining third submarginal cell near the beginning of its apical fourth; abdomen broad and convex, sericeous with scattered indistinct punctures on its apical half; dorsal surface bare, apex and ventral surface with abundant pale golden hair.

Hab.—Chapada, October. One specimen. Differs from typical *Megalopta* in the much longer third submarginal cell, with the second recurrent nervure entering it considerably before its end also by the first recurrent joining the second submarginal cell at its end.

(ii) Femora and tibiæ green.

Augochlora spinolæ n. sp.

♀. Length 11 mm., stoutly built, bright green; head and thorax yellowish green, with coppery tints, abdomen a bluer green, with bluish tints in certain lights; legs green, the tarsi, and hind tibiæ behind, very dark brown. Antennæ black, flagellum less than twice the length of the long scape; eyes rather small, subreniform; face broad, ocelli ordinary, *distance between lateral ocelli and eyes equal to at least four times the diameter of an ocellus;* vertex strongly coppery; front roughened with small, very close punctures; a short, low keel between the antennæ; clypeus with rather numerous punctures, its anterior part blue-black edged with pink, these colors extending as a narrow tongue upwards in the middle line; *mandibles black, scimitar-shaped, the blunt inner tooth a considerable distance from the end;* mesothorax strongly suffused with coppery red, microscopically tessellate and closely punctured with punctures of two sizes; scutellum shining, with punctures of two sizes; basal area of metathorax minutely roughened, not enclosed; tubercles with a dense short fringe of white hair; pubescence of legs all pale, more or less yellowish; tegulæ green at base, otherwise ferruginous; wings rather dusky, nervures and stigma dark ferruginous; compared with *M. idalia* the marginal cell is much shorter, the second submarginal larger, and the third higher in proportion to its length; abdomen with moderately dense small punctures, marking the insertion of the hairs; second and following segments with some inconspicuous short black hairs; hind margins of third and fourth segments white-pruinose; apex with short black hair, slightly mixed with pale; extreme sides of abdomen with shining pale hair.

Hab.—Chapada, April. One specimen.

Augochlora berenice Smith, 1879.

Hab.—Corumbá, April. One ♀. Uruguay (Smith).

The Corumbá specimen is about 9 mm. long, and the basal area of the metathorax is not enclosed by a ridge; still, it accords so well with the description of *berenice* that it must be assumed to be identical until a comparison with the type proves otherwise. The punctures of the mesothorax are extremely strong and dense. The distance between the lateral ocelli and the eyes is equal to about $2\frac{1}{2}$ times the diameter of an ocellus. The process of the labrum is deeply bifid.

II. Teeth of hind spur of hind tibia four or more, pointed.

(i) Scutellum with large punctures, sparse at sides of middle.

a. Abdomen black.

Augochlora polychroa n. sp.

♀. Length about 11 mm., general build of an *Andrena*. Face brilliant coppery red, vertex green; mesothorax dull green, with a slight coppery-red lustre; scutellum, postscutellum and base of metathorax shining brassy green, with a coppery lustre; pleura greenish black; abdomen dull black; legs black. Antennæ black, flagellum about twice the length of scape; ocelli ordinary, distance between lateral ocellus and eye about three times the diameter of an ocellus; front very closely and strongly punctured; clypeus strongly punctured, a broad black triangle on its anterior margin; mandibles piceous, the tooth on inner margin very short; mesothorax and pleura very strongly and closely punctured; base of metathorax microscopically tessellate, shining, with a beautiful purple iridescence in certain lights, not enclosed; sides of metathorax white-hoary; pubescence of legs shining grayish; tegulæ piceous, a little green in front; wings smoky, nervures and stigma piceous, stigma quite small; abdomen microscopically tessellate, well punctured, but the punctures shallow, very slightly hairy, hair at apex black, at sides beneath white.

Hab.—Santarem; one specimen. The coloration is partly as in *A. hebescens*, but the present species is easily separated by the black abdomen, color of pubescence of legs, etc.

b. Abdomen green, or cupreous-green.

a. Vertex and mesothorax green.

§. Abdomen with a coppery lustre.

Augochlora smithiana n. sp.

♀. Length $12\frac{1}{2}$ mm., stoutly built. Brilliant yellowish-green, the abdomen with a strong coppery lustre. Pubescence short and scanty, pale mixed with black on face, vertex, mesothorax and abdomen except the first segment. Face broad; clypeus and extreme sides of face coppery; front extremely closely punctured; clypeus and supraclypeal area sparsely punctured; antennæ black, scape punctured; sides of anterior margin of prothorax strongly angulate; mesothorax very strongly and closely punctured, it and the scutellum often tinged with coppery red; base of metathorax granular, the extreme base with short and vague longitudinal ridges; femora and tibiæ green, tibiæ tufted with black hair apically; tarsi piceous, with pale hair; tegulæ fulvotestaceous, green at extreme base; wings smoky, nervures and stigma dark testaceous; abdomen green with a coppery lustre, punctured, the hind margins of the segments with a very narrow and even fulvous fringe; fifth segment and apex covered with black hair, sides of apical segment with little silvery patches; ventral surface with pale hair.

For the ♂, see below.

Hab.—Chapada, March and April; 12 specimens. The species is named after its dicoverer.

Var. *a.* Basal portion of metathorax longitudinally plicate, the plicæ distinct and covering its surface.

Hab.—Chapada, September. One specimen.

§§. Abdomen with a purple-blue lustre.

Augochlora heterochroa n. sp.

♀. Length 10 mm.; blue-green, with beautiful purple reflections on the metathorax and abdomen; extreme sides of face, and edge of the black anterior margin of clypeus, coppery. Femora and tibiæ olive green, tarsi dark reddish brown. Antennæ black; face broad, front extremely closely punctured, clypeus sparsely punctured in the middle; maxillary palpi with the last joint slender, longer than the penultimate one; thorax with fairly abundant woolly-looking white hair; mesothorax extremely closely punctured; scutellum, between the punctures, microscopically tessellate; base of metathorax with numerous longitudinal ridges; pubescence of legs pale with a brownish tinge; tegulæ rufotestaceous, with a green patch at base in front; wings faintly smoky toward the apex; nervures and stigma dark testaceous; abdomen white-hoary, with small punctures at the insertion of the hairs; the middle (purple) portions of the segments after the first with more or less short black hair, the apical (green) margins with very short white hair; apex with black hair, sides beneath with white hair. For the ♂, see below.

Hab.—Chapada, March, October. Two specimens.

Var. *α*. Longitudinal plicæ of base of metathorax feeble or absent.

Hab.—Chapada, April, September, October. Four specimens.

The sculpture of the base of the metathorax is usually considered of specific value, but in this and the last species it is certainly variable.

β. Vertex and mesothorax cupreous.

Augochlora goeldii n. sp.

♀. Length $10\frac{1}{2}$ mm. Differs from *A. smithiana* by the smaller thorax, the angles of the prothorax in front much less prominent and less acute; the face, vertex and mesothorax coppery red, the other parts of the head and thorax yellowish-green with coppery tints, nowhere blue-green; middle tibiæ more slender; abdomen blue-green, hind margin of second segment, and of third more or less, steel-blue; narrow hair-fringes white instead of fulvous. Hair of apical segment black; base of metathorax granular; antennæ black; punctures of mesothorax of two sizes.

Hab.—Chapada, one specimen. I thought at first this might be an extreme variety of *A. smithiana*, but there are so many differences that I can only treat it as a distinct species.

(ii) Scutellum with punctures of two sizes, the small ones the more numerous.

a. Abdomen crimson.

Augochlora wallacei n. sp.

♀. Length nearly 9 mm. Head and thorax bluish-green, abdomen shining crimson. To the naked eye this is exactly like *A. subignita* from Mexico, except that the wings are a little more smoky. The lens reveals the following differences: Lateral angles of prothorax more produced; scutellum shiny, with the punctures conspicuously of two sizes (in *subignita* the scutellum is granular and closely punctured all over); punctures of second abdominal segment very distinct, resembling those of the first, but not quite so strong. Antennæ black, flagellum pruinose with very short yellowish-gray pubescence. *Process of labrum bifid.* Basal enclosure of metathorax plicate, surrounded by an obtuse but conspicuous microscopically tessellate rim.

Hab.—Chapada, March, April, December. Five specimens. Dedicated to A. R. Wallace.

b. Abdomen green.

a. A transverse groove behind the ocelli; margins of abdominal segments black.[1]

Augochlora chapadæ n. sp.

♀. Length 10 to 11 mm.; blue-green with purple tints, some specimens much bluer than others. Face broad only just above the antennæ, the eyes being deeply emarginate; antennæ black,

[1] It will be useful to give a separate table of the species of *Augochlora* having the hind margins of the abdominal segments black. The new species will be found described in detail further on. *A. labrosa* Say, from Mexico, cannot be included because of the inadequate description, though it probably may be recognized when specimens come to hand (see *Canad. Entom.*, 1897, p. 68). There is only one species (*A. chapadæ*) in the following table known to belong to *Augochloropsis*:

Punctures of mesothorax extremely large (Chapada). *foxiana*, Ckll., ♀, ♂.
Punctures of mesothorax small and close, ... 1
1. Margin of clypeus, labrum and mandibles yellow *graminea* (Fabr.) Smith, ♂
   Mandibles dark; clypeus usually without yellow (apically margined with yellow in *binghami*), ... 2
2. Small, 6 mm. long, wings rufohyaline, base of metathorax with radiating plicæ, and surrounded by a shining ridge; head and thorax brassy green, ... *urania*, Smith, ♀
   Larger, 7 mm. long at least, and of these the smaller species (*iheringi*, *cærulior* and *feronia*) with the enclosure of the metathorax not bounded by a shining ridge, ... 3
3. Punctures of scutellum large; blue-green species with purple tints, 4
   Punctures of scutellum of two sizes, small and large (not described in *feronia*); ventral surface of abdomen without a tooth, . . . 6
   Punctures of scutellum extremely dense, not of two sizes; abdomen with a sub-basal ventral tooth (Corumbá) . . . . *mulleri*, Ckll., ♀
4. Abdomen black, tinged with green and blue; apical joint of antenna normal (Mexico), ... *townsendi*, Ckll., ♂
   Abdomen brilliantly colored, green to purple, ... 5
5. Base of metathorax with regular radiating plicæ; apical joint of antenna normal (Pedra Branca, Bolivia), *belti*, Ckll., ♂; *perangusta*, Ckll., ♂
   Base of metathorax labyrinthine with irregular vermiform ridges; apical joint of antenna hooked (Mexico . . . *binghami*, Ckll., ♂
6. Larger, about 10 mm. long; base of metathorax with fine vermiform ridges, ... *chapadæ*, Ckll., ♀
   Smaller, 7 to 8 mm. long; base of metathorax with longitudinal plicæ; hind spur of hind tibia in ♀ simple or merely ciliate (not pectinate), 7
7. Punctures of mesothorax extremely close; greener species; wings strongly smoky; legs with green only on hind coxæ (Santarem), *iheringi*, Ckll., ♀
   Punctures of mesothorax not nearly so close; bluer species; wings almost clear; green of legs confined to coxæ and anterior femora (Corumbá) . . . . *cærulior*, Ckll., ♀
   Differs from *cærulior* by the pubescence of the legs being black; from *iheringi* by the wings being only faintly clouded at apex, *feronia*, Smith.

scape dull, with short black bristles; front extremely densely punctured; clypeus with large shallow punctures, its anterior edge broadly black; mandibles only faintly rufescent at the ends; *process of labrum entire;* pubescence of cheeks white, of lower parts of face white with a little black intermixed, of front and vertex black, of mesothorax and scutellum black, of postscutellum black in front and white behind, of metathorax white, of legs pale (a dense white floccus on hind femora), of hind tarsi fuscous, of hind tibiæ fuscous in front and white behind, of abdomen pale, with some black on the second and following dorsal segments, of apex of abdomen dirty grayish; mesothorax dullish, densely punctured, rather sparsely on disc; scutellum with well-separated punctures, conspicuously of two sizes; base of metathorax with oblique wavy ridges; tegulæ dark reddish-brown, green at extreme base; wings slightly smoky, with a yellowish tinge; nervures and stigma dark brown, the latter rather reddish; legs dark brown, the femora and tibiæ in front green; abdomen with very close strong punctures, green with purple tints, apical margins of segments broadly black.

Hab.—Chapada, March, April, December; Corumbá, April (with label h. l.); Maruru, April. Five specimens.

β. No transverse groove behind the ocelli; margins of abdominal segments green.

Augochlora brasiliana n. sp.

♀. Length $8\frac{1}{4}$ to $10\frac{1}{2}$ mm.; bluish-green, the abdomen with tints of purple-blue; occasionally the head and thorax are yellowish-green, with coppery tints. Face rather broad, emargination of eyes shallow; antennæ black; front closely punctured; clypeus with semilunar punctures, a dark purple or purple-black triangular area on its anterior margin; *process of labrum deeply bifid;* pubescence of cheeks white, of face yellowish-white, some black hairs on front and vertex, of mesothorax and scutellum black with a little pale intermixed, of pleura, postscutellum and metathorax dull white with a brownish tint, of legs brownish-white and rather abundant, of abdomen brownish-white, with inconspicuous black hairs on the second and following dorsal segments, of apex of abdomen brownish-gray to blackish, but never altogether black; mesothorax minutely granular, the punctures extremely dense at the sides, but in the middle well separated, some larger than others;

scutellum with punctures of two sizes, but the smaller ones not very small; base of metathorax microscopically tessellate, not plicate nor enclosed; legs dark brown, femora, and tarsi in front, green; tegulæ reddish-testaceous, green at base; wings yellowish-hyaline, nervures and stigma dull testaceous; abdomen with only small punctures marking the insertion of the hairs, dorsal segments shot with brilliant purple, hind margins of first two segments very shortly and regularly ciliate with yellowish-white hair, apical margins of third and fourth segments broadly pruinose; ventral surface more or less tinged with green.

Hab.—Corumbá, February, April, two marked "lowland;" Chapada, December; Pedra Branca (Bolivia), April. Fifteen specimens. This differs from the description of *A. paphia* Smith, by its somewhat larger size, flagellum not testaceous beneath, margins of abdominal segments green instead of purple, the purple color being on the middle and anterior portions of the segments. It is just possible that *paphia* is one of the forms of this variable species, but the probabilities are against it.

There is also a specimen of *brasiliana* marked Uacarizal, February.

(iii) Scutellum with large close punctures all over.

a. Abdomen coppery, clothed with short fulvous hair, the segments also with narrow even fulvous fringes.

Augochlora vesta Smith, var. **cupreola** n. var.

♀. Length 8 to 9 mm.; yellowish-green, abdomen brassy green, tinged with coppery-red, or even entirely coppery-red except the extreme base. Differs from the description of *vesta* by the rather larger size, flagellum hardly or not testaceous beneath toward the apex, pubescence of legs very pale fulvous, instead of "dark fuscous," abdomen usually more or less green, and with only small, though distinct, punctures marking the insertion of the hairs. Apex of abdomen black; base of metathorax not enclosed by a shining rim, variably roughened, but without distinct plicæ; punctures of mesothorax and front strong and as dense as is possible; anterior margin of clypeus with a semilunar black area, usually narrowly edged with crimson; *process of labrum bipartite.* For the ♂, see below.

Hab.—Chapada, February, March, April, September, October, December; Corumbá, April, one only; Maruru, April, two; San tarem, three. Twenty-three specimens in all. *A. vesta* was described from Columbia and it is quite likely that it is a distinct species from *cupreola*, though closely allied. The specimens of *cupreola* from the basins of the Amazon (Santarem) and the Paraguay (Corumbá, etc.) do not seem to differ.

A. pandora differs from *cupreola* by having the metathoracic enclosure bounded by a distinct elevated margin, and the flagellum fulvous beneath. *A. acidalia* differs in the same respects.

b. Abdomen green.

Augochlora calypso Smith, 1879.

♀. Process of labrum bipartite; *base of metathorax longitudinally plicate,* with a raised rim.

Hab.—Two from Santarem, the type locality. Also two closely allied species, or subspecies, separable as follows:

Wings strongly smoky; ridge of metathoracic enclosure not marked by a groove; hair-fringe at apex of first abdominal segment entire; extreme sides of face deep blue varying to bluish-green. (Santarem) . . *calypso*, s. str.

Wings clear or almost.

Ridge of metathoracic enclosure marked by a groove; extreme sides of face coppery; hair-fringe at apex of first abdominal segment broadly interrupted in the middle. (Chapada, February).
calypso subsp. *cupreotincta*, n. subsp.

Ridge of metathoracic enclosure not marked by a groove; extreme sides of face coppery; hair-fringe at apex of first abdominal segment entire; head smaller, and face more narrowed below than in the other two forms. (Rio de Janeiro, November).
calypso subsp. *eucalypso*, n. subsp.

All three agree in having the pubescence of the abdomen light fulvous, the mandibles with a green spot near base, the flagellum testaceous beneath at apex, and the ventral surface of the abdomen green, or mostly so.

Augochlora monochroa n. sp.

♀. Length 8 to 9 mm. Brilliant bluish-green, the abdomen varying from green to almost entirely purple, always very shiny. No coppery tints, except sometimes on the margin of the large black clypeal patch. Coxæ, femora and tibiæ green, hind tarsi more or less green at base; tarsi otherwise piceous, the small joints deep ferruginous; pubescence of legs pale fulvous, becoming golden on tarsi, of face and cheeks pale, some black on vertex, of mesothorax black and pale mixed, of postscutellum and sides of metathorax pale and rather long, of apex of abdomen brown-black with a coppery lustre. Base of metathorax rugose, with vague plicæ. Process of labrum bifid. This is very similar indeed to *A. heterochroa*, but differs as follows: It is smaller, with the abdomen shorter and more convex, shining and without distinct pruinose bands; the even fringe at the apical margins of the first two segments is somewhat shorter, and the apical portions of these segments are not pruinose; the apical portions of the third and fourth segments are white-pruinose, but the fact is not conspicuous except in certain lights; most of the ventral surface of the abdomen is metallic green; the hind tibiæ are green on both sides; *the sides of the metathorax near the truncation are smooth and shining* (in *heterochroa* they are covered with punctures); the scutellum is much more densely punctured; the mesothorax is also much more densely punctured, and the punctures are stronger; the stigma usually has a more ferruginous tint.

Hab.—Corumbá, April, one is marked "h. l."; Pedra Branca, April. Ten specimens. Four from Chapada, March and August, and one from Uacarizal, February, represent a slight variety, averaging a yellower green, with the fringe at apex of first two abdominal segments usually a trifle longer, and pale fulvous.

Augochlora monochroa subsp. nov. **moreiræ.**

♀. Brassy green with coppery tints; abdomen rather longer and less shiny than in *monochroa*, decidedly less globose; anterior lateral edges of prothorax prominent but rounded (in *monochroa* they are distinctly angulate); fringe at apex of first and second abdominal segments pale and short; a smooth punctureless area on each side of metathorax just below the basal area (in *heterochroa* and *brasiliana* this place is covered with punctures). Process of labrum bipartite; hairs at apex of clypeus orange-fulvous; mandibles with a green spot; wings rather strongly suffused with brownish.

Hab.—Rio de Janeiro, November. One specimen. Named after Carlos Moreira.

Both *monochroa* and *moreiræ* are easily distinguished from the *calypso* forms by the rugulose base of the metathorax; in *calypso* and its subspecies this is plicate, with a shining rim.

Augochlora janeirensis n. sp.

♀. Length 8 to 10 mm; blue-green, with purple tints on the abdomen in certain lights. Process of labrum bipartite; wings rather smoky, especially toward the apex; *base of metathorax finely rugulose, not plicate; sides of metathorax just below the basal area punctured.*

This is so very close to *monochroa*, *heterochroa* and *brasiliana* that it is only necessary to mention the comparative differences. *A. janeirensis* differs at once from all these three by the comparatively long and quite fuscous hair-fringes of the first and second abdominal segments, and by the stronger punctuation of the abdomen, although the punctures are still only those at the bases of the hairs. It agrees with *heterochroa* and *brasiliana*, and differs from *monochroa*, in having the sides of the metathorax just below the basal area punctured; it differs from *heterochroa* and *brasiliana* in the punctuation of the scutellum, which is very strong, the punctures large and close, and not of two sizes.

Hab.—Rio de Janeiro, November; two specimens. For the ♂, see below.

In *calypso*, *monochroa*, *janeirensis*, and the various subspecies, the distance between the lateral ocelli and the orbital margin is not (usually not nearly) so great as that between the outermost margins of the ocelli. In the next species (*bucephala*) the ocelli are small and close together, and the distance between the lateral ocelli and the orbital margin is as great as the distance between the outermost margins of the lateral ocelli. *A. bucephala* will also be recognized by its relatively large size, and very broad face.

Augochlora bucephala Smith, 1853.

♀. Length about 11 mm.; process of labrum bipartite; base of metathorax minutely roughened, not plicate. In our specimens the flagellum is not "testaceous beneath," though pruinose, and the tarsi are much darker than I should call "ferruginous." The mesothorax has punctures distinctly of two sizes, as described by Smith.

Hab.—Rio de Janeiro, November. Seven specimens. For the ♂, see below.

Series II. Hind spur of hind tibia of ♀ simple or not pectinate. Here also will be found males which belong to AUGOCHLOROPSIS.

1. Abdomen with a subbasal ventral tooth.

Augochlora mulleri n. sp.

♀. Length 9 to 12 mm., rather narrow, dark shining peacock blue or blue-green; hind margin of first abdominal segment very narrowly black, of second broadly black, of the third and fourth deep purple with the extreme edge black; a tooth, directed obliquely backwards, on the first ventral segment. Punctuation of face, front, vertex, mesothorax, scutellum and sides of metathorax excessively close; punctures of clypeus large, on a shining surface, clypeus only very narrowly edged in front with black; front with a strong if low median keel; flagellum fulvous beneath; lower part of face with sparse short white pubescence; mandibles with a dark purple spot at base, only seen in certain lights; *process of labrum truncate, not bifid, but the truncation nodulose;* base of metathorax longitudinally plicate; the truncation, and the area between the truncation and the basal portion, coarsely roughened, this roughening gradually changes at the sides of the metathorax into dense strong punctures; tegulæ piceous with a blue and green patch on the anterior portion; wings rather smoky, especially toward the ends; nervures and stigma dark; legs piceous with white pubescence, tarsi dark ferruginous, front and hind coxæ tinged with blue; *middle coxæ very small, their trochanters broad and flattened, with the hind edge sharp;* abdomen with the first and second segments strongly punctured, the punctures not connected with the pubescence, which is lacking on these parts.

Hab.—Corumbá, April (two are marked h. l.); Chapada, December, January; Pedra Branca (Bolivia), April. Sixty-four specimens. Dedicated to the memory of Fritz Müller.

2. Abdomen without a subbasal ventral tooth.

(i) Femora and tibiæ green, tarsi yellow: males with anterior margin of clypeus not at all yellow. These appear to be all males of *Augochloropsis.*

a. First joint of flagellum swollen in front, honey-color, contrasting with the rest of the antenna, which is black; antennæ rather short for a male.

Augochlora callichroa n. sp.

♂. Length $8\frac{1}{2}$ mm.; brilliant yellowish-green, the abdomen slightly brassy. Head rather densely covered with very pale yellowish hair, becoming white on cheeks; front very densely punctured; clypeus with large punctures; mesothorax shining, with large, strong and well-separated punctures, except at the sides, where they become confluent; scutellum with very large punctures, a round impunctuate space on each side of the middle; base of metathorax enclosed by a rim, and covered with strong wavy plicæ; sides below the enclosure with very strong punctures; wings perfectly hyaline; nervures and stigma rather dark testaceous; abdomen very shiny, punctures of first segment strong, of second much more minute; hind margins of first two segments with a narrow even pale fulvous band, the surface generally on the apical half thinly covered with pale fulvous hair.

Hab.—Chapada, December, one. This may be the ♂ of *A. calypso* subsp. *cupreotincta*. The rather peculiar sculpture of the base of the metathorax is quite of the same type, but the punctures of the scutellum are larger and much less dense in the present insect than in *cupreotincta*.

β. First joint of flagellum normal in color and form. Hind coxæ furnished above with an apical tooth.

§. Small, not over 8 mm. long: abdomen strongly tinged with coppery red.

Augochlora vesta var. **cupreola**, Ckll., ♂ (♀ supra).

Hab.—Chapada, December.

§§. Larger, at least 9 mm.; abdomen at most slightly coppery.

x. Blue-green species, the abdomen shining purple in certain lights.

Augochlora janeirensis Ckll., ♂ (♀ supra).

Hab.—Rio de Janeiro, November. Variable in size, like the ♀.

xx. Yellowish-green, the abdomen often more or less brassy, or even slightly coppery.

y. Enclosure at base of metathorax smooth and shining; abdomen narrow, parallel-sided.

Augochlora bucephala Smith ♂ (♀ supra).

Hab.—Rio de Janeiro, November. The head is only of the ordinary size, not large as in the ♀.

yy. Enclosure at base of metathorax covered with vermiform plicæ, more or less longitudinal.

Augochlora smithiana Ckll., ♂ (♀ supra).

Hab.—Chapada, April, October. Less bulky than the ♀, with the punctures of the mesothorax and scutellum more dense.

(ii) Tarsi dark.

a. Base of metathorax longitudinally plicate.

§. Scutellum with very small close punctures.

Augochlora iheringi n. sp.

♀. Length about 8 mm.; rather dull blue-green, the middle of the face yellowish-green, the clypeus marked with peacock blue, the middle of the basal area of the metathorax purple, the legs very dark brown, only the hind coxæ with some green; abdomen black dorsally, blue-green at the sides, the hind margins of the segments broadly black; wings grayish-fulvous. Punctures of front, mesothorax and scutellum small and very dense, the front may be said to be minutely rugose; base of metathorax longitudinally plicate, the plicæ numerous, strong and distinct; sides below the basal area minutely roughened, with no shining rim; truncation of metathorax dull, its lower part striate; abdomen impunctate dorsally, sides of first segment with very small punctures; flagellum obscurely ferruginous beneath; mandibles ferruginous in the middle; *process of labrum truncate, not bifid;* ventral surface of abdomen piceous, with long pale hair; scutellum and postscutellum with sparse black hairs, the latter with also pale hairs.

Hab.—Santarem. One specimen.

Augochlora cærulior n. sp.

♀. Length 8 mm.; shining prussian green, the hind margins of the abdominal segments black. Legs piceous, tarsi and anterior tibiæ dark ferruginous, front and hind coxæ green; *process of labrum entire, broadly truncate,* longitudinally plicatulate; antennæ piceous, flagellum ferruginous beneath; punctures of front extremely dense, of clypeus large; mesothorax minutely granular, punctures very distinct, in the middle well separated; punctures of scutellum extremely small, with a few larger ones interspersed, but even these not so large as those of the mesothorax; base of metathorax strongly longitudinally plicate, no shining rim; tegulæ dark ferruginous; wings slightly dusky, nervures and stigma dark brown;

abdomen with minute punctures; ventral surface very dark brown. Hair of legs all pale.

Hab.—Corumbá, April. Two specimens.

§§. Scutellum with large punctures.

Augochlora batesi n. sp.

♂. Length 9 to 10½ mm.; brilliant green, more or less golden about the middle of the face, abdomen with purple shades in certain lights; head ordinary, antennæ very dark brown, not very long; punctuation of front and vertex extremely close; lower sides of face and clypeus, and cheeks, conspicuously bearded with white hair; mandibles with a green spot at base; *process of labrum bifid;* mesothorax microscopically tessellate, with close large punctures; scutellum the same; base of metathorax irregularly longitudinally plicate, no shining rim, sides below base very densely and strongly punctured; truncation of metathorax quite densely punctured; tegulæ green and punctured at base; wings hyaline, nervures and stigma dull pale reddish-brown; coxæ, femora and tibiæ green, tarsi very dark brown, pubescence of legs wholly pale and quite dense; abdomen strongly punctured, even the depressed margins of the segments punctured; hind margins of the first two segments with a narrow even fulvous hair-band; hind margins of third and fourth segments broadly white pruinose; sides and base of abdomen quite hairy; *on each side, from beneath the margin of the fourth segment, projects a little brush of hair, slightly fulvous in color;* first three ventral segments green, the others dark-brown.

Hab.—Chapada, September, October. Several specimens. Evidently a male *Augochloropsis.* It greatly resembles *A. heterochroa*, but differs in several particulars, such as the more prominent lateral angles of the prothorax. It is also very similar to *A. acis* Smith, but that is smaller.

Augochlora belti n. sp.

♂. Length 10 mm.; blue-green, with strong purple tints, especially on the abdomen, strongly punctured, and little hairy. Eyes deeply emarginate; face considerably narrowed below; clypeus with large close strong punctures, its apical margin narrowly black; front and vertex extremely densely punctured; *mandibles slender, pointed, with no inner tooth; process of labrum a broad crenulate ridge, not at all bifid;* tongue long and slender; flagellum clear ferruginous beneath; anterior lateral angles of prothorax prominent; mesothorax and scutellum with dense strong punctures; base of metathorax with strong longitudinal plicæ, the intervals between them shining; truncation of metathorax ill-defined and densely punctured; punctures of sides of metathorax conspicuously larger than those on and near the truncation; a small minutely granular area, free from punctures, on each side below the enclosure; tegulæ shining piceous, convex, punctured and green at the extreme base; wings rather dusky toward the tips, nervures and stigma dark-brown; legs piceous; coxæ, anterior femora and the other femora more or less, green; tarsi becoming ferruginous at the ends; abdomen with subparallel sides, strongly punctured, the punctures on the first segment largest; hind margin of first segment very narrowly, of second segment broadly, of the other segments rather broadly, black; first, third, fourth and fifth ventral segments tinged with blue; apex with two pale orange fimbriate processes.

Hab.—Pedra Branca, April. One.

Var. **perangusta** n. var.

♂. Length $8\frac{1}{2}$ to $9\frac{1}{2}$ mm.; narrower; second submarginal cell narrow, higher than its breadth at base, whereas in *belti* it is much broader.

Hab.—Corumbá, April, several; Pedra Branca, April, one. This looks as if it might be a distinct species, but the characters mentioned are the only ones I can find to separate it. The punctureless space at the sides of the metathorax just behind the enclosure is wanting in the Corumbá examples.

Augochlora foxiana n. sp.

♀. Length 9 to 10 mm.; head ordinary, front rough with large and extremly close punctures; face and front greenish golden to golden green, strongly tinged with coppery-red, especially on the supraclypeal area; vertex and cheeks green; antennæ dark, flagellum faintly tinged with ferruginous beneath; mandibles bidentate at apex, ferruginous in the middle, with no green spot at base; *process of labrum bifid, consisting of two little nodules;* anterior lateral angles of prothorax approximately right angles; thorax except the middle of the mesothorax (which is dull black) bluish-green, verdigris color; mesothorax with extremely large and more or less confluent punctures, the area between them dull because microscopically tessellate; scutellum with large not very numerous punctures, and numerous minute ones between; basal area of metathorax narrow in a longitudinal direction, delicately longitudinally plicate, with no shining rim; sides and truncation of metathorax rough with large punctures; tegulæ very dark brown, without any green; wings smoky, nervures and stigma very dark brown; second submarginal cell about as broad as long; legs very dark brown, anterior coxæ tinged with greenish; pubescence of legs pale fulvous; abdomen black, with the segments (especially the first) showing a variable amount of green, the margins, however, always black, that of the first only very narrowly so; where the segments are green, they are punctured (the first segment strongly so), where they are black, impunctate; apex with short sooty hair; ventral surface without any green.

♂. About 8 mm. long, in most respects similar to the female, but more slender, with somewhat longer antennæ; face greener, mesothorax with less black; anterior margin of clypeus, labrum, and mandibles except their ferruginous ends, dull yellow; anterior and middle femora green; anterior tibiæ and middle and hind tibiæ in front, lively ferruginous, or orange-ferruginous.

Hab.—Chapada, January, March, April, September, November, December. Fifty specimens (♂ in November).

Var. **perimelas** n. var.

♀. Perhaps a trifle larger; face and vertex coppery-red; flagellum distinctly ferruginous beneath; mesothorax with the punctures a trifle smaller, black, with only the extreme lateral and hind margins greenish; scutellum black; postscutellum black tinged with blue or green in the middle; basal enclosure of metathorax deep blue, varying to green; pleura black, or faintly tinged with blue; abdomen black, with only a little blue or green at the sides of the first, and sometimes second and third segments. Process of labrum binodulose or entire, really a fair intermediate between the two types (bifid and entire), varying in both directions.

Hab.—Corumbá, April, two; Rio de Janeiro, November, one. Perhaps a distinct species.

The species is named after Mr. William J. Fox, who has contributed so much to the knowledge of Brazilian Hymenoptera.

β. Base of metathorax granular.

§. Green species.

Augochlora heterochroa Ckll., var. *a* (♀ supra).

Hab.—Corumbá, April, several; Chapada, December. Very similar to the ♀; no yellow on clypeus, labrum or mandibles. The anterior lateral angles of the prothorax are not prominent as in *batesi*.

§§. Black species. (*Megaloptidia*, subg. n.)

Megalopta contradicta n. sp.

♂. Length 9 to 11 mm., brown-black with sometimes the faintest suggestion of blue about the face and pleura. Ocelli very large, their distance apart and the distance of the lateral ocelli from the eyes considerably less than the diameter of an ocellus; these ocelli resemble those of *Sphecodogastra;* eyes very large, emarginate, strongly converging below, so that the lower part of the face is very narrow; sides of face with short white plumose pubescence; vertex with a few dark hairs; scape rather dark ferruginous; flagellum delicately pruinose, dark reddish-brown, inclined to be compressed basally; face and front dull, minutely granular; labrum ferruginous, convex, not at all bifid; maxillary palpi light ferruginous, with slender joints, the last two longer than the two before; mandibles short and simple, without any inner tooth; mesothorax and scutellum rather shining, subsericeous, with shallow indistinct punctures and scattered inconspicuous erect hairs; basal area of metathorax shining, minutely granular, with a few very small indistinct plicæ at its extreme base; truncation and sides of metathorax hoary-pubescent; lower parts of thorax white-hoary; tegulæ shining red-brown; wings yellowish-hyaline, hairy, nervures and stigma dark ferruginous, second submarginal cell narrow; legs very dark brown, small joints of tarsi ferruginous; pubescence of legs pale, more or less black on the hind surfaces of the hind tibiæ and tarsi, and pale ferruginous on the small joints of the tarsi; all the claws deeply cleft; abdomen very sparingly pubescent, subsericeous, impunctate; two brushes of hair projecting from the middle of the apical margin of the fourth ventral segment; apical segments strongly retractile within the others, so as to make the abdomen appear truncate.

Hab.—Santarem, two; Benevides, July, one. A very singular species. The first recurrent nervure in one specimen joins the second transverse-cubital, but in another enters the third submarginal cell at its extreme base. The second recurrent nervure joins the third submarginal cell well before its apex.

Divisions of Augochlora.

The arrangement of the species given above is artificial, intended merely to make easy their identification. It is by no means so simple to construct a natural classification, and the present attempt must be regarded as more or less provisional.

It will be observed that the first and last species are assigned to *Megalopta* Smith (not *Megaloptera*, as Ashmead has it in *Tr. Am. Ent. Soc.*, XXVI, 92). They do not agree in detail with the type of that genus, but they have the large ocelli, whereby *Megalopta* differs from *Augochlora* as *Sphecodogastra* does from *Halictus*. Smith figures the second recurrent nervure of *Megalopta* as interstitial with the third transverso-cubital, and Ashmead so has it in his tables; but Smith's *description* says that the second recurrent enters the second (error for third) submarginal cell *near* its apex. In both our species this nervure enters the third submarginal cell a very appreciable distance before the apex. Smith *figures* the first recurrent as entering the second submarginal cell near its middle, but he *describes* it as entering near or at its apex, as it does in *M. idalia*, one of the species he had before him.

M. bituberculata Smith is to be regarded as the type of *Megalopta*. *M. idalia* may prove not to be truly congeneric, when the mouth-parts are properly examined: I have not been able to determine the characters sufficiently from the single example seen.

M. contradicta is certainly subgenerically distinct, at least. It may be regarded as the type of a new subgenus *Megaloptidia*, distinguished by the first recurrent nervure being interstitial with the second transverso-cubital, or even entering the third submarginal cell, the conspicuously hairy wings, the scutellum convex but not bituberculate, and doubtless other characters which would be apparent on a comparison of specimens.

The remaining species, with normal ocelli, are assigned to *Augochlora*.

Augochlora s. str. may be held to include those species in which the hind spur of hind tibia is not pectinate in the ♀, and the process of the labrum is not bifid.

Augochloropsis Ckll. contains species in which the hind spur of the hind tibia is pectinate in the ♀, and the process of the labrum is bifid.

Each of these groups is numerous in species, and they differ appreciably in general appearance, *Augochloropsis* being usually broader and less parallel-sided, with more brassy or even coppery colors, while *Augochlora* s. str. tends to be longer, more blue-green tending to purple, with the hind margins of the abdominal segments commonly black. These characters of form and color, however, are by no means absolute.

An argument against the separation of these groups as distinct genera is found in the existence of certain intermediate types.

A. chapadæ Ckll. has the colors of an *Augochlora* s. str., and also the labrum; but the tibial spurs of *Augochloropsis*. It may be regarded as an aberrant *Augochlora* s. str.

A. foxiana Ckll. has the spurs of *Augochlora* s. str., but the process of the labrum is of an intermediate type, and quite variable.

A. mulleri Ckll. is peculiar for the subbasal ventral tooth of the abdomen, recalling *Acanthosmia* and *Acanthosmioides*.[2] This could be regarded as a subgeneric character. In *mulleri* ♀ the labrum is triangular, produced to a point at an angle of about 50°, the sides ciliate with long stout bristles, from 120 to almost 200 μ long. The shape is much as in *Megalopta*.

The palpi throughout the series have not yet been examined. The following measurements (in μ) relate to two species:

		Joint 1.	2.	3.	4.
A. (*Augochlora* s. str.) *mulleri*, Ckll. ♀.	Labial palpi,	200.	100.	100.	110.
A. (*Augochloropsis*) *vesta* var. *cupreola*, Ckll. ♀.	Labial palpi,	150.	100.	100.	110.

The first joint is long and slender in *mulleri*; shorter and stout in *cupreola*.

		Joint 1.	2.	3.	4.	5.	6.
A. mulleri, ♀.	Maxillary palpi,	100.	140.	130.	120.	120.	115.
A. v. cupreola, ♀.	" "	130.	100.	110.	115.	110.	150.

Thus, while the total lengths of the palpi are so near together as 725 and 715 μ, the proportions of the joints are very different.

Augochlora titania Smith, 1853, is not an *Augochlora*, and must be called *Corynura titania*.

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[2] Ashmead, *Tr. Am. Ent. Soc.*, XXVI, 76, describes *Acanthosmioides* under the head of species having the body black, which is incorrect; it is brassy green.

Genus **AGAPOSTEMON** Smith, 1853.

Agapostemon semimelleus n. sp.

♀. Length 10 mm.; head and thorax brilliant yellowish-green; apical margin of clypeus yellow, the yellow edged with blackish; mandibles with the basal half yellow, the apical portion dark ferruginous; flagellum ferruginous beneath, its second joint ferruginous, shorter than the third; tegulæ shining rufotestaceous; wings dullish hyaline, apical margin smoky; nervures and stigma dark-brown; apical half of anterior femora in front, and anterior tibiæ in front, yellow; hind tibiæ with a patch of black hair above at base; *abdomen honey-color*, bases of segments 2 to 4 with a broad band of yellowish-white pubescence; immediate sides of anal rims with pale hair, but the segment on each side covered with sooty hair; second to fourth segments with a dark spot at extreme side at base, the first has also a more or less defined dark spot. Anterior lateral angles of prothorax very prominent, acute. Similar in appearance to *A. melliventris* Cresson; besides the differences which may be learned from the above description, it differs from *melliventris* by its scape not being yellow in front, the mesothorax and scutellum having scattered dark hairs, the triangle at the base of the metathorax less defined, the first abdominal segment not white-hoary, and the darker legs. The stigma is very dark-brown in *semimelleus*, clear yellow in *melliventris*.

♂. Head and thorax green like the ♀; clypeus broadly margined with yellow, the yellow coming to a point above in the middle line; scape yellow in front, flagellum ferruginous beneath; legs yellow, hind coxæ green above; hind femora swollen, dark-brown above at apex; hind tibiæ with a broad stripe of dark-brown behind on the basal half; abdomen strongly punctured, yellow, with broad black bands on the apical portions of the first to sixth segments.

Hab.—Chapada, January, both sexes.

Agapostemon chapadensis n. sp.

♀. Length 10 mm.; head and thorax brilliant green; *abdomen black*. Yellow markings of clypeus and mandibles, sculpture and pubescence of thorax (except that the scutellum is sparsely punctured at the sides of the middle) as in *A. semimelleus*. Wings dusky hyaline. Legs dark; hind coxæ green above; anterior legs, from the second third of the femora down, orange-fulvous in front. Flagellum ferruginous beneath.

Closely related to *A. viridula* (Fabr.), but differs by its smaller size, yellower green, clypeus margined with yellow, stigma dark-brown (honey-yellow in *viridula*), base of metathorax more coarsely sculptured, abdomen more strongly punctured, and the anterior lateral angles of prothorax much more acute.

♂. Resembles that of *semimelleus*, but differs by having the first abdominal segment black at the base, the bands on the other segments very broad, toward the apex practically covering the segments; the anterior femora with a broad, the middle femora with a narrow, greenish stripe behind; the hind femora mostly dark-brown within, a little yellow blotch on the brown near the hind margin; all the tibiæ, and the hind tarsi, marked with brown.

Hab.—Chapada, March, both sexes; a ♀ also in January.

April 3.

The President, Samuel G. Dixon, M.D., in the Chair.

Nineteen persons present.

A paper entitled "Arachnida from Alabama," by Nathan Banks, was presented for publication.

The death of St. George Mivart, a correspondent, was announced.

April 10.

The President, Samuel G. Dixon, M.D., in the Chair.

Seventeen persons present.

A paper entitled "Trochocyathus Woolmani, a new coral from the Cretaceous of New Jersey," by T. Wayland Vaughan, was presented for publication.

Remarks on Water Analysis.—Mr. S. Harbert Hamilton desired to call the attention of the Academy to an observation he had been enabled to make while engaged in the examination of an unusually pure sample of water submitted to the Academy's laboratory by Dr. Dixon. The two standard works the speaker had consulted before undertaking the analysis had directed that a piece of previously ignited pumice stone be dropped into the alembic to prevent bumping during the distillation of the albuminoid ammonium compounds. It is possible this is a dangerous method of procedure, for pumice, whether of natural (volcanic) or artificial (blast-furnace) origin is very likely to contain nitrogen, either as sal ammoniac or cyanogen compounds, which would be so held in the pores as to likely escape removal during ignition. Mr. Hamilton was not sure whether this possible source of error had been previously called to the attention of chemists.

APRIL 17.

The President, SAMUEL G. DIXON, M.D., in the Chair.

One hundred persons present.

A paper entitled "A Review of the Physæ of Northeastern Illinois," by Frank C. Baker, was presented for publication.

The death of Charles E. Smith, a member, on the 15th inst., was announced.

Respiratory Quotient and Loss in Volume of Expired Air.—DR. HENRY C. CHAPMAN called attention to the fact that the so-called "respiratory quotient," as originally defined by Pflüger[1] is the ratio of the weight of the oxygen absorbed during inspiration to the weight of the oxygen in the carbon dioxide exhaled during expiration. Inasmuch, however, as the volume of carbon dioxide formed is equal to the volume of oxygen entering into its formation, the "respiratory quotient" is usually defined as being the ratio of the volume of oxygen absorbed to the volume of carbon dioxide exhaled. Thus, for example, on the supposition that 100 litres of air be inspired, that 4.78 litres = 6.834 gr. of oxygen be absorbed, and that 4.34 litres = 6.205 gr. of oxygen be exhaled, the respiratory quotient will be

$$\frac{\text{Oxygen}}{\text{Oxygen}} = \frac{6.205 \text{ gr.}}{6.834} = \frac{4.34 \text{ lit.}}{4.78} = 0.907$$

or

$$\frac{\text{Carbon dioxide}}{\text{Oxygen}} = \frac{4.34 \text{ lit.}}{4.78} = 0.907$$

It will be observed that in making use of the expression "respiratory quotient" in the sense used by Pflüger, it is indifferent whether the oxygen absorbed and that exhaled in the carbon dioxide be estimated in grammes or litres, but that in the second case the ratio will be only 0.907, when the ratio of volumes are compared. It is also quite obvious, though it appears to have hitherto escaped the attention of physiologists, that on the supposition that the "respiratory quotient" = 0.907, the loss in the volume of the expired air, as compared with that inspired, must be less than the one-fiftieth of a volume, as usually stated, and as originally determined by Despretz,[2] rather the one-two hundred and fiftieth

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[1] *Pflüger's Archiv*, XIV, 1877, S. 472.
[2] *Annales de chimie et de physique*, XXVI, p. 337.

of a volume, since 4.78 minus 4.34 = 0.4 the loss, and $\frac{100}{0.4} = 250$. It may be mentioned in this connection that the loss in the volume of the expired air is due to the fact that all of the oxygen absorbed does not reappear in the carbon dioxide exhaled, part of it forming in the economy other combinations, such as water, and to some extent also, sulphuric and phosphoric acids, etc. In order to avoid misunderstanding, it should be stated that as a matter of fact the volume of the expired air is greater than that inspired, on account of the usually higher temperature of the former. When, however, the volumes of the inspired and expired air are reduced to standard temperature and pressure, then the volume of the expired air will be found to be less than that inspired, the loss being about that just stated, varying according to the respiratory quotient, the latter depending in turn upon the diet.

Mr. D. Shepherd Holman made an illustrated communication on sound-waves. (No abstract.)

April 24.

The President, Samuel G. Dixon, M.D., in the Chair.

Twenty-seven persons present.

Philip P. Calvert, Ph.D., was appointed a member of the Committee on Publications, to fill the vacancy caused by the death of Charles E. Smith.

The deaths of William Camac, M.D., a member, and of Prof. Alphonse Milne Edwards, a correspondent, were announced.

Walter T. Taggart and Milo G. Miller, M.D., were elected members.

The following were ordered to be printed:

NOTICES OF NEW JAPANESE LAND SNAILS.

BY H. A. PILSBRY.

Certain species of Japanese land mollusks, described by the author in these *Proceedings* for 1899, pp. 525–530, have been redescribed by Mr. G. K. Gude in *Proceedings* of the Malacological Society of London, IV, March, 1890, pp. 8–23, Mr. Gude having been unaware of their previous definition. The necessary corrections of nomenclature will be made by Mr. Gude in an article now about to be published. The diagnostic characters of a number of new Japanese land snails may be stated as follows:

Key to Japanese Species of Alycæus.

a.—Operculum typical; *thin*, concave and nearly smooth outside.

b.—Last whorl moderately contracted behind the aperture.

c.—Broadly and perspectively umbilicated; last whorl smooth near the aperture; whorls 3½. Alt. 2½, diam. 4½ mm. Operculum thin, tawny brown. Yokohama, under the bark of pine trees. *A. japonicus* Martens.

c'.—Umbilicus moderate and deep, its width contained 3¾ times in that of shell; last whorl constricted into a smooth neck, beyond which it is striate again; no spiral striæ on the early whorls; whorls 3½. Alt. 2.6, diam. 3.75, umbil. 1 mm. Operc. thin, tawny yellow, showing the edges of the whorls slightly. Kashima, Harima. *A. harimensis* n. sp.

b'.—Last whorl scarcely contracted, rib striate to the aperture.

c.—Umbilicus moderate, its width contained 3½ times in that of the shell; whorls 3½, densely and almost evenly rib-striate to the aperture, not spirally striated. Alt. 1.7, diam. 3.2, width of umbilicus .9 mm. Operc. thin, yellowish. Kashima, Harima. . . . . *A. reinhardti* n. sp.

c'.—Umbilicus open; whorls 4, the post-nepionic one spirally striate. Alt. 2, diam. 4 mm. Yedo. *A. nipponensis* Reinh.

a'.—Operculum thickened outside by conspicuous concentric or oblique laminæ, thin in the middle (*Metalycæus* n. sect.).

b.—Operculum with blackish concentric laminæ. Shell openly umbilicate, the umbilicus less than one-third the diameter of shell; whorls $3\frac{1}{2}$, the post-nepionic spirally striate, the last half of the last swollen and straightened, more finely rib-striate, then contracted, nearly smooth beyond the contraction. Alt. 2.6, diam. 4, umbilicus $1\frac{1}{4}$ mm. Hakone Mountains. *A. melanopoma* n. sp.

b'.—Operculum with raised oblique laminæ around the edge of the outer face, like a single coil of tarred rope ; a pit in the middle. Shell with the general shape of *A. japonicus*, the width of umbilicus one-third that of the shell; whorls $3\frac{1}{2}$, the post-nepionic one not striated spirally, all but the nepionic finely rib-striate, the last moderately swollen and then somewhat contracted, smooth or nearly so beyond the constriction. Alt. 2.7, diam. 4.7, umbilicus 1.5 mm. Kioto. *A. hirasei* n. sp.

Full descriptions have been prepared to be published as soon as the necessary figures illustrating them can be drawn.

Diplommatina pusilla var. **omiensis** n. var.

Smaller than *D. pusilla*, and more closely costulate, the intervals between the riblets smooth. Alt. 1.9, diam. 1 mm.

Ibuki, prov. Omi, Japan (Y. Hirase).

In the form I have identified as *D. pusilla* the riblets are more spaced, about 12 to a millimeter, on the circumference of the last two whorls, and the intervals are seen to be densely striated spirally on the penultimate whorl, when viewed under a high magnification.

In var. *omiensis* there are about 18 riblets in the space of one millimeter, and the interstices look smooth under the same lens. The form is much alike in the two species, but *D. pusilla* is a trifle larger, a specimen measuring alt. 2.2, diam. 1.1 mm. Both are sinistral forms. *D. pusilla* was collected by Prof. von Martens at Uweno, in the immediate vicinity of Tokyo.

Macrochlamys micrograpta n. sp.

Shell narrowly umbilicate, the width of umbilicus contained about eighteen times in the diameter of the shell, depressed, glossy, pale corneous brown, adults a little whitish around the umbilicus, subtransparent, the earlier whorls visible through the base. Sculpture of slight growth striæ and excessively close, deeply engraved and minute spirals. Spire very slightly raised, narrow; whorls $4\frac{3}{4}$, slowly increasing, the last much wider, double the width of the preceding, rounded at the periphery. Aperture but slightly oblique, rather broadly lunate, the peristome simple and acute, a little retracted toward the insertion above, the columellar insertion produced forward and a little dilated.

Alt. 4.6, diam. 9.5 mm.

Similar in general form to *Helix rejecta* Pfr., as figured by Reinhardt,[1] but *micrograpta* differs in the less oblique and less laterally dilated aperture. No mention of spiral striæ is made in the description of *H. rejecta*. In *H. dönitzi* Reinh. the last whorl is conspicuously narrower, as seen from above.

Kaliella multivolvis n. sp.

Shell minute, imperforate, trochiform with convex base and carinated periphery; thin and subtransparent, of a brownish yellow tint. Surface smooth, glossy beneath, a little less bright above. Spire regularly and straightly conic; the apex obtuse. Whorls $6\frac{1}{2}$–7, the first rather large, the rest very narrowly revolving, decidedly convex, the last whorl depressed-globose, with a rather acute peripheral keel and quite convex base, which is narrowly but rather deeply impressed around the axis. Aperture mainly basal, shaped like a narrow, weakly curved crescent, with blunt or truncate ends. Upon the base may be seen, in most specimens, one or two nearly straight white radial stripes, produced by low radiating barriers within, the last one often visible within the mouth, upon the basal wall.

Alt. 1.7, diam. 2.2 mm.

Kashima, prov. Harima (Y. Hirase).

Apparently allied only to *K. stenogyra* (A. Ad.), from Tsu-Sima, described as a *Conulus;* but the present species differs in the strongly convex whorls of the spire. It is also smaller with fewer whorls. The low radial ramparts within the last whorl are similar to those of the American *Conulus chersinus dentatus* Sterki. Some species of the little group *Taxeodonta* Pils. have internal armature of the same kind.

In *K. multivolvis* the barriers are placed at intervals of a third

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[1] *Jahrb. d. d. Malak. Ges.*, IV, 1877, p. 316, Pl. 10, f. 1.

of a whorl, when more than one is present. Two specimens of six sent by Mr. Hirase show no barriers.

Vitrea harimensis n. sp.

Shell narrowly umbilicate, small, depressed, thin, brownish-yellow, translucent, the surface smooth and polished, growth-striæ being scarcely visible. Spire slightly convex. Whorls 3½, the first one rather large, the rest very slowly widening to the last, which is much wider, about double the width of the preceding. Sutures appressed and margined, the margin concave. Periphery equably rounded, the base somewhat convex. Aperture somewhat oblique, deeply crescentic.

Alt. 1.8, diam. 3.5 mm.; width of umbilicus 0.3 mm.

Kashima, Harima, Japan (Y. Hirase).

With much the form of *V. radiatella* Reinh., this species is distinguished by the smoothness of the brilliantly glossy surface. Mr. G. K. Gude has recently placed *radiatella* under *Zonitoides nitidus* as a synonym, but from the description and figure given by Mr. Reinhardt I am quite unable to follow him.

Georissa japonica n. sp.

Shell minute, imperforate, high-conic, flesh or salmon tinted, rather thin, finely lirulate throughout, but the threads often almost obsolete basally. Whorls 3¾, the nucleus large, globular and projecting, glossy and rather translucent; following whorls very convex, separated by deep sutures. Aperture slightly oblique, half-round, the outer lip simple and thin, unexpanded, parietal and columellar margin a little concave; the umbilical region covered by a heavy white callus, triangular in shape, as seen from in front.

Alt. 2, diam. 1.7 mm.

Operculum semicircular, whitish externally, bearing a long curved process within.

Kashima, Harima (Mr. Y. Hirase).

I do not know that this genus has been reported from Japan hitherto. The median field of the radula is nude, uncini extremely numerous, in very oblique rows.

NEW SOUTH AMERICAN LAND SNAILS.

BY HENRY A. PILSBRY.

For most of the specimens described, the Academy is indebted to Dr. H. von Ihering, whose work in developing the zoölogy of southern Brazil continues with unabated vigor. Others were collected by Mr. J. B. Steere, in Peru, and submitted to me by Mr. H. E. Sargent.[1]

STREPTAXIDÆ.

Scolodonta interrupta (Suter). Pl. XII, figs. 6, 7, 8.

Size and general form much as in *Zonitoides nitidus*. Umbilicus showing all the whorls within, its width contained nearly 4 times in the diameter of the shell. Surface glassy, subtranslucent white, scarcely showing growth-lines, but with several former peristomes at unequal distances, each indicated by a slightly sinuous distinct groove, with a whitish streak behind it. Whorls 5, slowly increasing, the last decidedly wider, rounded at the periphery and beneath; sutures moderately impressed. Aperture round-lunate, about one-third of the circle excised by the preceding whorl, slightly oblique; peristome a little sinuous, a trifle thickened within, unexpanded, the columellar margin a little dilated.

Alt. 3.5, greater diam. 6.5, lesser 5.6 mm.

Os Perus, Prov. Sao Paulo, Brazil (Dr. H. von Ihering).

A small whitish species, No. 1,186 of von Ihering's register.

Happia Iheringi, n. sp. Pl. XII, figs. 1, 2, 3.

Shell umbilicated, depressed, discoidal, translucent, corneous. Surface glossy, showing very slight, fine growth-wrinkles under the lens, and occasional white lines indicating the positions of former peristomes. Spire concave, very narrow, its width contained $3\frac{1}{3}$ times in that of the shell. Whorls slightly exceeding three, the last very wide, rounded at the periphery, convex beneath, umbilicus narrow, rapidly contracting, its width contained $4\frac{1}{2}$ times in the diameter of the shell. Aperture broadly lunate,

[1] Since this paper was in type, I have received an advance copy, without plates, of a paper by Mr. H. Suter, published in Portuguese, anticipating several of the species I had described as new. I have substituted Mr. Suter's names for my own.

deeply excised by the preceding whorl, a little oblique; peristome thin and simple.

Alt. 2, greater diam. 5, lesser 4.3 mm.

Os Perus, Prov. Sao Paulo, Brazil (Dr. H. von Ihering).

A small nautiloid species, No. 1,185 of Dr. von Ihering's catalogue. He notes (*in litt.*) that it has a small jaw, and a radula of typically carnivorous type, with the formula 13. 1. 13. The presence of a jaw suggests the pertinence of *Happia* to the family *Circinariidæ*, rather than to *Streptaxidæ;* but we are still profoundly ignorant of the anatomy of the South American Streptaxes.

Happia vitrina (Wagner).

Cubatao, Alto do Serra, Sao Paulo (No. 1.184 of Dr. von Ihering's register). It is *Streptaxis tumescens* of Suter.

Another *Happia*, No. 807 of von Ihering's register, is somewhat like *H. vitrina* (Wagner), but with wider, less depressed spire, wider umbilicus and rougher, wrinkled surface; diam. 15 mm., habitat, Piquete, Sao Paulo. This is evidently undescribed, but as the lip of the single specimen sent is broken, I defer its formal characterization. It is No. 71,247 Coll. A. N. S. P.

Guppya seminlini (Moricand).

Os Perus, Sao Paulo (No. 1,183 of von Ihering's register).

Dr. von Ihering remarks (*in litt.*) that he can see no reason for referring *seminlini* to a different genus from *fulvus;* and while it is customary to separate the tropical and South American species of this form as a genus *Guppya*, it must be acknowledged that there are absolutely no differential generic characters *in the shells* between the two species mentioned above. The typical forms of *Guppya* have a fleshy prominence or horn above the caudal gland, which, so far as I know, is wanting in the North American and Palæarctic *Conulus*.

However, the name *Conulus* is preoccupied by Rafinesque; and although his *Conulus* is a synonym of *Conus* Linné, still the name cannot be revived. It is also in use in Echinodermata. Under these circumstances, it seems that *Guppya* will stand as the generic name for the tropical and South American species. A rapid survey of the South American species in the collection of the Academy shows that they are more numerous than the literature would indicate, and often various forms appear under one or another of the older names. The true *seminlini* has an excessively minute sculpture giving a silky lustre to the upper surface, while the base is glossy, with extremely fine, close, superficial circular striæ. A specimen measures: alt. 3.7, diam. 4.6 mm, whorls 5⅓.

A smaller species or variety, alt. 2, diam. 2.6 mm., from Os Perus (No. 1,182 of von Ihering's register), is allied to *seminlini* Moric., *paraguayana* Pfr., *anguina* Anc. and *martinezi* Hid. The form is much as in *seminlini;* whorls a trifle over 5, the last angular, surface with a silky lustre above and a band of the same just below the periphery, just as in "*Conulus*" *chersinus* var. *polygyratus* Pils. The rest of the base is glossy, but under sufficient magnification shows spiral striæ in places. This may be called var. *subseminlini*.

ENDODONTIDÆ.

Stephanoda pleurophora (Moricand). Pl. XII, figs. 4, 5.

This species, described from the Province of Bahia, has been found by von Ihering at Sao Paulo. As the original description and figures leave much to be desired, new figures are here given.

There are 4½ whorls, the earlier one and one-half smooth, the rest with raised, lamellar rib-striæ, which are sinuous, and about 8 to a millimeter on the front of the last whorl, becoming more crowded near the aperture. The width of the umbilicus is contained nearly four times in the diameter of the shell. Alt. 2.3, diam. 3 mm.; width of umbilicus .5 mm.

The jaw and radula have been examined by Dr. von Ihering. The former is but little arcuate, composed of twenty well-united narrow plates, being like that of *Charopa*, *Endodonta*, etc. The radula has the formula 15. 1. 15, the central teeth tricuspid, with the middle cusps much shorter than the basal plates; laterals also tricuspid, the middle cusps longer than the basal plates; marginals wide, multicuspid, the cusps being split into some five acute denticles.

Stephanoda patagonica (Suter). Pl. XII, figs. 9, 10, 11.

Shell minute, depressed, subdiscoidal, umbilicated, the width of the umbilicus contained nearly four times in the diameter of the shell. Spire slightly convex; whorls 3¾, convex, separated by deep sutures, the earliest 1½ whorls smooth, the rest finely and densely rib-striate, the striæ rather low, straight, about 20 in the space of a millimeter on the last whorl; last whorl rounded at periphery and below. Aperture rounded-lunate, slightly oblique.

Alt. 1.15, greater diam. nearly 2 mm.; width of umbilicus .5 mm.

Santa Cruz, Patagonia (No. 1,181 of Dr. von Ihering's register).

The specimens of this very minute species were obtained from dried mud. It is smaller than any other described form from the region.

HELICIDÆ.

Polygyratia Sargenti n. sp.

Shell planorboid, flat above, having a deep, broadly funnel-shaped or conical umbilicus below; yellowish-corneous, subtranslucent, glossy; finely striatulate, and showing some faint spiral lines, visible only under a strong lens, above. Whorls $7\frac{1}{2}$ to 8, the first one wider than the next, very closely coiled and slowly widening, the last whorl deviating and somewhat descending toward the aperture, rounded peripherally and below, flattened and impressed behind the upper lip. Umbilicus half the width of the shell, or a little less. Aperture irregularly bilobed, quite oblique; peristome slightly expanded, more so below, a little thickened, the upper margin straightened and bearing a conic median tubercle; outer margin arched, basal margin nearly straight or only weakly arcuate; the terminations widely separated.

Alt. 11, diam. $3\frac{2}{3}$ mm.

This species is allied to *P. Ortoni* Crosse, from which it differs in the smaller size, paler color, decidedly narrower and more conical umbilicus, and greater height compared to the diameter. It has one or two whorls less than specimens of *P. Ortoni* before me from Boya, Peru. The aperture resembles that of *P. Ortoni.*

It is named in honor of Mr. H. E. Sargent.

Polygyratia affinis n. sp.

Shell planorboid, flat above, and somewhat concave in the middle, having a broadly conic umbilicus below, pale yellow, very glossy, faintly striatulate whorls $8\frac{1}{2}$, excessively closely convoluted, the last whorl about four times as wide as the preceding, rounded at the periphery, tangentially deviating and somewhat descending near the aperture. Aperture quite oblique, deeply lunate, the peristome simple and unexpanded, the upper margin somewhat straightened, sloping, outer and basal margins arcuate.

Alt. 4, diam. 11⅓ mm.; width of umbilicus 5 mm.

Peru. Coll. A. N. S. P. No. 57,671.

This species was in the collection of the Academy under the name *H. stenogyra* Pfr. It is nearly allied to *P. polycycla* Morel., but is less depressed, the last whorl wider, and the umbilicus is much narrower. In *P. systrophia* the last whorl, seen from above, is much narrower. *P. stenogyra* is an allied but larger and otherwise differing species.

Polygyratia stenostrepta var. **declinata** n. var.

Similar to *stenostrepta*, but with the last whorl much more deeply deflexed anteriorly, the suture terminating at the middle or lower third of the height of the whorl; groove above the upper lip strongly developed; basal lip well expanded. Whorl 9⅔.

Alt. 4½, diam. 13 mm.

Alt. 4, diam. 11½ mm.

Peru. Types No. 78,140, Coll. A. N. S. P.

Epiphragmophora oresigena var. **bernardius** v. Ihering, n. var.

Shell similar to *E. oresigena* (Orb.), but smaller, and lighter colored, yellow or greenish-yellow, with three blackish-brown bands, two above the periphery, one wider band on the base. Whorls 4½, the last subangular at the periphery; surface lirate-malleate, the wrinkles tangential to the last whorl of the suture. Aperture white or purplish, and banded within, the lip white; umbilicus partly or nearly covered.

Alt. 17, diam. 30 mm.

Alt. 16, diam. 28 mm.

Serra da Bocaina, State of Sao Paulo, Brazil (Dr. H. v. Ihering).

The typical *E. oresigena* is a larger, heavier and darker shell from the northeastern slope of the eastern cordillera and the province of Yungas, Bolivia. It will probably prove to be a variety of the still larger *E. audouinii* Orb., from the same region. The types of var. *bernardius* are No. 71,253 Coll. A. N. S. (No. 872 of Dr. von Ihering's register).

Strophocheilus oblongus (Müller).

The geographic range of this species is greater than that of any other *Strophocheilus*. In the north there is one insular variety, *albolabiata* E. A. Smith,[2] of Tobago. In the south there are several varieties, as follows:

Var. *crassus* Albers. Parana region (Orbigny, Gülich).

Var. *alba* Smith. As large as the type, but pure white, lip rose-pink. Pampa Ruis, Bolivia (Orbigny).

Var. *sanctæpauli* v. Iher. and Pils., n. v.

Very slender and elongated, not compressed between face and back, with narrow, produced spire. Substance of the shell reddish, with light subsutural band; cuticle persistent; surface typically costulate, but later two whorls without microscopic granulation. Aperture small, half the shell's length, pink within; peristome brilliant rose colored. Whorls 6. Alt. 84, diam. 43 mm.; alt. of aperture 43 mm.

Botucatú, Sao Paulo, Brazil (von Ihering).

This variety resembles *S. santacruzii* somewhat.

Dr. W. H. Rush found the typical form of *oblongus* at Fray Bentos, on the Uruguay river, and with it a small, solid race with obtuse spire, and small, brilliant rose-lipped aperture.

Strophocheilus paranaguensis Pils. and v. Iher., n. sp. Pl. XI, figs. 1, 2.

Shell ovate, *decidedly compressed dorso-ventrally*, moderately solid, *the spire short*, obtuse. Shell substance dull pink, with a pale band below the sutures; cuticle mainly retained on the later two whorls, yellow below the sutures and back of the outer lip, *elsewhere yellowish-chestnut, with rather numerous, narrow, obliquely longitudinal chestnut streaks*. Surface moderately shining, irregularly, *strongly wrinkle-costulate*, as in *S. oblongus;* showing under the lens a microscopic granulation (similar to that of the spire of *S. oblongus*), which is largely or entirely lost on the last half whorl. Nepionic whorls finely costulate, as in *S. oblongus*. Whorls $5\frac{3}{4}$, the earlier five regularly and moderately widening, with slightly oblique sutures, the last half whorl (in a dorsal view) rapidly descending, its *suture extremely oblique*. Aperture somewhat oblique, whitish inside; peristome well expanded, brilliant rose-colored; columella with a moderate fold.

[2] The synonymy of this variety is as follows :

Borus oblongus var. *albus* Müll., W. G. Binney, Ann. N. Y. Acad. Sci., iii, p. 115 (jaw and teeth; shell not described).

Bulimus oblongus var. *albolabiatus* E. A. Smith, Proc. Malac. Soc. Lond., i, p. 137 (1894).

Strophocheilus oblongus var. *tobagoensis* Pilsbry, Man. of Conch (2 Ser.), x, p. 30, Pl. 14, f. 70 (1895).

Alt. 92, diam. maj. 55, min. 47 mm.; length of aperture 62 mm.
Paranagua, coast of Prov. Parana, Brazil.

With the sculpture of *S. oblongus*, this species unites the contour of *S. ovatus*. It differs from *oblongus* in the streaked cuticle, dorso-ventral compression, short spire, and very oblique last suture. It is more obese than *S. granulosus* Rang, with less pronounced granulation, coarse surface costulation, and closer apical riblets.

Strophocheilus globosus (Martens).

The locality of this species has hitherto been unknown. It occurs subfossil at Montevideo, Uruguay, whence specimens have been sent by Dr. von Ihering. It will doubtless be found living in the same region. The apical sculpture is that of the *S. oblongus* group. Some specimens are so globose as to suggest the European *Helix aspersa*.

BULIMULIDÆ.

Bulimulus Steerei n. sp.

Shell umbilicate and *broadly rimate*, ovate-conic, with *straight-sided spire* and convex last whorl, *the base angular around a large umbilical excavation;* solid and strong, opaque soiled white, with indistinct brown stains in most specimens, and usually an indistinct whiter girdle at the periphery, the apex white. Surface lustreless, *finely wrinkled longitudinally, and densely granose in spiral series*, as in *B. proteus* or *B. Montezuma;* the granules small but strongly expressed. Apex obtuse, earlier 1½ whorls strongly vermiculate-wrinkled, the wrinkles anastomosing and largely transformed into a netted pattern. Sutures not impressed, being filled by the peripheral keel of the young shell. Whorls 6½, the first two convex, *those following almost completely flat*, the last whorl convex, without trace of a peripheral angle or carina, usually ascending in front. Aperture subvertical, ovate, built forward nearly to the level of the ventral convexity, brown tinted within; *peristome broadly expanded, thickened within*, brown or white, *acute at the edge.* Columella oblique, *making an angle with the basal margin;* its edge dilated; parietal callus moderate or slight, whitish.

Alt. 38, diam. 21, longest axis of aperture 20½, greatest width 13½ mm.

Alt. 35, diam. 20, longest axis of aperture 21, greatest width, 13½ mm.

Alt. 36, diam. 19, longest axis of aperture 20, greatest width, 12½ mm.

Peru, J. B. Steere expedition. Types in Coll. A. N. S., No. 78,144, and Coll. University of Michigan.

The granose surface gives this species some resemblance to *B. Proteus*, but it differs in the characters of the aperture and the flat whorls of the spire. The young and half-grown shell is evidently acutely carinate at the periphery. In this respect *B. Steerei* is like *B. Cora* Orb., and other forms referred to the genus *Neopetræus*; but it has the apical sculpture of a true *Scutalus*, wholly unlike that of *Neopetræus*.

The deeply excavated tract behind the columellar lip leads to a tubular umbilicus, which is evidently large and open in the immature shell, but is more or less constricted in most adults.

Bulimulus hæmatospira n. sp.

Shell rimate, *pillar-shaped*, the *last 4 whorls of about equal diameter and white, those above tapering and deepening to a blood-red color;* thin, but moderately strong, opaque, nearly lustreless. Apex obtuse, the earlier 1⅔ whorls convex and sculptured with *delicate, spaced and straight longitudinal riblets;* next whorl or two nearly smooth, with merely some series of long granules; longitudinal ribs gradually appearing; *the white, cylindrical portion of the shell being sculptured with strong, arcuate ribs,* narrower than their intervals, and several spiral series of long, narrow, crowded granules. Whorls 8½ to 9, the earlier convex, the later 3 or 4 somewhat flattened. Aperture small, oval, longer than wide, white within; peristome simple and unexpanded.

Length 16, diameter above the aperture 3, length of aperture 3 mm.

Length 16.3, diameter above the aperture 3, length of aperture 3 mm.

Length 15, diameter above the aperture 3.1, length of aperture 3 mm.

Locality unknown, probably Peru. Types in Coll. A. N. S., No. 78,135, and in Coll. University of Michigan.

This beautiful little *Bulimulus* would be considered a *Peronæus*, from its narrow form and calcareous texture, were it not for the apical sculpture, which is like *Næsiotus*, *Protoglyptus* and *Orthotomium*. This shows it to be not a *Peronæus*, but a stock of different ancestry, parallel to that group, such as I have shown to exist in various Bulimulid groups.

Odontostomus kühnholtzianus (Crosse). Pl. XII, fig. 12.

An enlarged view of the aperture is given to show the arrangement of teeth. The specimen figured is from Montevideo, collected by J. Arechavaleta, Director of the National Museum of Montevideo (No. 1,015 of Dr. von Ihering's register, 78,037 Coll. A. N. S. P.).

HELICINIDÆ.

Helicina iguapensis n. sp.

Shell depressed, the *diameter about twice the altitude, lens-shaped, acutely keeled;* very pale yellow, the apex and basal callus white. Surface lightly striate, irregularly grooved and finely striate spirally, this sculpture weaker on the last whorl, finer beneath. Spire low conic; whorls 5, the first smooth, the last slighty convex, becoming concave above the acute peripheral keel. Base evenly convex. Aperture oblique, subtriangular, white within; peristome rather broadly reflexed, white, angular at the termination of the peripheral keel; the upper margin nearly straight, basal margin moderately arcuate; columella very short, *vertical, produced below in a projecting angle.* Callus thin, white.

Alt. 8.5, diam. 16 mm.

Operculum scarlet outside, fading to whitish at the nucleus, lightly striate, irregularly triangular, the nucleus marginal, nuclear edge straight, with reflexed scarlet margin.

Iguape, S. Paulo, Brazil. Type from Dr. H. von Ihering, No. 78,028, Coll. A. N. S. P. (940 v. Ihering's register).

This species resembles *H. carinata* Orb., *angulata* Sowb., and *gonochila* Pfr. in the salient angle or tooth in which the columella terminates below; but it is a far larger and more depressed shell. In general form it is almost exactly like *H. caracolla* Moric., which differs in completely lacking any trace of an angle at the base of the columella.

The sculpture above seems to consist of rather low, flat liræ, over which much finer spiral striæ run. This is best developed on the next to the last whorl.

Helicina inæquistriata n. sp.

Shell thin, subglobose-depressed, rather bluntly carinated; varying from a dull reddish color to pale sulphur yellow. Surface dull, sculptured with fine growth lines and numerous unequal, low and flattened spiral liræ, with a sculpture of fine spiral striæ over them, giving the appearance of groups or fascicles of more prominent, alternating with bands of less prominent spiral striæ. Spire low conic; whorls $4\frac{1}{2}$ slightly convex, the last decidedly angular at the periphery, convex, not descending anteriorly. Aperture subtriangular, the outer angle rounded; peristome white, narrowly subreflexed, its face thickened in old specimens; upper margin but slightly arcuate, basal margin strongly arched, forming a right angle with the straight and vertical columella, the base of which is outwardly angular. Basal callus rather small, whitish.

Alt. 7, diam. $9\frac{1}{2}$ mm.

Raiz da Serra, Sao Paulo, Brazil. Types from Dr. H. von Ihering, No. 78,038 Coll. A. N. S. (938 von Ihering's register).

Appendix: Description of a New Strophocheilus, by Dr. H. von Ihering.

Strophocheilus Pilsbryi n. sp. Pl. XI, fig. 4.

Shell perforate, oblong, moderately solid, chestnut brown, with a blackish line followed by an ill-defined yellow band below the suture; irregularly plicatulate and beautifully granose microscopically throughout, the granulation barely visible to the naked eye, and arranged in regular spiral series; spire thick, obtuse. Whorls 5, the first one planorboid, the next tumid above; last whorl oval, convex, its later half more descending, shortly ascending at the aperture. Aperture ovate, bluish within; peristome reflexed, red; columella oblique and straight above, concave below, its margin dilated above, almost closing the narrow perforation.

Length 48, diam. 24 mm.; aperture 25 mm. long.

Piquete (Serra da Mantigueira), Sao Paulo, Brazil.

This species seems to be allied to *S. rhodocheilus* (Reeve), but has not the color-pattern or columellar fold of that species, the aperture is smaller, and the surface irregularly plicatulate as well as granulous.

PRELIMINARY NOTES ON THE RATE OF GROWTH AND ON THE DEVELOPMENT OF INSTINCTS IN SPIDERS.

BY ANNIE BELL SARGENT.

The following work[1] was taken up in the fall of 1898 for the purpose of determining how young spiders develop through the winter, what instincts or intelligence they may possess and when these appear.

In October I collected, on a vacant lot in Philadelphia, several hundred cocoons, in all probability *Argiope cophinaria*, as that was the adult spider most commonly found among the cocoons. Dr. McCook in his *American Spiders and Their Spinning Work* (7) has described the structure of these cocoons so exactly that I need not go into it here.

Although the spider probably has not an intelligence comparable to that found in higher animals, that it does possess complex instincts is evident in the making of the cocoon. Four kinds of silk, of as many colors, are found in each completed nest; the whole is shaded over with a fifth, which renders it less conspicuous, and it is moored to its place by a sixth, (see McCook, (7), Vol. II). Each kind of silk has its respective place, which never varied in all the cocoons I examined, although in some a layer was omitted. However these differences are produced, an instinct that guides its possessor through such intricacies is of a high order.

All the occupants of a single cocoon were in the same stage of development, and until November cocoons containing all stages, from the egg to the just-hatched embryo, were found. After November the eggs that had not hatched dried up.

GROWTH.

Before the time of Balbiani's work (1) in 1873, the development of Araneæ had been studied chiefly with regard to the exter-

[1] Accepted as a thesis for the degree of Bachelor of Science in Biology, University of Pennsylvania, June, 1899.

nal features by such writers as Herold (4), 1824; Rathke (10), 1842; Von Wittich (11), 1845; and Claparède (3), 1862. Balbiani (1) has given a detailed description of the early development, but does not describe completion of the abdominal organs. In 1880 Balfour (2) gave notes on the development from completion of segmentation to completion of thoracic organs, but gave nothing with regard to the eventual fate of yolk and the formation of intestine. In 1886 Locy (6) gave a very complete account of the development of *Agalena* from laying of the eggs to hatching of the embryo. He showed that the intestinal tract is still incomplete at time of hatching, and my observations tend to confirm this. Kishinouye (5), in 1891, made observations on *Lycosa* and *Agalena* from laying of the egg to hatching. He has not followed out the completion of the intestine.

In the works of the last two writers, it is difficult to determine whether by the term " hatching " they mean leaving the egg membrane or leaving the cocoon. Locy speaks of one moult before hatching in *Agalena* and Kishinouye says there are two or three moults before hatching in *Agalena* and *Lycosa*. In *Argiope* there was no indication of a moult before the leaving of the egg membrane, but there were two or three moults before the leaving of the cocoon. In this paper hereafter by " hatching " is meant the leaving of the egg membrane. My observations agree with those of the above writers in showing that the spider leaves the egg in a very embryonic condition, and that the intestine is not complete until just before or just after leaving the cocoon.

For the purpose of determining how the young spiders develop, I killed a number for sectioning from time to time through the winter. Picro-sulphuric acid gave the best results as a fixing fluid. Second to this was picro-acetic acid. Both require from twelve to twenty-four hours to kill, because the many little hairs on the body enclose a jacket of air which buoys the spider up and keeps the fluid from reaching the skin. It is very difficult to make stains penetrate the tissues and I found the following a very good method. Having removed the legs, or, in the case of very young spiders, pierced the abdomen with a fine needle, stain *in toto* in picro-hæmatoxylin for twenty-four hours. It may be necessary to harden in alcohol and again stain in picro-hæmatoxylin. Take up to seventy per cent. alcohol and stain for twelve hours in alcoholic eosin. The picro-hæmatoxylin will penetrate the abdomen slightly if at all; but the eosin stains it fairly well. The best results were obtained by embedding in celloidin and paraffin and fixing on the slide with hot water.

Argiope cophinaria.

As early as November the cephalo-thorax is complete ; the stomach and œsophagus, the nerve mass surrounding them, the blood vessels around the nerve mass, muscles, poison glands, pigment and eyes are fully developed and throughout the winter I observed no change in this part of the body. The abdomen is the reservoir for the great quantity of yolk which remains even after so much of the body is completed. The intestine and "liver" have not made their appearance in November, although all the other abdominal organs have. This entire space is filled with solid yolk masses divided by three main blood sinuses which run down from the heart. The heart is much compressed at this time, and has few corpuscles in it (Pl. IX, figs. 2, 3 and 4). In January the yolk masses begin to break up and are slightly absorbed. In February the intestine shows distinctly in section and the "liver" can be distinguished among the yolk masses. There is a decided change in the shape of the abdomen—from rounded to elongated, flattened dorso-ventrally. In March (Pl. IX, fig. 1) the alimentary canal is almost complete from mouth to anus. The mouth is lined on both upper and lower lip with chitinous ridges, which interlock to form a strainer. A large quantity of yolk still surrounds the intestine and is scattered among the abdominal organs. As the yolk masses diminish, movements are noticed. At first there is a mere waving of legs, then rolling and scrambling over each other, and finally a definite, though awkward, climbing along the threads of the cocoon. Increase in size is slight, and takes place very slowly after the spider leaves the egg-membrane. Then follows a period of slow-development, which lasts through the cold months and consists in absorption of yolk, increase in pigment and change in shape to that of the adult spider.

Agalena nævia.

In addition to the Argiopes there came into my possession the cocoon of *Agalena nævia* Hentz. These eggs were laid on October 10, 1898, and hatched November 15. Within two weeks after hatching these spiders were perfectly black, running about the box in which the cocoon lay and making an irregular web all through it. Their activity was in striking contrast to that of *Argiope.* In the matter of spinning webs and climbing on them they were skilled acrobats, and behaved as if this had been their habit for months. At this time they did not eat and showed no fear of each other, although they became wildly excited and ran in every direction when the box was disturbed or anything was dropped into the web.

In a few days they began to eat and increased notably in size. From time to time I made camera drawings as the increase warranted (Pl. X, figs. 5–14).

When the spider is full-fed and about to moult, the skin is very tight and shiny; the abdomen seems out of proportion to the cephalo-thorax. After the moult, the actual increase in size seems slight. The expanse of the legs is greater, there is an increase in length and in width of the cephalo-thorax, but the abdomen is shrunken. As soon as the spider begins to eat again, it increases rapidly in size until the limit is reached, when a moult again occurs. It is possible that this increase is due to filling out of folds in the skin.

Development of Instinct.

There has been some discussion as to whether the spiders have, in any degree, intelligence. There have been many scattered anecdotes and marvelous tales, such as those related in *The Naturalist in La Plata,* that would credit the spider with intelligence; but careful scientific investigation tends to refute all such ideas and places the spiders among animals having complex instincts. The most valuable work that has been done along this line is that of George and Elizabeth Peckham (9) and Dr. McCook (7).

It is certain that young spiders gain nothing by imitation, for many of the most highly developed species lay their eggs in the fall and give them no further attention. In the spring, when the young leave the cocoon, and when they would be most benefited by the example of others, they separate and each, with its own inheritance of instincts and tendencies, starts out to do battle for itself. And yet here as elsewhere in the animal kingdom, one is impressed with individual differences, as will be shown later.

Among the hunting spiders (*Lycosidæ*), too, there is no chance for imitation. At the time when the young leave their mother's back they separate, as in the case of the weavers. This does not imply that the spider leaves the cocoon, or its mother's back, as skilled and as agile as she is. It must learn and practice to perfect itself.

As early as February, and long before it leaves the cocoon, young *Argiope* can spin a little drop line, but the line is short; it requires considerable stimulus, as shaking, to cause it to spin; the spinner in many cases seems unable to climb back, and when it does climb back it is with exceedingly clumsy efforts. The young hunting spider at an early age obeys its instinct to catch a moving gnat, but its first attempts are rarely successful, and for some time it is very awkward.

Observations on Argiope Cophinaria, October to April.

All during October, spiders were hatching, and at this time gave no indication of any sense except that of touch.

In November they had moulted once or twice, and were slightly more active when disturbed.

In December they were decidedly more active, but seemed not to notice light or heat.

In January development was very slow and no changes were observed.

In February most of the little spiders could be made to spin a little drop line by violently shaking the egg ball. They made awkward attempts to walk, and did not use their hind legs in guiding them along the threads of their cocoon. Off the cocoon silk they were perfectly helpless, soon became tired and lay with legs drawn up.

To try the effect of severe winter weather on young spiders outside of the cocoon, I placed a number of specimens in a little pasteboard box and left them in an open window of an unheated room. Some individuals were in the silk of the cocoon, others were not. The following observations were made. Unfortunately, the exact amount of cold to which these spiders were subjected was not determined. In the absence of such data the official records of the Weather Bureau of the minimum temperatures for the nights in question are given:

February 9.—Removed spiders from cocoon as described above and exposed all night. Weather Bureau record, —1° F. (= —18.3°C.).

February 10.—Still living and active when touched. Exposed again all night. Weather Bureau record, — 6° F. (= — 21° C.).

February 11.—Less active. Exposed all night. Weather Bureau record, — 6° F. (= — 21° C.).

February 12.—No change. Exposed all night. Weather Bureau record, 4° F. (= — 15.5° C.).

February 13–16.—No change. Exposed each night. Weather Bureau record, 7°, 9°, 11°, 21° F. (= — 13.8°, — 12.7°, — 11.6°,—6° C.).

February 17.—Seemed more active. No definite movement toward any point or return to the ball on the part of those not in the silk (36°F. = 2° C.).

February 18.—Several of those lying on bottom of the box and outside of the meshes of the silk dead; others not so active (32° F. = 0° C.).

February 23. —All spiders lying on bottom of the box and not in the meshes of the silk, dead, except three beneath the silk of the cocoon; these three very sluggish (37° F. = 2.7° C.).

February 24–27.—Less active each day; nearly all the spiders in the box died, including those beneath the silk. The lowest temperature was 26° F. (= — 3.3° C.), on the 25th.

March 1.—Four living in the silk of the cocoon.

March 6.—All dead.

From observations made since, it is probable that these spiders died, rather from their scattered condition, than from the cold.

As opening cocoons seemed to have no effect upon the occupants, to determine how they would behave if deprived of the cocoon entirely, I made these observations:

February 9.—A brood of spiders clinging to the cocoon silk was removed from the cocoon and spread out in a glass globe. They showed plainly that they were disturbed. Some moved along the threads of the silk, although for the most part they simply waved their legs and rolled over each other, trying to form into little balls wherever a few were together. No attempt was made to return to the cocoon, although it hung still attached to the silk. Aphids were offered as food, but the spiders did not seem to see these; also water, but no attention was paid to it.

February 10.—A decided grouping into balls was noticed at points where most of the spiders happened to be as the silk was drawn out. Moved awkwardly, or waved their legs, when brought near heat. No attempt to spin. Turned the globe so that light fell on it differently, but this produced no effect.

February 11.—No difference in position of balls; balls somewhat larger; fewer spiders moving along the web; all resting with ventral side uppermost, but moving with dorsal side uppermost.

February 17.—I placed the globe so that rays from a lamp fell on some of the spiders, while others were in shadow; after thirty minutes there was activity among those exposed to light—a general tumbling and rolling over each other, but no definite movement toward the light or away from it. Activity evidently caused by the light, as those spiders in the shadow remained quiet, with ventral side up as before.

March 12.—Drew silk away from one of the groups, scattering some of the spiders; all moved actively, apparently trying to get into centre of the mass; in a few hours all the stragglers had gone back to the group; acted as if stiff from cold, although temperature was not low.

March 13–31.—No change in groups; most of the isolated spiders died.

April 1.—Still no attempt to weave webs.

April 2.—More active, and moved along web with less waving of legs, using hind legs as guides; soon formed into groups when scattered.

April 26.—Those spiders on outside of groups shriveled up.

At this time I took some of the spiders out on a sheet of paper and noticed that they moved away from anything touching them, but were not aware of an approaching object until actually touched.

On March 10 I opened twenty-six cocoons that had been kept in a locker all winter. In these all were dead except six from different cocoons. These six were further developed than those taken from cocoons earlier in the year, were more active and moved as if accustomed to using their legs. As they seemed able to take care of themselves, I put them into a glass box, where they had ample opportunity to weave, and made these observations. I put into the box the tops of two cocoons, which they soon moored to the bottom, not as the result of a definite purpose, but of mere wandering before settling down. Two finally crawled into a bit of the silk still clinging to one of the tops.

March 11.—Moved at the least jarring; all hung, ventral side up, on individual threads from lid of box.

March 22.—Two dead, in same position as when alive.

March 23.—Four survivors not so active.

April 9.—Not so active.

April 10.—Third one dead.

April 11.—Three remaining dropped to bottom of box as soon as disturbed, lay motionless an instant, then ran actively about, finally returning to original position—suspended from lid.

April 18.—Offered water, which they drank eagerly; bodies seemed to swell. Still no attempt at regular web.

These observations indicate that during the winter months the young Argiopes change very little in any way. In most of the cocoons the spiders were all alive and active until March, when very few cocoons had any living occupants. This must have been due to the heat of the house, as the spiders were all shriveled in appearance. On March 14 I gathered twelve cocoons in a vacant lot, and found that in all of them there were hundreds of living spiders, all at the same stage of development as the ones living in the house all winter.

The question arises here, what may be the use of the cocoon? It can scarcely be for retaining animal heat, as the amount of heat generated by the young spiders must be extremely little; their abdomens are packed with yolk and there is very little muscular activity among them. If taken out of the cocoon they form into close balls, and those which are able to keep in the centres of these balls live just as well as those in the cocoons, while those on the outside dry up. If kept in stoppered bottles they all live as well as in the cocoon. The chief use of the cocoons seems to be to keep the spiders together and to prevent evaporation of moisture. I took a number of spiders from cocoons that had been indoors all winter and from others that had been out of doors all winter, gave them some cotton to burrow into, wrapped them in separate pieces of very thin cloth and hung them outside where they would be exposed to March snow and wind and April rain; yet those that had been indoors all winter lived and kept pace with those in the cocoons until April 18. Those that had been out of doors all died except one. From April 18 to April 26 the weather was very dry and it became very warm where the spiders were hanging. In that time they all dried up except the one from the cocoon that had been out of doors all winter. This survivor was very active and seemed ready to leave. the nest. Spiders in cocoons hanging in the same place were all active and healthy, although every cocoon had been opened. This shows that they can endure cold, wind and rain, for the snow packed in all over the little bags of cotton and cloth, melted and dried in the sun. Absorbent cotton was used, and it must have been saturated many times. The cocoon holds the little spiders together for the purpose, as I think, of keeping them moist, and prevents evaporation of that moisture. The silk furnishes a suitable support, as is shown by the fact that they soon grow weary in attempting to walk on a surface, and that without a place of attachment, moulting becomes a great difficulty. The cocoon also prevents their being scattered into unfavorable places by dashing rains and high winds. The view that the cocoon prevents evaporation is borne out by the later life of the spider; for as soon as it leaves the nest and begins an independent existence, abundance of water is absolutely necessary. A spider will live indefinitely without food, but without water it will survive only a few days. The cocoon, of course, protects the young spiders against numerous enemies—birds, wasps, toads, etc., some of which, however, often pierce the cocoon. The great majority of the cocoons of *Argiope* which I examined had been bored into, and in some the eggs were ravaged; but I failed to find any traces of parasites (see McCook, 7). In other species I have found ichneumons and I wondered at their absence here.

At first I thought the young spiders always kept the ventral side uppermost, but later found that they always keep the ventral side outwards. Why they maintain this position is an unanswered question. Removing a nest from the cocoon I placed it in a black bag and hung it in a recess where no light could enter. On taking the nest out, at intervals for weeks, I saw that all the spiders had the ventral side turned out, even those on the bottom. It is evident that light has nothing to do with this phenomenon. It is possible that respiration is facilitated by this position.

I have not been able to make any valuable tests as regards the development of the senses in *Argiope*, since the spiders are never hungry nor thirsty, and the first of these conditions is very important in determining range of sight. Fear has been shown only in the case of the three spiders taken from the cocoon on March 10, when they dropped on being disturbed. The other spiders would not move away from an approaching object, and would even sit still and be eaten up by older spiders of other species. Tests for hearing and the sense of smell would also be useless because of this lack of motive.

Argiope, then, in April, is about ready to leave the cocoon, can drop itself from danger on a little line and drink water. It makes no attempt to weave a snare, to eat its fellows or anything else, has little more than a rudiment of fear, and if it sees, the stimulus arouses no response.

Observations on Agalena nævia.

As the specimens of *Agalena nævia* grew too active and independent to be kept in an ordinary box, I placed them in an olive bottle, where all their movements could be easily watched. About December 15, when put into the bottle, they showed unmistakable signs of fear and acted as if they were in a strange place, running excitedly here and there. I gave them a little corner of an envelope for a refuge and point to collect on. After an hour they were quieter and set about weaving an irregular web from side to side of the bottle. This web became denser from day to day, and showed little tunnels running through it. The tunnel is very characteristic of the adult of this species. No attention whatever was paid to the refuge. They could see at least an inch, and recognized each other as cannibals. I draw this conclusion, because I observed that they charged upon each other when they came within that distance. I could not measure these distances accurately, but preferred to make the distance less, rather than greater than it actually was, and I am sure it was no less. That they feared each other was evident from the way the pursued ran from the pursuer.

They ate aphids or one another indifferently, increasing notably in size from day to day, or shriveling up and dying. Until February 18 I allowed them to live together, the larger ones eating the smaller and less active, and many dying. At this time seven only survived. I put each one into a separate bottle, 6.3 cm. high and 1.6 cm. wide. The bottles were lettered *a, b, c, d, e, f, g*. From day to day each spider was observed and notes recorded. They grew much more rapidly than *Argiope* and formed an interesting study of specific and individual differences, as well as of developing instinct. That these spiders also are able to endure cold is proved by the fact that on February 9 they were exposed to the same temperature as the *Argiope* spiders. The moisture in the bottle froze all over the inside, but the spiders, beyond being stiff, until they were taken into a warm room, were not at all affected. The following are the records that were made. The spiders were kept under conditions as normal as possible, under the circumstances, and their behavior under these conditions carefully noted.

SPIDER A.—This spider busied itself for three days spinning a web back and forth across the bottle.

February 21.—Afraid of a little fly offered as food. After a few minutes it made an attempt to catch the fly. After five or six attempts, it caught the fly by its hind legs; fly escaped and was recaptured a number of times; spider spread its spinnarets and made a motion as if to enshroud its prey and tried to push under the fly's wings to seize it by the abdomen.

February 22.—Decided increase in size of spider; skin tight and shiny; color lighter than that of the other spiders.

February 24.—Introduced a little globule of water; no attention paid to it; finally I guided it until two feet dipped into the water, but it would not drink; refused to eat.

February 28.—Placed the spider in a shallow box for drawing; very much frightened and climbed out five or six times, then began to weave a web, but, although it climbed to the edge many times, it merely fastened the web and returned to the box. It frequently rested and cleaned itself, as does an adult spider.

March 3–5.—Drank water eagerly, but refused to eat.

March 6.—Moulted.

March 7.—Seized small fly, when offered it, at once.

March 12.—Increase in size evident.

March 19.—Dead.

SPIDER B.—*February 18.*—This spider was seen circling around a black, winged aphis, occasionally approaching it from the rear, as if to seize it. Beside the aphis and moved by every struggle, lay an old white spider skin. This the spider finally took hold of and tried to drag away. After fifteen minutes, it left the skin and for fifteen minutes more seemed undecided, then seized the aphis near the head and proceeded to eat it. This was the largest of the spiders and the one that I had noticed most frequently devouring aphides, as well as its own kin, in the olive bottle.

February 20.—Greatly increased in size.

February 21.—Leaped at once upon thorax of a little fly and proceeded to eat it.

February 22.—Notable increase in size; skin of abdomen shiny, tight.

February 23.—Web very evident half-way up the bottle, woven irregularly from side to side.

February 24.—Dropped a small fly into the web; spider greatly excited at once, but seemed unable to locate fly; ran to dead fly in the web, then to one above, and back to lower one. Settled down finally as if discouraged and made no further efforts even when fly came immediately beneath its feet.

February 28.—Removed to shallow dish for purpose of making a camera drawing; behaved much as A did under similar circumstances, but quieted down much sooner (Pl. X, fig. 10).

March 1–2.—Refused to eat.

March 3.—Moulted.

March 7.—Deftly seized a mosquito by the thorax.

March 10–11.—Body large and shiny.

March 12.—Unusually excitable (Pl. X, fig. 11).

March 17.—Dropped down on a line on being disturbed; never did so before.

March 18.—Offered two little *Argiopes*—evidently a new kind of prey; spider much excited; approached, circled around, drawing out web all about and over little *Argiope;* an evident but feeble attempt to enshroud the prey; did not guide the thread at all with the hind legs and wasted much silk by not touching prey; went away from the little spider and after a few minutes went to other one, which it seemed not to see before, and, without any encircling movements, ate it.

March 20–22.—Skin very tight and shiny; refused to eat.

March 23.—Had moulted in the night; refused to eat.

March 27.—Caught a mosquito and again made motions as if to enshroud it (Pl. X, fig. 12).

April 4.—I turned the bottle on its side; in time the spider came out of the bottle, walking away about two inches in an excited, jerky manner; touched it with a pencil and it instantly rushed into the bottle; did not come out again.

April 5.—Would not come out of the bottle of its own accord.

April 6.—Increase in size noticeable.

April 7.—Pattern on ventral side of abdomen very distinct.

April 10.—Ate a small fly, but refused an ant.

April 11.—Refused to eat.

April 12.—Moulted.

April 13.—Decided difference in pattern and general shape; now a long, slender spider, much more excitable; turned and ran quickly to bottom of bottle on least disturbance.

April 14.—Attacked an ordinary house-fly and seized it by the abdomen (Pl. X, figs. 13 and 14).

April 16–17.—Rapid increase in size.

April 18.—Returned to dead fly of April 14.

April 19.—Fixed itself at once on thorax of house-fly; made movements as if to enshroud it.

Spider c.—*February 21.*—Made attempts to catch a fly entirely too large for it.

February 23.—Very sluggish.

February 24.—Three anterior legs of left side seemed crippled and a white exudation appeared at their bases.

February 27.—Dead.

Spider d.—This was one of the most active and excitable of the spiders from the start.

February 21.—Offered a little fly twice as large as itself; sprang at it and seized one hind leg; fly struggled violently and finally escaped; spider seized it again by abdomen and held on until fly was exhausted and gradually shifted its own position until it had its cheliceræ fastened into the back of the fly's thorax; made weaving movements with the spinnarets.

February 22.—Noticeable increase in size.

February 24.—Introduced little globule of water; spider was moving about and finally wandered into water, which it drank with evident satisfaction; made some cleaning movements afterwards.

February 28.—Very active; would not stay in shallow dish as others had done, although put back many times (Pl. X, fig. 5).

March 4–5.—Moulted some time in the night; refused to eat.

March 7.—Offered larger fly; spider attacked at once and seized one hind leg; clung for several minutes; after fly was worn out, the spider ran about it, excitedly spinning a web in a circle around it, but not touching it; after some time, proceeded to eat it.

March 10.—Body large and shiny (Pl. X, fig. 6).

March 18.—Offered a little *Argiope;* recognized a new kind of prey; circled around and around, secreting silk, but very little of the web touched the *Argiope.*

March 20–22.—Skin very tight and shiny; refused to eat.

March 23.—Had moulted in the night; refused to eat (Pl. X, fig. 7).

April 11.—More excitable; went through usual winding movements before eating (Pl. X, fig. 8).

April 14.—Had become expert at catching prey.

April 15.—Body very large; skin tight and shiny (Pl. X, fig. 9).

April 18.—Moulted.

April 19.—Looked exactly like B; more excitable than ever; still made movements with spinnarets on catching prey.

SPIDER E.—This was an active little creature, although one leg was missing on the right side.

February 21.—Made a number of attempts to catch a fly; finally seized it by a hind leg; settled down on fly's thorax; after twenty minutes began to weave a web with fly as a centre; moving the bottle did not disturb the worker; after eating there was a distinct, but awkward, attempt to clean itself.

February 27.—Noticeable increase in size.

February 28.—When removed to shallow dish, made efforts to escape, but after five or six trials began to weave a web contentedly.

March 2.—Dead; posterior abdomen white.

SPIDER F.—This was the smallest and weakest spider.

February 21.—Two hind legs on right side crippled; made unsuccessful attempt to catch a fly.

February 22.—Dead.

SPIDER G.—*February 21.*—Became excited when offered a fly, but began to weave a web and paid no further heed, even when fly walked over it.

February 22.—Made several attempts to catch a fly; finally succeeded.

February 23.—Dead.

In reading over these records of *Agalena nævia*, one is at first impressed with the small number of survivors, but we must remember that they were not under perfectly normal conditions. Had they been out in the fields, they would not have had so good an opportunity to kill each other, but their enemies would have had a better chance to prey upon them. In the bottles they were protected from storms, but were more liable to disease. Whether these factors counterbalance each other remains a question. These records also indicate that the spider's early life is greatly influenced by the quantity of food and by individual as well as specific differences. Some of the spiders are distinguished from the outset by size, strength or quickness, and these are thus able to provide themselves with more food and grow accordingly. When the spiders were well fed the moults occurred closer together, although they will moult or make the attempt to do so, after a long time when food is scarce.

At first these spiders were all fed on aphides which they relished, but as they grew larger and were offered other things, the aphides were refused. Flies were eagerly caught, but ants were never touched. This would indicate that they have some kind of discrimination.

Another very interesting phenomenon has been the attempt to enshroud prey. From watching these movements many times, I am sure it is an instinctive impulse they attempt to obey, and which is utterly useless because imperfectly performed. Adult spiders that have this habit hold the victim firmly in their jaws and twirling it around, wind it in a web drawn from the abdomen by the hind legs. *Agalena* does not have this habit when adult, but drags its prey into a tunnel. The young were frequently seen attempting to drag the struggling flies, although they had made no regular tunnels in their webs. The attempt to enshroud must be the result of an instinctive return to a habit that is lost.

Summary.

1. Growth is gradual through regular, successive stages, which follow each other rapidly or slowly, according to the species and the individual.

2. Increase in size takes place chiefly between the moults and is largely dependent on the food.

3. Moulting does not occur at regular intervals after the spiders leave the cocoon, but according to the amount of food.

4. Sensory reactions to external stimuli are poorly developed in the very young animals, and are not manifested until the spiders seem ready to put them to immediate use. They then develop and become more acute with practice. The earliest reactions to appear can be interpreted as fear.

5. Although at an early stage distinction between light and darkness is possible, distinction between objects is not.

6. Cannibalism does not appear while the young are in the cocoon, although in *Agalena* it is a marked characteristic afterwards.

7. Young spiders can withstand a very cold, moist atmosphere, but not a warm, dry atmosphere.

8. Young *Argiope* always rest with the ventral side uppermost when isolated; the ventral side is turned outwards when the spiders are in a ball or group.

9. The cocoon prevents evaporation of moisture and serves as a support for the young spiders, and, to a less extent, as a protection against enemies.

10. Young spiders differ in growth and habits, specifically and individually.

11. Those instinctive reactions which are most advantageous to the species become habitual through repetition and selection.

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EXPLANATION OF THE PLATES.

Plate IX.

Fig. 1. Longitudinal section of abdomen of *Argiope cophinaria* in March; approximate age, five months. Reichert oc. 2, obj. 7a.

Fig. 2. Longitudinal section of *A. cophinaria* in November; approximate age, one month. Reichert oc. 2, obj. 3.

Fig. 3. Longitudinal section of cephalothorax of *A. cophinaria* in November. Richert oc. 2, obj. 7a.

Fig. 4. Longitudinal section of abdomen of *A. cophinaria* in November. Reichert oc. 2, obj. 7a.

Plate X.

Figs. 5–11. Outlines of cephalothorax and abdomen of *Agalena nævia*, "d" and "b," × 9.

Fig. 5. "d," February 28, age 105 days from hatching, length of body 2.2 mm.

Fig. 6. "d," March 14, age 119 days, length 2.28 mm.

Fig. 7. "d," March 23, age 128 days, length 3 mm.

Fig. 8. "d," April 11, age 147 days, length 3.65 mm.

Fig. 9. "d," April 15, age 151 days, length 4 mm.

Fig. 10. "b," February 28, age 105 days, length 2.36 mm.

Fig. 11. "b," March 14, age 119 days, length 3.5 mm.

Fig. 12. *A. nævia*, "b," dorsal view, March 23, age 128 days, length of body 4.5 mm. × 7.

Figs. 13 and 14. Dorsal and ventral views respectively of *A. nævia*, "b," April 14, age 150 days, length of body 5 mm. × 7.

All the figures 1–14 are from camera drawings.

MAY 1.

Mr. CHARLES MORRIS in the Chair.

Seventeen persons present.

A paper entitled "Flora of Willow Grove and the Edgehill Ridge," by Alexander McElwee, was presented for publication.

MR. THOMAS MEEHAN was appointed to prepare a biographical notice of the late Mr. Charles E. Smith for the PROCEEDINGS.

MAY 8.

Mr. CHARLES MORRIS in the Chair.

Twenty-seven persons present.

A paper entitled "A Review of the Physæ of Northwestern Illinois," by Frank C. Baker, presented for publication April 17, was, at the request of the author, transferred to the editor of *The Nautilus.*

Mr. Charles Morris was, at his request, granted permission to withdraw his paper entitled "Subterranean Waters," presented for publication March 27, 1900.

Mr. CHARLES ROBERTS was elected a member of the Council to fill the vacancy caused by the death of Mr. Charles E. Smith.

MAY 15.

The President, SAMUEL G. DIXON, M.D., in the Chair.

Twenty-five persons present.

A paper entitled "Observations on the Anatomy of Hylobates leuciscus and Chiromys madagascariensis," by Henry C. Chapman, M.D., was presented for publication.

MAY 22.

The President, SAMUEL G. DIXON, M.D., in the Chair.

Twenty persons present.

MAY 29.

The President, SAMUEL G. DIXON, M.D., in the Chair.

Sixteen persons present.

A paper entitled "On the Osteology of Vulpes macrotis," by R. W. Shufeldt, was presented for publication.

The death of William Wynne Wister, Jr., a member, the 27th inst., was announced.

The following was ordered to be printed:

OBSERVATIONS UPON THE ANATOMY OF HYLOBATES LEUCISCUS AND CHIROMYS MADAGASCARIENSIS.

BY DR. HENRY C. CHAPMAN.

Hylobates leuciscus.

As the opportunity of dissecting a gibbon is comparatively rare, it is hoped that a brief account of the results of the dissection of the young individual that recently died at the Philadelphia Zoölogical Garden may prove acceptable to the Academy. The gibbons, of which there are several species, are found, as well known, over a considerable area of Eastern Asia and the Malay Archipelago. Together with the gorilla, chimpanzee and orang, they constitute the group of Anthropomorpha, or anthropoid apes, of which they are the least anthropoid in their nature, resembling man more particularly in the character of the thorax. The gibbons are the smallest of the anthropoids, rarely attaining a height of more than three feet. The head is small, and the body and limbs are slender. They are the only anthropoids that exhibit ischial callosities. The most striking peculiarity of the animal externally is the length of the upper extremities, the fingers touching the ground when standing erect, which it often does. While they can run very rapidly, putting the sole of the foot flat upon the ground, which they often do, the genus is naturally arboreal in its habit, passing quickly from bough to bough in the forests which it inhabits, the movements being executed by means of its long arms with marvelous accuracy and force, twenty feet and more being covered at one bound.

Notwithstanding the small size of the gibbons, all observers agree as to the great volume of their voice, the cry of the Siamang, *Hylobates syndactylus*, being heard in its native woods miles away, its vocal sound being more powerful than that of any human singer. It may be also mentioned in this connection that the gibbon is the only mammal that can be really said to sing. The Wouwoo, *Hylobates agilis*, has been heard to emit at the London Zoölogical Garden the rising and falling scale of the semitones of the octave.[1] The gibbon presented to the Academy by the Philadelphia Zoölogical Society, and upon the dissection of which this communication is based, is that known to zoölogists, according to Mr. Arthur E. Brown, Secretary of the Society, as *Hylobates leuciscus*, the silvery gibbon. As the anatomy of the gibbons is more or less well known, attention will only be directed to those parts of the economy of the animal under consideration which differ more particularly from those of man and the remaining anthropoids.

Muscular System.—Our gibbon, a young male, measured from the crown of the head to the heel 21.75 inches (55 centimeters). The length of the upper extremity from the shoulder to the tip of the middle finger was 17 inches (43 centimeters), that of the lower extremity from the hip to the tip of the middle toe only 13.25 inches (33.5 centimeters).

The muscles of the face were undifferentiated. In the cervical region the levator claviculæ was observed extending, as in the other anthropoids, from the transverse process of the atlas to the acromial end of the clavicle. The biceps arose by two heads, both, however, being humeral in origin, the small head arising from the lesser tubercle of the humerus instead of from the coracoid process, as in man. The latissimo condyloideus extended to the condyle of the humerus, not merely to the centre of the humerus, as stated by Hartmann.[2] The brachialis anticus was well developed, though its presence was not noted in the gibbon described by Bischoff.[3] The pronator radii teres arose by one head. There was nothing especially noticeable about the flexors sublimis and profundus digitorum. The slip from the tendon of the flexor profundus supplying the ring finger split, however, into two tendons, one of which, that ordinarily present, perforating the tendon of the sublimis, the other, the accessory one, being inserted into the first phalanx of the index finger. The latter disposition was probably an abnormal one. The part of the flexor profundus supplying the thumb was so completely separated from the rest of the muscle that it might almost be regarded as a distinct flexor longus pollicis, as is the case in man.

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[1] C. L. Martin, *A General Introduction to the Natural History of Mammiferous Animals*, etc., 1841. Owen, *The Anatomy of Vertebrates*, Vol. III, p. 600.

[2] *Anthropoid Apes*, p. 164.

[3] *Beiträge zur Anatomie des Hylobates leuciscus.*

All of the muscles of the thumb—viz., the abductor, opponens, flexor and adductor pollicis—were present and well developed. In addition to the muscles of the little finger usually present, the abductor, flexor and opponens, it was also supplied by a distinct extensor proprius minimi digiti.

There was nothing particularly noticeable about the muscles of the dorsal surface of the upper extremity. The extensor indices split into three tendons, which supplied the ring, middle and index fingers. The extensor ossi metacarpi pollicis gave off two tendons, one of which passed to the metacarpal bone, the other to the trapezium, as is often the case in man and monkeys. The extensor primi internodii pollicis was absent; the extensor secundi was so inserted, however, as to act on both the first and the second phalanges of the pollex. The lumbricales were well developed. Of the contratentes digitorum, or the little muscles passing from the deep fascia over the metacarpal bones to the digits, two were observed, those supplying the second and fifth digits. The palmar and dorsal interossei were much developed, indeed remarkably so considering the size of the hand. The nerves of the upper extremity were exceedingly well developed, the median ulnar and radial especially so.

There was nothing especially to be noted about the muscles of the hip and thigh. The soleus was observed to arise from the fibula alone, and not as in man from both fibula and tibia. The plantaris, peroneus tertius and flexor accessorius were absent. The flexor longus hallucis gives a strong tendon to the big toe and three perforating tendons to the second, third and fourth toes, with lumbricales for the third and fourth toes only. The flexor longus digitorum contributes to the formation of the tendon of the flexor longus hallucis and supplies the third, fourth and little toes, the tendons supplying the third and fourth toes only being perforated by the two corresponding tendons of the flexor longus hallucis. The flexor brevis digitorum appears to supply the second toe only; it is perforated by the corresponding tendon of the flexor longus hallucis. The tendon to the fifth toe, corresponding functionally to that of the flexor brevis digitorum in man, appears when present to be derived from the flexor longus digitorum, as well as the deeper tendon from the same muscle already referred to. The muscles of the big and little toe, usually present, were noticed. Of the contratentes digitorum, that supplying the little toe was the only one observed.

The interossei were not as well developed in the foot as in the hand.

The Larynx.—In accord with what has just been said as to the voice being so powerful in the gibbon, one would naturally expect to find the larynx large and well developed, with its lateral ventricles dilated into enormous air sacs, as seen in the gorilla, chimpanzee and orang, or some modification of the hyoid apparatus such as occurs in the South American Howler, *Mycetes alouetta.* As a matter of fact, however, in our gibbon the larynx was not unusually large nor were the vocal membranes or ventricles specially well developed. Not a trace of a laryngeal sac was to be seen, either as sacs communicating with the larynx by the ventricles or by openings in the thyro-hyoid membrane, as is said to be the case in the Siamang.[4] Indeed, it is only in the latter species of gibbon that a large air sac has been found, the sac in this species being globular and to be regarded morphologically as a development of the thyroid hyoid membrane.

It must be admitted that the manner in which the loud voice is produced in the gibbons is not understood. That a laryngeal sac exerts but little influence in this respect is shown by the fact that the voice of the gibbon in which the sac is absent is as loud as in that in which it is present. Indeed, beyond the statement that a laryngeal sac acts as a resonator, there is little to be said as to the function even of the enormous sacs present in the remaining anthropoids.

Origin of the Great Blood Vessels.—The manner in which the great blood vessels are given off from the aorta in the gibbon differs from that in man. In the gibbon the aorta gives off an innominate and a left subclavian artery, the innominate in turn giving rise to the right subclavian and the two common carotid arteries, the disposition being similar to that observed in the orang.

Alimentary Canal.—There was nothing especially remarkable in the anatomy of the alimentary canal. The salivary glands were large and the rugæ of the palate were very prominent. The absence of a uvula was noted. The stomach was rather of a globular form, and resembled the human stomach much more than that of the

[4] Huxley, *Anatomy of Vertebrated Animals*, p. 412.

orang, which is much elongated. Valvulæ conniventes were absent; the patches of Peyer were, however, well developed. The urogenital apparatus did not present any remarkable peculiarity. The kidney exhibited, as in the case of the orang, only one papilla. There was one pancreatic duct and it opened into the duodenum close to that of the hepatic duct. The gall bladder was large and elongated, which was possibly due to the presence of gall stones. The vermiform appendix was present, measuring three centimeters ($1\frac{1}{4}$ inches), but was both relatively and absolutely smaller than that of other anthropoids.

The Brain.—The brain in the present individual, as in the gibbons generally, was small. Unlike that of the Siamang,[5] however, the posterior lobes of the cerebrum covered completely the cerebellum, as was also the case in the brain of the silvery gibbon described and figured by Bischoff.[6] There was nothing particularly noticeable about the gyri and sulci, the principal ones being identified. It should be mentioned, however, that the calcarine fissure passed continuously into the hippocampal fissure, the gyrus fornicatus being separated, therefore, from the hippocampal gyrus, a disposition which, according to Ecker,[7] does not obtain in the genus *Hylobates*. The parieto-occipital fissure did not reach the calcarine, the two fissures being separated by the convolution known as the "deuxième plis de passage interne" of Gratiolet, or the "untere innere sheitelbogen-windung" of Bischoff. The ventricle was well developed and contained the hippocampus minor, and what appeared to be the remains of the eminentia collateralis. The brain of the gibbon resembles in some respect that of the *Semnopithecus* and in others that of the orang. Indeed, so much so is this the case, that it may be regarded as bridging over to a considerable extent the gap in cerebral development between the two.

The study of the organization of the gibbon, a *résumé* of which has just been given, leads to the conclusion, long since reached by the author, that the proposition advanced by the late Prof. Huxley, that the difference between man and the anthropoids is less than that between the anthropoids and the remaining Simiæ, except as regards the skeleton, is not true. The gibbon, for exam-

[5] Flower, *Phil. Trans.*, 1862, I, p. 185.

[6] *Op. cit.*, S. 76.

[7] *The Cerebral Convolutions of Man.* Translated by R. T. Edes, M.D., p. 76.

ple, as regards the general character of the brain, in the presence and absence of certain muscles, in the origin of the great blood vessels, and in other respects, resembles the lower Simiæ more than it does man. Further, the association of the four anthropoids in one group Anthropomorpha, as contrasted with the remaining Catarrhine or Cynomorpha, is an artificial, not a natural one, since there is no evidence to show that the anthropoids have descended from a common ancestor or are directly related genetically to each other. On the contrary, it is much more probable that each anthropoid has descended from some highly specialized Catarrhine—the gorilla, for example, from some Cynocephalus, Macacque, or like form; the gibbon from a Semnopithecoid one, and so on, the gibbon and orang being closely related on the one hand, the chimpanzee and gorilla on the other.

Chiromys madagascariensis.

The Aye Aye, so called on account of the natives uttering that exclamation the first time the animal was seen, was discovered by Sonnerat in the island of Madagascar about the year 1785, and was first described and figured by that naturalist.[8] For a long time after its discovery considerable difference of opinion prevailed among systematists as to its exact zoölogical position. According to Sonnerat the animal resembled a squirrel in some respects, in others a lemur. Buffon regarded it as a squirrel, Cuvier as a squirrel with quadrumanous affinities, Schreber as a lemur, etc. Indeed, it was not until the year 1863, nearly a century after it was discovered, that the Aye Aye was shown conclusively by the researches of the late Prof. Owen[9] to be essentially in its nature a lemur.

As our knowledge of the organization of the Aye Aye is somewhat limited, the only works treating of its anatomy, so far as is known to the author, being the monograph of Owen just cited and the later supplementary account of Peters,[10] it is hoped that the following observations will not be regarded as superfluous. The individual upon whose dissection the present communication is

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[8] *Voyage aux Indes des Orientales et à La Chine.* Paris, 1806. Tome IV, p. 121. Plate 92.

[9] "On the Aye Aye," *Trans. of the Zoölogical Society.* London, Vol. V, 1866.

[10] *Ueber die Säugethiergattung Chiromys.* Abhdlg. d. Berlin, Akad., 1865.

based, though preserved in alcohol for several months, was in fairly good condition. It was a female, and measured from crown of head to the heel 45 centimeters (18 inches). The length of the upper extremity from shoulder to tip of middle finger measured 22.5 centimeters (9 inches), that of the lower extremity from hip to tip of middle toe 30 centimeters (12 inches).

Nervous System.—Owing to the softened condition of the brain, necessitating its removal enclosed in the dura mater, and to the subsequent unsuccessful hardening of the same, we have but little

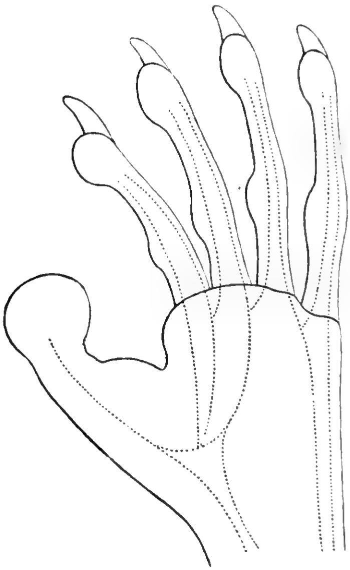

Fig. 1.

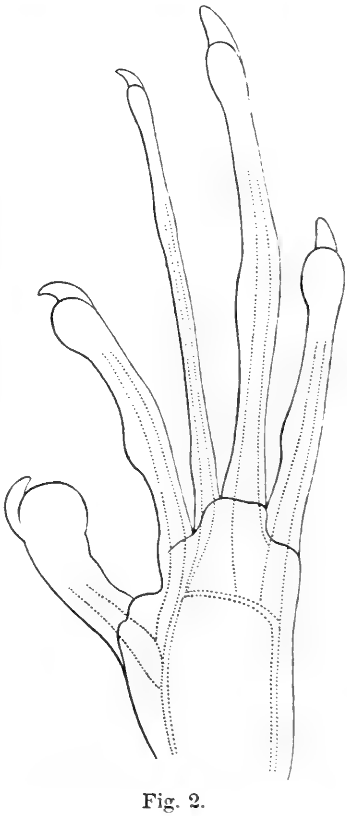

Fig. 2.

to say about it other than that in the general configuration, in the presence of a well-developed corpus callosum, in the simple character and paucity of fissures, and in the almost entire exposure of the cerebellum, the posterior lobes of the cerebrum being so little developed, it resembled that described and figured by Owen. As the nerves of the extremities are not described by either Owen or Peters, it should be mentioned that, as regards the distribution of the nerves to the hand, it was observed that while the thumb and index finger were supplied by the median nerve, and the little and ring fingers by the ulnar nerve, the middle long slender finger was supplied by two branches which came from somewhat of a plexus formed through the union of the median and ulnar nerves, as shown in Fig. 2. It need hardly be mentioned that such a disposition is an unusual one, the little finger and ulnar side of the ring finger being supplied in five-fingered animals by the ulnar nerve, the radial side of the ring and remaining fingers and thumb by the median nerve. We shall see, however, presently that the middle slender finger is not only supplied by nerves derived from both the median and ulnar nerves, but by a greater number of muscles than ordinary.

Such disposition appears to be correlated with the function of the long middle finger which, as is well known, the Aye Aye makes use of in searching for its food, inserting it into pieces of wood containing the grubs upon which the animal preferably feeds. That the view just offered as accounting for the rich nervous and muscular supply of the middle finger is the correct one is further shown by the fact that in the case of the foot the big toe, second, middle and tibial side of fourth toe are supplied by the internal plantar nerve, and the little toe and fibular side of the fourth toe by the external plantar nerve (Fig. 1).

Muscular System.—As the muscular system of the Aye Aye has been described with considerable detail by Prof. Owen, attention will be directed more particularly to such muscles as were not noticed by that anatomist or which differed in regard to their disposition.

Of the muscles of the cervical region and upper extremity two were observed not mentioned by Owen. They are especially interesting as being found in all lemurs and monkeys, from the Aye Aye to the gorilla. These are the elevator claviculæ, extending from the transverse process of the atlas to the acromial end of the clavicle, and the latissimo condyloideus, passing from the latis simus dorsi to the internal condyle of the humerus.

The three short muscles ordinarily supplying the little finger and the four short muscles supplying the thumb were all well developed. The tendon of the flexor longus pollicis came off, however, from the tendon of the flexor profundus digitorum, the muscular belly of the pollicis being entirely undifferentiated from that of the profundus. The four tendons of the sublimis were perforated as usual by the four tendons of the profundus, four lumbricales being given off by the latter, as was observed by Owen, instead of three, the usual number. The interossei were well developed. The extensor muscles of the hand were four in number—an extensor communis digitorum supplying the four fingers, a second extensor situated beneath the communis supplying the ring and middle fingers, an extensor indicis supplying the index and middle fingers, and an extensor minimi digiti supplying the little and ring fingers. It will be observed, therefore, that the middle finger is supplied by three distinct muscles, an unusual number, the significance of which has been already referred to.

In addition to the four extensor muscles just mentioned, there were present two long extensors of the thumb, an extensor ossi metacarpi pollicis and an extensor secundi internodii pollicis.

Regarding the muscles of the lower extremity and more especially of those of the leg and foot, it may be mentioned that the tibialis anticus, the extensor proprius hallucis, the extensor longus and brevis digitorum were well developed. In addition to the peroneus longus and brevis, two other peronei muscles were observed not noticed by Owen, viz., a peroneus quarti digiti and a peroneus quinti digiti, the two muscles being inserted into the terminal phalanges of the fourth and fifth toes respectively. The two short muscles of the little toe and the four short muscles of the big toe were well developed. No trace was found, however, of the extensor brevis hallucis described and figured by Owen.

The tendon of the flexor longus hallucis enters largely into the formation of that of the tendon of the longus digitorum, the former supplying more particularly the big toe and the second and fifth toes, the latter the third and fourth toes. The only portion of the flexor brevis digitorum observed arising from the calcaneum was the muscular slip supplying the fifth toe, the three remaining slips coming off from the conjoined tendons of the longus digitorum and longus hallucis. All four tendons of the flexor sublimis were perforated by the tendons of the longus hallucis and longus digitorum. Four lumbricales were present, as in the case of the hand, and the interossei were equally well developed.

The Viscera.—There was nothing especially noteworthy regarding the alimentary canal and its appendages other than what have already been described by Owen and Peters. The caput coli, however, at least in the specimen dissected by the writer, exhibited a decided constriction into two parts, a proximate portion corresponding to the cæcum and a terminal one, much narrower, about 2.5 centimeters (1 inch) in length, resembling very closely the vermiform appendix of man and the anthropoids.

The great blood vessels arose from the aorta, as described by Peters, the right subclavian and the trunk of the common carotids springing from an innominate, the left subclavian separately from the aorta.

No trace of a laryngeal pouch such as that described by Owen was observed, its absence being perhaps due to the fact that the animal was a female.

The uro-genital apparatus agreed essentially in its structure with that described by Peters, the urethra passing into the vagina through the anterior wall of the latter instead of perforating the clitoris, as is usually the case in lemurs. The clitoris and external orifice of the vagina were concealed externally by a circular fold of integument. It is an interesting fact that while the imperforate condition of the clitoris in *Chiromys* is exceptional among the lemurs, on the other hand the perforated condition of the clitoris, as in *Capromys,* is exceptional among the Rodentia, the urethra passing in the latter into the vagina.

According to many systematists, the lemurs, including *Chiromys,* together with the Simiadæ and man, are classed together as Primates; according to others the lemurs are separated from the Simiadæ and man and classed apart as half apes or Prosimii, and are regarded as being the ancestors of the Simiadæ, Insectivora, Cheiroptera and Rodentia. If the latter view be adopted, then the slender *Loris* may be regarded as the ancestor of the Simiadæ, *Tarsius* of the Insectivora, *Galeopithecus* of the Cheiroptera and *Chiromys* of the Rodentia, the rodent affinities of *Chiromys* being shown not only by its general resemblance to a squirrel and the form of its incisor teeth, but by the character of its alimentary canal and uro-genital apparatus.

JUNE 5.

MR. CHARLES MORRIS in the Chair.

Sixteen persons present.

A paper entitled "Notes on Hyacinth Roots," by Ida A. Keller, was presented for publication.

A Collapsing Crater.—MR. EDW. GOLDSMITH referred to his communication on a volcanic crater of the Mesozoic age near Pottstown, a locality within easy reach by trolley cars. In fact, it is a popular resort because of the peculiar formations occurring there.

Several years ago the crater in question had a perfect cauldron-like contour within; but this has changed in such a way as to indicate its gradual collapse.

The southern and western sides apparently remain intact, but all of the northern and part of the eastern sides show the rocks to have moved toward the centre of the crater.

The huge rocks which have moved inward were, two years ago, in a vertical position, but were cracked straight down to the bottom of the crater, probably from the main mass in situ.

These cracks at that time presented an opening of an inch, more or less, but now, since their movement toward the centre, they have become so large that a man can crawl through the gap. Three masses, standing on edge, and weighing in the aggregate one hundred tons or more, have taken part in the movement.

As the inner contour remains, there is evidence of the actual former existence of a crater, although the clear cauldron-like form is changed. When further movement takes place it will entirely disappear, leaving an irregular pile of rocks grouped in the greatest disorder, upon which the weather will work its smoothing effects just as is now observable in a number of places on the same hill, all of which are, as he had formerly demonstrated, collapsed craters.

That they were craters is clearly evidenced by the existence of the enormous fragments of basaltic columns, by the tachylite which is an opaque obsidian, by the four lava-flows forming the terraces, and by the amygdaloidal rocks. The last crater in that locality is now working toward its own annihilation.

JUNE 12.

CHARLES SCHAEFFER, M.D., in the Chair.

Thirteen persons present.

A paper entitled "Note on the Australian Pupidæ," by Henry A. Pilsbry, was presented for publication.

JUNE 19.

Mr. CHARLES MORRIS in the Chair.

Sixteen persons present.

Papers under the following titles were presented for publication:
"A New Crayfish from New Mexico," by T. D. A. Cockerell and Wilmatte Porter.
"The Structure of the Diatom Girdle," by T. C. Palmer and F. J. Keeley.

JUNE 26.

The President, SAMUEL G. DIXON, M.D., in the Chair.

Seventeen persons present.

A paper entitled "On the Osteology of Vulpes macrotis," by Dr. R. W. Shufeldt, was ordered to be published in the JOURNAL.

The following were ordered to be printed:

NOTE ON THE AUSTRALIAN PUPIDÆ.

BY HENRY A. PILSBRY.

To ascertain the geographic range of the genus *Bifidaria* I was led to examine the Australian species in the collection of the Academy, and as no author seems to have indicated their place in the system, it may be as well to put the facts on record.

Four genera of the family *Pupidæ* are represented, of which one, *Cylindrovertilla*, has been found in Australia and New Caledonia only, the others being widely distributed.

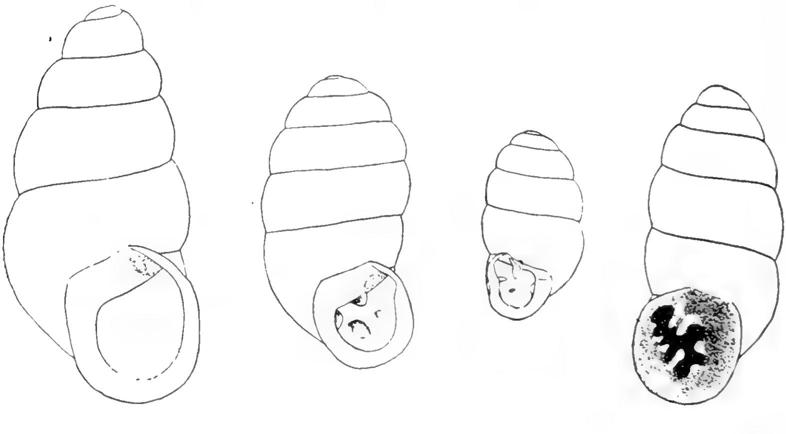

Fig. 1. Fig. 2. Fig. 3. Fig. 4.

Fig. 1. *Pupoides pacificus* (Pfr.), Facing Isl., Queensland. Fig. 2. *Pupa ficulnea* Tate, Palm creek, central Australia. Fig. 3. *Cylindrovertilla kingi* (Cox), Sydney, N.S.W. Fig. 4. *Bifidaria strangei* (Pfr.), Narrabri, N. S. Wales.

Key to Genera.

a.—Aperture toothless except for a nodule (angle lamella) usually developed at the posterior angle; peristome expanded or reflexed; shell brown, tapering above, *Buliminus*-shaped, PUPOIDES (fig. 1).

a^1.—Aperture with a parietal and a columellar lamella, and one or two palatal folds, or toothless; form cylindric, blunt at the ends, the whorls narrow, hardly oblique, PUPA (fig. 2).

a^2.—Angle lamella developed, no parietal; a small columellar lamella and upper palatal fold. Sinistral and minute, CYLINDROVERTILLA (fig 3).

a^3.—Angle lamella and a more immersed parietal lamella developed, the two converging and usually more or less united; a columellar lamella and two or three palatal folds generally present. Shell whitish, teeth white, BIFIDARIA (fig. 4).

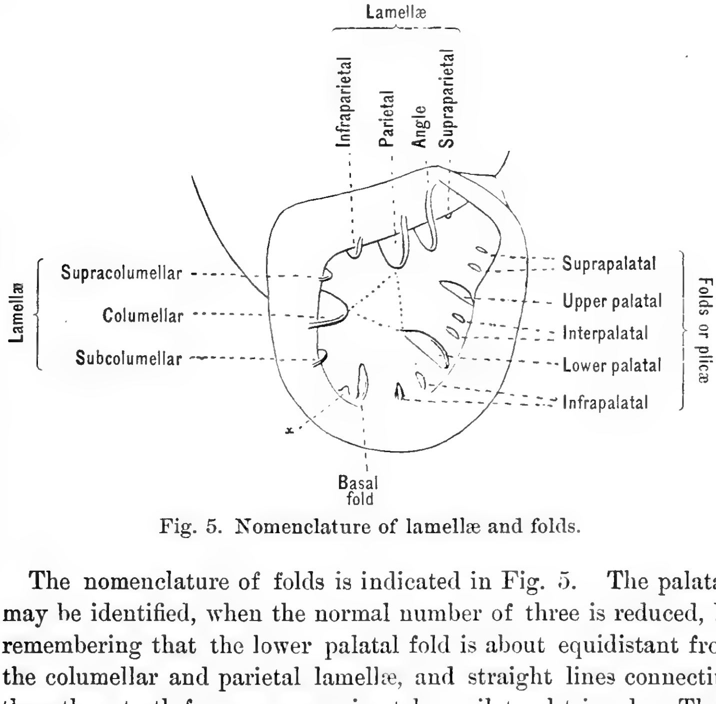

Fig. 5. Nomenclature of lamellæ and folds.

The nomenclature of folds is indicated in Fig. 5. The palatals may be identified, when the normal number of three is reduced, by remembering that the lower palatal fold is about equidistant from the columellar and parietal lamellæ, and straight lines connecting these three teeth form an approximately equilateral triangle. There are sometimes accessory folds within the lip, designated infrapalatal, interpalatal or suprapalatal, according to their positions.

I have confined my observations on Australian species to those in the collection of the Academy, referring merely to Dr. Cox's Monograph, Mr. Smith's paper on Western Australian shells, and Prof. Tate's report on the Horn Expedition for confirmation of the identifications. A wider reference to the literature would probably increase the number of species, but is unnecessary for my present purpose.

Genus **PUPOIDES** Pfr., 1854.

Besides its distribution in the two Americas and Antilles, this genus is represented in southern Asia (*P. cœnopictus*, *P. lardeus*), in tropical Africa (*P. senegalensis*), and in Australia, where it is represented by *P. pacificus* Pfr., *P. adelaidæ* A. and A., *P. contrarius* Smith, *P. ischnus* Tate, and I suppose *P. lepidulus* A. and A. (described as *Chondrula*), and *P. myoporinæ* Tate, the latter two not known to me by specimens.

Some Australian and African species are sinistral, and at least one, *P. contrarius* Smith, either sinistral or dextral. Prof. Tate's *P. ischnus* is perhaps the most aberrant of the Australian group, but they all seem closely allied.

Genus **PUPA** Drap., 1801.

The Australian species exhibit the common characters of this genus, which, though wanting in Polynesia and South America, is pretty generally distributed elsewhere. Even when toothless, like the original type of *P. muscorum*, the contour of the shell readily distinguishes it from *Pupoides*. Generally a parietal and a columellar lamella and the lower palatal fold are developed, frequently the upper palatal also, in Australian forms.

Pupa australis A. and A., *P. ficulnea* Tate and *P. lincolniensis* Cox belong here, and also, judging from description and figure, *P. nelsoni* Cox.

Genus **CYLINDROVERTILLA** Boettger, 1881.

The arrangement of folds is quite peculiar in this group, which was founded for the New Caledonian *P. fabreana* Crosse. The single lamella upon the parietal wall is not the usual parietal lamella, but the supraparietal or angle lamella; and the larger denticle on the palatal side is apparently the upper palatal fold rather than the usually persistent lower palatal.

C. kingi Cox, the only Australian species, is shorter, more oval than *fabreana*, but both species are alike in being sinistral and quite minute. The dentition varies somewhat, a lower palatal fold often being developed.

Genus **BIFIDARIA** Sterki, 1889.

The converging, often united, angle and parietal lamellæ, and the whitish shell with white teeth are characteristic. The extra-Australian distribution of the genus is wide, though less extended than that of *Pupa* or *Pupoides*. In America the greatest modifications as well as most species occur; but in eastern Asia, from Japan to India, it occurs, and *B. pediculus*, or slight modifications thereof, are widely spread in Polynesia and the East Indies.

The Australian group of species is closely allied to *B. pediculus*, and falls into the typical section of *Bifidaria*. Some American forms, such as *B. prototypus* Pilsbry and *B. dalliana* Sterki, are very similar, though in most other American, as well as the Chinese forms of the typical section of *Bifidaria*, the angle lamella and parietal lamella are more intimately united, forming a single sinuous, bifid, or emarginate lamella. But this varies by easy stages from complete union to separation of the lamellæ.

Some of the Australian species, like *B. larapinta* Tate and *B. rossiteri* Braz., have the form of the American *B. procera* group, with teeth like *B. prototypus*, while others are rather more conic. *B. strangei* Pfr. is usually sinistral, but not aberrant in dentition. In *B. mooreana* Smith the angle lamella is much reduced or even absent, a reduction parallel to what has taken place in the American *B. pilsbryana* and *B. pentodon*.

I have not seen *P. wallabyensis* Smith, *P. macdonnelli* Braz., *P. margaretæ* Cox, and *P. moretonensis* Cox, species probably referable to *Bifidaria;* the latter two certainly belonging there.

The occasional presence of an infraparietal lamella in some Australian species is unlike most of the Americans, in which this tooth is very rarely developed.

I do not regard *Bifidaria* as related to the Polynesian groups of which *P. lyrata* Gld. and *P. tantilla* Gld. are representatives, further than by the general bond of common ancestry which connects *Bifidaria*, *Hypselostoma*, *Torquilla*, *Faula* and these Polynesian forms.

Summary.—Three of the four Australian genera of *Pupidæ* are common to that continent and Indo-China, extending thence to Africa and America, and one (*Pupa*) to Europe. One genus, *Bifidaria*, is represented also in Polynesia by the widely spread species *pediculus.*[1] The only local group is *Cylindrovertilla* which occurs elsewhere in New Caledonia. There is no "Antarctic" type in the *Pupidæ*. So far as their Australian distribution is concerned, the *Pupidæ* agree with the Epiphallogonous Helices and probably reached Australia by the same land connection and at the same time, from the northward.

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[1] Probably the range of *B. pediculus* has been greatly extended by human agency.

NOTE ON POLYNESIAN AND EAST INDIAN PUPIDÆ.

BY HENRY A. PILSBRY.

Inquiries bearing on the origin and affinities of the land snails of Polynesia caused me to investigate the Pupa groups of the region. The chief work upon them is that of Boettger, who gives in the second volume of Prof. von Martens' *Conchologische Mittheilungen* a review of the species, illustrating those known to him by specimens. Several later papers by the same industrious author have appeared in the *Berichte der Senckenbergische Gesellschaft*, dealing with East Indian forms. The general grouping adopted by Boettger seems to be supported in the main by my own observations; but a few minor points may require revision. In referring East Indian forms to the Madeiran group *Staurodon* of Lowe, it seems to me that a mere analogy has been given undue weight. The form and structure of the angle *tubercle*—for it can hardly be called a "*lamella angularis*"—is quite different in the Madeiran *Staurodon saxicola* and the Oriental so-called *Staurodon* species. In the latter it has the form of that in the group I call *Nesopupa*,[1] only much shortened. I would therefore remove *Staurodon* from the nomenclature of Oriental *Pupidæ*.

We have, then, four groups remaining, as follows:

1. *Bifidaria* Sterki. The characters and synonomy of this genus have been discussed in my paper on Australian Pupidæ, and will be more fully considered in that by Mr. Vanatta and myself on the American forms.

The species of the area under discussion are widely distributed over Polynesia, except the Sandwich group, the single species *B. pediculus* Shuttlw. having a tremendous range, probably in part owing to human transporting agencies. There are several other closely allied forms, such as *B. pfeifferi* Bttg. and *B. recondita* T.-C., of more limited range, all of them allied to Australian

[1] I am aware that this name is of mixed parentage, but a mongrel in this case may be more convenient than a thoroughbred.

forms. The smooth surface, white teeth, and more or less united angle and parietal lamellæ readily separate this type from *Nesopupa*.

2. *Cylindrovertilla* Boettger. So far as known, confined to New Caledonia, where there are two species, and eastern Australia, one species. It therefore scarcely enters the region we are considering.

3. *Costigo* Boettger.[2] This group resembles *Nesopupa* in the dull brown, costulate or striate surface. It differs in having no angle lamella, only a simple parietal on the parietal wall, a columellar always present, palatals two or none. It is probably a *Nesopupa*, in which the angle lamella has become obsolete. Distribution, Saparua Island and Philippines.

4. *Nesopupa* Pils.[3] Small, dark brown, opaque and lustreless; ribbed, costulate or striate; the aperture armed with an angle lamella and a parietal, which remain distinct, not uniting as in *Bifidaria;* columellar lamella and palatal folds as usual, the latter rarely absent; lip expanded. Type *N. tantilla* Gld.

This is *par excellence* the Polynesian type of *Pupa*. It is absent in Australia, but occurs in the Philippines, Borneo, etc., and also in Mauritius and Mayotte. A number of sections may perhaps eventually be distinguished, but only one seems to me to have any foundation in nature. This may be defined thus:

Nesopupa ss. Peristome discontinuous above; palatal folds of moderate length.

Lyropupa n. sect. Peristome continuous; upper palatal fold very long; shell strongly costate. Type *N. lyrata* Gld.

The section *Lyropupa* contains several Hawaiian species, *lyrata* Gld., *perlonga* Pse., *costata* Pse.[4]

Typical *Nesopupa* includes *tantilla* Gld. with the numerous forms recognized as varieties by Boettger (*l. c.*), *capensis* Bttg., and

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[2] *Bericht Senckenb. Naturforsch. Ges.*, 1891, p. 270. Type *Vertigo* (*Costigo*) *saparuana* Bttg.

[3] The following are synonyms:

Pagodella H. Ad., *P. Z. S.*, 1867, p. 304. Type *Pupa* (*Pagodella*) *ventricosa* H. Ad. (Mauritius). Not *Pagodella* Swainson, 1840.

Ptychochilus Boettger. *Conch. Mittheil.*, II, p. 47, 1881. Type *P. tantilla* Gld. (Polynesia). Not *Ptychocheilus* Agas., *Pisces*, 1855.

Staurodon Bttg., *olim*, for *minutalis* Morel., *moreleti* A. D. B. Not of Lowe, 1852.

[4] *Vertigo cubana* Dall, *Proc. U. S. Nat. Mus.* XIII, 1890, pp. 1, 2, f. 1, 2, is identical with *costata* Pease. My friend was naturally misled by the false locality, "Cuba," of his specimen. The figures are excellent.

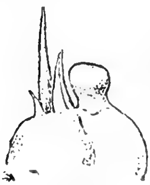
the Hawaiian forms, *newcombi*, *admodesta*, *parva*, which have the angle lamella shorter. The Philippine forms referred to *Staurodon* also belong here, *moreleti* A. D. Brown, *quadrasi* Mlldff. (Guam), etc., and likewise *minutalis* Morel. (Mayotte), *ventricosa* H. Ad. (Mauritius), and *incerta* Nevill. (Bourbon). The forms with a short angle lamella are probably not closely allied to each other, but nearer the species with a long angle lamella, occurring in their respective regions.

A NEW CRAYFISH FROM NEW MEXICO.

BY T. D. A. COCKERELL AND WILMATTE PORTER.

Cambarus gallinus n. sp.

Specific Characters.—Agrees with *C. simulans* Faxon, except that the apical portion of the rostrum is shorter; the areola is not carinate, or at best there is only the faintest indication of a carina; the first abdominal appendages of the ♂ (form I) have the apical process of the inner side long, straight, reaching considerably beyond the inner processes as shown in the figure. It has, with *simulans*, the broad, excavated rostrum; the lines of dots on the areola; the antennæ shorter than the body (when folded back reaching about to middle of third abdominal segment); the long, tuberculate chela; the sternum hairy; the third pair of legs alone hooked, etc. The sides of the carapace have a double punctuation, small punctures being interspersed among the larger.



♂ 1st. abd. app.
C. gallinus.

Color.—Carapace and abdomen light pinkish-brown, flecked with olive-green; abdomen with dorsal markings consisting of oblique broad stripes on the segments, forming a row on each side, these stripes darker than the general surface, and edged with a somewhat paler tint. Ventral surface decidedly pink. Ends of claws reddish.

Measurements.—The numbers in brackets are the percentages of the total length. The measurements are in mm.:

	Length from tip of rostrum to end of teleon.	*Breadth of carapace.*	*Length of carapace.*	*Length of areola.*	*Width of areola in middle.*	*Length of rostrum.*	*Length of chela.*
Las Vegas spn....	78	21 (26.9)	41 (52.5)	15 (19.2)	2.5 (.03)	11 (14)	37 (47.4)
Roswell spn.	69	18 (26)	35 (50.7)	13 (18.9)	1 (.01)	10 (14)	30 (43.4)
[C. simulans.......	97	27 (27.8)	51 (52.5)	18 (18.5)	1.3 (.01)	11.5 (11.8)	50.5 (52)]

It will be seen that while *C. simulans* is a larger animal than ours, the proportions of the parts are about the same. The Roswell specimens, though containing eggs, are all small. The size of the chela is variable, as thus:

Specimen	(1) ♂	(2) ♀	(3) ♂	(4) ♂	(5) ♀	(6) ♂
Total length	73	72	71	91	72	65
Length of chela	28	22	32	38	22	28

The first of these is from near Watrous, the other five are from the Gallinas river.

Hab.—Abundant in the Gallinas river at Las Vegas, and in neighboring waters; also found in lakes near Watrous, N. M. (*Edward Springer*), and at Roswell (*J. D. Tinsley*). Belongs to the Pecos River basin in New Mexico, and is closely allied to *C. simulans* from Dallas, Tex., and Fort Hays, Kans. It would be reasonable to regard it as a slight geographical race of *simulans* but for the quite distinct character of the first abdominal appendages, which remains constant in the very considerable series, both from Las Vegas and Roswell, which we have examined. No *Cambarus* has heretofore been recorded from New Mexico.

The types will be placed in the U. S. National Museum, and cotypes in the Academy of Natural Sciences of Philadelphia and the Museum of Comparative Zoölogy.

A brief semi-popular notice of this species appeared in *The Southwest*, April, 1900, p. 133.

TROCHOCYATHUS WOOLMANI, A NEW CORAL FROM THE CRETACEOUS OF NEW JERSEY.

BY T. WAYLAND VAUGHAN.

The two specimens upon which the description of the following species is based were sent me from the Academy of Natural Sciences of Philadelphia in compliance with the request of Mr. Lewis Woolman:

Trochocyathus woolmani sp. nov.

1898. *Platytrochus speciosus* C. W. Johnson, Geol. Survey N. J., Ann. Rep. for 1897, p. 265 (in Lewis Woolman's Report on Artesian Wells in New Jersey).

1898. *Platytrochus speciosus* C. W. Johnson, Proc. Acad. Nat. Sci. Phila., 1898, p. 462 (non *Platytrochus speciosus* Gabb and Horn, Jour. Acad. Nat. Sci. Phila., 2d ser., Vol. IV, 1860, p. 399, Pl. LXIX, figs. 15–17).

Corallum short, inversely conical, living attached, transverse outline circular.

Dimensions.—Diameter of calice, 3.5 mm.; altitude of corallum, 4 mm.; diameter of area of attachment, 1 mm. Wall rather thick, naked, ornamented externally by twenty-four costæ, corresponding to all cycles of septa, and showing a fairly regular alternation of larger and smaller—*i.e.*, there are twelve larger costæ of the same size corresponding to the septa of the first and second cycles, and twelve smaller corresponding to the septa of the third cycle. Near the calice they are prominent, with acute edges and broad bases; as the base of the corallum is approached they decrease in prominence. They possess granulations along their edges, and some scattered granulations on the sides.

There are three cycles of septa, divided into six systems. The members of the first cycle are appreciably larger than the other septa, and pass directly from the corallum wall to the columella space without forming part of any septal group. The members of the third cycle bend toward the members of the second, and fuse to the sides of the latter below the level of the calice. The septal margins project very slightly above the upper edge of the corallum wall. The septal faces are ornamented with distant subconical granulations.

The inner end of each of the primary septa is thickened, the thickening apparently representing a palus, and before each group of the members of the second and third cycles is what appears to be a slender palus; therefore, there are apparently slender pali before the septa of the first and second cycles.

The columella is not large; it is fasciculate, with a papillary upper termination.

The calicular fossa is shallow.

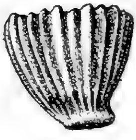


Fig. 1.

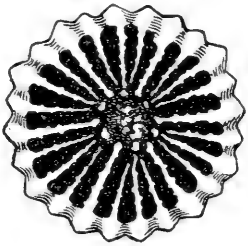


Fig. 2.

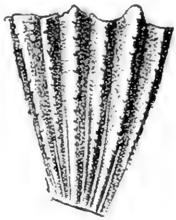


Fig. 3.

Figs. 1 and 2 drawn from the type (No. 685, Acad. Nat. Sci. Phila.). Fig. 1, upright view of corallum, altitude of specimen 4 mm. Fig. 2, calicular view of the same, diameter of calice 3.5 mm. Fig. 3, costæ of another specimen, much enlarged, length specimen 4 mm.

Locality.—From artesian well, Mt. Laurel, N. J., between 150 and 160 feet below the surface.

Geological horizon.—Cretaceous, Matawan clay marls.[1]

Type.—No. 685, Acad. Nat. Sci. Phila.

Mr. C. W. Johnson had identified this species with *Platytrochus speciosus* Gabb and Horn,[2] but it certainly is not that species. According to Gabb, *Platytrochus speciosus* is .5 in. high and the calice is .57 in. in diameter. It would be three times as large as *Trochocyathus woolmani*, besides it possesses a deep calice. It should be added that *Platytrochus speciosus* is certainly no *Platytrochus*, and it is impossible to identify it from Gabb's description or figures. The type, I believe, is at the Vanderbilt University, Nashville, Tenn., but I have been unable to see it. As I could not by any means find out what Gabb meant, I have discarded the species altogether. The species is almost surely not Cretaceous but Eocene.

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[1] L. Woolman, *Geol. Surv. N. J. Ann. Rep.* for 1897, 1898, p. 262; C. W. Johnson, *Proc. Acad. Nat. Sci. Phila.* for 1898, p. 461.

[2] *Jour. Acad. Nat. Sci. Phila.*, 2d ser., Vol. IV, 1860, p. 399, Pl. LXIX, figs. 15, 16, 17.

NOTES ON HYACINTH ROOTS.

BY IDA A. KELLER.

Last October I purchased a dozen hyacinth bulbs which were said to be specially selected and intended for water-culture. They were placed in appropriate glasses and treated according to approved methods ; that is, they were kept in the dark during the following eight weeks. At the end of that time six had produced extensive root systems, five showed but a meagre development in this respect and had begun to decay, the odor being extremely offensive. I was about to dispose summarily of the weaklings when I determined to give them another trial. I carefully removed the decayed tissue and washed the bulbs with a solution of listerine. The odor soon disappeared and in a short time roots began to form. Soon other bulbs began to decay and they were treated in like manner, and then they also proceeded to form new roots. I had no success with hyacinth culture, but I believe the fault lay in the bulbs, which seemed to fail quite generally during the season. In no case did I see the flower stalk push out with that fine vigor which is so characteristic of the well-formed bulb. Even the six plants above referred to with the normal root-system, which indeed had become so extensive that it made a heavy mat in the bottom of the glass, produced nothing but a much-shriveled flower stalk with the blooms wilted before they had an opportunity to expand. In these cases, however, the leaves unfolded quite normally.

Although convinced that the bulbs were not worth keeping for the purpose of floral display, I continued watching them, having become interested in the formation of the new roots. Some of these were particularly thick and vigorous, and differed greatly in appearance from those which are normally first formed. They seemed to be a second crop of adventitious roots, the first formed also belonging to this category since they originate from mature tissue of these metamorphosed stems. Some slender roots were also formed, but the thick roots were far the more numerous. On one of the bulbs whose original roots had all decayed and which I had treated in the manner described above, thirty such roots had made their appearance with not a single slender root among them (Plate XIII, fig. 1). On the six healthy plants with normally developed root-systems, some of these thick roots were to be found after some time among the first formed more slender roots, and both continued alive (figs. 2 and 3).

Is this secondary formation the expression of a more vigorous growth of the plant which follows with the expansion of the foliage, or is it due to the greater need because of the increase of the transpiring surfaces ? Perhaps both of these factors come into play as they both bear a direct relation to root development—the foliage depending entirely upon the absorbing action of the roots; the roots, in their turn, being the result of the protoplasmic activity of the leaves.

I endeavored to discover whether these roots differed in their anatomical structure from those first formed. A great difference was not to be expected, since roots, in general, are of very uniform construction These organs seem particularly indisposed to variations in the relative positions and character of their elements.

A cross section of an ordinary root showed the usual arrangement—the epidermis, the cortical parenchyma, the endodermis, and the central cylinder with its axillary bundle of fibrovascular tissue, a little distorted, but with a hexarch radial structure, the six very small component bundles converging to the centre, and separated from each other by a few interstitial cells (Plate XIII, fig. 4). Further examination showed that there was some variation in the number of these bundles. In fig. 5 the bundles converge toward two wide vessels, and a tendency to a diarch arrangement is quite pronounced, the rays forming two more or less distinct masses. In a cross section of the *thick* roots near the base this diarch arrangement was quite plain; there are two distinct bands of vascular tissue (fig. 7).

The polyarch radial structure was striking in a cross section about one and a half inches from the base and at this point there was no trace of a diarch tendency. This is probably the result of later development. In this section are to be found ten groups of vascular tissue, with a comparatively large quantity of undeveloped tissue in the centre (fig. 6). This is quite usual in roots, the tissue in the centre remaining in an undeveloped state for a time after the peripheral vessels are fully developed. Cross sections such as shown in fig. 8 illustrate this point clearly. The large circular spaces represent the lumina of vessels with as yet unthickened walls.

Comparison of the drawings will show to what extent these two kinds of roots differed from each other in their histological elements. The greatest difference lies in the relative quantity and development of the vascular tissue. On counting the number of cells in the cortical parenchyma I found that, in the cross section represented in fig. 4, that of the thread-like root, there were ten layers of cells, while in the cross section represented by fig. 7, that of a thick root, there were twenty cells in the corresponding tissue, just double the number. Of course here also variations were to be found, but this was an average.

These thick roots were particularly good objects for the study of root structure and development. They are easy to section and show interesting variations in their radial symmetry.

July 3.

Mr. Charles Morris in the Chair.

Eight persons present.

A paper entitled "Certain Antiquities of the Florida West Coast," by Clarence B. Moore, was presented for publication.

July 10.

Mr. Charles Morris in the Chair.

Eleven persons present.

A paper entitled "Additions to the Japanese Land-Snail Fauna, No. II," by Henry A. Pilsbry, was presented for publication.

The death of Wilfred H. Harned, a member, May 31, was announced.

July 17.

Mr. Benjamin Smith Lyman in the Chair.

Six persons present.

The death of Dr. John Ashhurst, Jr., a member, July 7, was announced.

Papers under the following titles were presented for publication:

"Notes on Certain Mollusca from Southwestern Arkansas," by Henry A. Pilsbry.

"The Musculus cruciformis of the Order Tellinacea," by H. von Ihering.

JULY 24.

Mr. CHARLES MORRIS in the Chair.

Seven persons present.

A paper entitled "On the Zoölogical Position of Partula and Achatinella and their Zoögeographical Significance," by Henry A. Pilsbry, was presented for publication.

JULY 31.

Mr. USELMA C. SMITH in the Chair.

Eleven persons present.

A paper entitled "Description of a New Rabbit from Liu Kiu Islands and a New Flying Squirrel from Borneo," by Witmer Stone, was presented for publication.

A paper entitled "Certain Antiquities of the Florida West Coast," by Clarence B. Moore, presented for publication the 3d inst., was ordered to be printed in the JOURNAL.

The death of Franklin Platt, a member, the 24th inst., was announced.

The following were ordered to be printed:

ADDITIONS TO THE JAPANESE LAND SNAIL FAUNA. II.

BY HENRY A. PILSBRY.

The discovery of the forms described herein is due to the well-directed industry of Mr. Y. Hirase, of Kyoto, Japan, to whom the Academy is indebted for many Japanese land snails. There can be little doubt that the land molluscan fauna of Japan will prove to be very prolific in specific forms, like most insular faunas.

The Clausilias of Japan have been worked up by Dr. O. Boettger, who in his masterly *Clausilienstudien* has laid a firm foundation for future builders. Subsequent work has been done by Kobelt, von Moellendorff, Smith, Sykes and the present writer. Arthur Adams' contribution to the literature of Japanese Clausilias is, like all of his Japoniana, quite worthless.

Clausilia hakonensis n. sp. Pl. XIV, figs. 1, 2, 3.

Shell rather slenderly fusiform, moderately attenuated above, the earlier $3\frac{1}{2}$ whorls scarcely increasing in diameter, then gradually increasing to the penultimate whorl which is widest, the last whorl being distinctly compressed and tapering. Whorls 12. Reddish or olivaceous brown, paler below the sutures, glossy where not eroded, distinctly, finely striated obliquely. Aperture subvertical or slightly oblique, ovate, the peristome continuous, white, well expanded. Superior lamella strong, oblique, reaching the margin, continuous with the spiral lamella, but becoming abruptly lower at the junction. Inferior lamella converging to the superior, strongly folded, rapidly tapering below, becoming very high, stout and very strongly spiral within. Subcolumellar lamella very deeply immersed, not visible from the aperture. Principal plica rather short; upper palatal plica short, oblique, passing into a strong, curved lunella, which is connected below with the middle of the rather short lower palatal plica, somewhat like a Greek letter τ inverted.

Length 32, diam. of penultimate whorl 7 mm.; length of aperture 7.7, width 5 mm.

Hakone Mts. (B. Schmacker), types No. 60,370, coll. A. N. S. P.

A *Hemiphædusa,* differing from all of the *platydera* group by the strongly spiral and heavily developed inferior lamella and wholly immersed subcolumellar lamella. The clausilium has the characteristic parallel-sided contour of the section. *C. hakonensis* will become the type of a new group or "Formenkreis" in *Hemiphædusa,* characterized by the strongly spiral, *Stereophædusa*-like inferior lamella.

Clausilia awajiensis n. sp. Pl. XIV, figs. 15, 16, 17.

Shell shortly rimate, obesely fusiform, thin, a little transparent, strongly but shortly attenuated above, the last whorl decidedly tapering. Corneous-brown; the last whorl reddish, glossy, distinctly, finely striate. Whorls $9\frac{1}{2}$. Aperture small, pyriform, the peristome white, moderately expanded, rather thin. Superior lamella rather thin, oblique, continuous with the spiral lamella. Inferior lamella very low and inconspicuous, stronger within and almost vertically ascending. Subcolumellar lamella not reaching the lip-edge, even immersed. Principal plica long, reaching almost to the lip, extending inward beyond the lateral lunella. Upper palatal plica very short, its outer end connected with a rather strong, oblique lunella, recurved toward its lower end; no lower palatal plica. Clausilium slender, tongue-shaped, emarginate posteriorly, slowly tapering below.

Length $12\frac{1}{3}$, diam. $3\frac{1}{2}$ mm.

Fukura, Awaji Island (Mr. Y. Hirase).

A *Hemiphædusa* near *C. aurantiaca* Bttg., but with fewer whorls, the lunella more lateral, not I-shaped, a lower palatal plica being absent.

Clausilia subaurantiaca n. sp. Pl. XIV, figs. 5, 6, 7.

Shell slenderly fusiform, attenuated above, the last whorl rather narrower; brown, but slightly glossy, weakly striate, more strongly so on the last whorl. Whorls nearly 11, the upper convex, the last two nearly flat. Aperture small, somewhat oblique, retracted and with a well-marked sinulus above, pyriform, produced; peristome thick, well reflexed. Superior lamella strong, oblique, continuous with the spiral lamella. Inferior lamella immersed, inconspicuous in a front view, becoming strong and subvertical within. Subcolumellar lamella very weak, not extending upon the expansion of the lip, or immersed. Plica principalis very long (the whorl outside a little swollen above it), extending nearly to the lip. Upper palatal plica extremely short, united with the lateral, nearly straight lunella; no lower palatal plica. Clausilium long, tongue-shaped, somewhat tapering toward the blunt apex.

Length 16, diam. 3 mm.

Deyai, Prov. Nagato (Mr. Y. Hirase).

This *Hemiphædusa* differs from *C. aurantiaca* Bttg. by wanting a lower palatal plica (which in *C. aurantiaca* makes an I-like figure with the lunella and the upper palatal plica); by the lateral, not ventral, position of the lunella, and the more slender contour. *C. awajiensis* is much more obese.

Clausilia aulacophora n. sp. Pl. XIV, figs. 18, 19, 20.

Shell small, slender, moderately attenuated above, opaque, dull reddish brown, paler above; finely striate, the last whorl more coarsely so. Whorls 10, convex, the last short, compressed laterally, hardly narrower than the preceding, a little turgid below the suture and at the base. Aperture small, pyriform, with well-defined and slightly retracted sinulus. Peristome white, thickened and well expanded, the outer margin excavated above. Superior lamella strong, oblique, continuous with the spiral lamella, and extending to the margin; a groove on the right side of it, usually producing a notch or emargination in the upper margin of the lip, and followed by a small rounded tubercle, to the right of which there is sometimes a second shallow groove in adult shells. Inferior lamella immersed, becoming strong and subvertical within. Subcolumellar lamella completely immersed. Principal plica a half whorl long, visible within the aperture. Upper palatal plica short, continuous anteriorly with and curving into the lunella, which is united with the middle of the lower palatal plica. There is a punctiform plica below the latter. Clausilium long, tongue-shaped, emarginate behind, the margins slowly converging toward the apex, which is bluntly attenuated.

Length 10, diam. 2.1 mm.

Fukura, Awaji Island (Mr. Y. Hirase).

Belonging to the Hemiphædusan group of *C. platydera*, as defined by Dr. Boettger, this small species is well distinguished by the groove in the peristome on the right side of the superior lamella.

Clausilia Hirasei n. sp. Pl. XIV, figs. 8, 9, 10, 11.

Shell small, solid, slenderly fusiform, regularly tapering above to an obtuse apex; glossy, irregularly striate, chestnut brown. Whorls 8–8½, rather weakly convex, the last two long, last whorl somewhat narrower, compressed. Aperture small, rather rhombic; peristome narrowly expanded, a little thickened. Superior lamella low, separated widely from the spiral lamella. Inferior lamella immersed, becoming strong and vertical within. Subcolumellar lamella weak but emerging. Principal plica less than a half-whorl long, extending well inward beyond the lateral lunella. Upper palatal plica oblique, not united with the lunella, which is nearly straight above, curved below. Three short sutural plicæ are developed above the upper end of the lunella, the second one shortest, upper one low; within the upper end of the spiral lamella there is sometimes an inserted lamella (*lamella inserta*), or perhaps this is a recrudescence of the inferior lamella; and outside of it there is a short fulcrum (*lamella fulcrans*, fig. 10, *l.f.*) and a longer parallel lamella (*lamella parallela*, fig. 10, *l.p.*).

Length 9.3, diam. 2.2, length of aperture 2.2 mm.

Length 7.3, diam. 2.2 mm.

Kagashima, Satsuma (Y. Hirase).

This is, so far as I know, the smallest Japanese *Clausilia* known. Internally it has the straightly vertical inferior lamella of *Hemiphædusa*, but in several fresh specimens opened I found no clausilium. In the development of the sutural plicæ it resembles *C. hyperoptyx*. The superior lamella is widely separated from the spiral lamella, and there is a *lamella inserta* developed in some examples. The internal complication is greater than in any other Japanese species known to me. Fig. 10 of Plate XIV, is diagrammatic.

It is named in honor of Mr. Y. Hirase, of Kyoto, who has brought to our knowledge a large number of interesting Japanese land snails.

Clausilia hyperoptyx n. sp. Pl. XIV, figs. 12, 13, 14.

Shell small, slender, moderately attenuated above, glossy, of a dark, rich reddish-chestnut color, finely and rather irregularly, not deeply, striate, the last whorl densely and more deeply so. Whorls 8½, convex, the last more flattened, a trifle narrower than the preceding. Aperture ovate, the peristome thick, expanded, whitish at the edge. Superior lamella rather low, vertical, attaining the margin, widely disconnected from the spiral lamella. Inferior lamella immersed, scarcely visible in a front view, strong and vertical within. Subcolumellar lamella emerging, continued to the edge of peristome. Principal plica about a half-whorl long, visible within the aperture. Upper palatal plica very short, slightly united with the nearly straight, oblique lunella, which is lateral in position. Two short sutural plicæ developed a little further inward than the upper end of the lunella. Spiral lamella and inferior lamella of equal length within, a rather long *lamella fulcrans* and a *lamella parallela* developed, each standing free. Clausilium rather narrow, parallel-sided, bluntly tapering at the apex.

Length 10, diam. 2.2, length of aperture 2.1 mm.

Loo Choo Islands (Mr. Y. Hirase).

This slender, dark-colored *Hemiphædusa* is a beautiful little species, distinguished by the two sutural plicæ and the development of a fulcrum and parallel lamella, as in *C. Hirasei.* It differs from that species in the dark color, attenuated and concave spire, stronger superior lamella, and various other details of the closing apparatus.

C. Hirasei and *C. hyperoptyx* form a new group of *Hemiphædusa* characterized as follows:

Superior lamella widely separated from the spiral lamella; a fulcrum and parallel lamella present; sutural plicæ developed; upper palatal plica independent or united with the well-developed lunella; no lower palatal plica.

Just what relation this group holds to Dr. von Moellendorff's group of *C. sublunellata* I do not know, but as he does not describe the complicated closing apparatus I find in my species, I presume it to be quite different.

Clausilia japonica var. **surugæ**, n. v. Pl. XIV, fig. 4.

Similar to *C. japonica* but smaller, strongly attenuated above for a longer distance, the aperture smaller with rather stronger principal lamella; upper palatal fold shorter, the lower palatal short or obsolete.

Mikuria, Prov. Suruga (Mr. Y. Hirase).

Having examined some hundreds of specimens of *C. japonica* from several localities, collected by Mr. Stearns, Mr. Hirase, Prof. M. R. Gaines and others, I conclude that *C. nipponensis* is hardly tenable as a variety. The gibbous penultimate and slender last whorl occur sporadically among typical *japonica*. The size varies a good deal in *C. japonica*, but the above-described variety presents a peculiar and quite recognizable contour.

EXPLANATION OF PLATE XIV.

Figs. 1–3. *Clausilia hakonensis* n. sp. Fig. 2, natural size.
Fig. 4. *Clausilia japonica* var. *surugæ* n. var., natural size.
Figs. 5–7. *Clausilia subaurantiaca* n. sp.
Figs. 8–11. *Clausilia Hirasei* n. sp. Fig. 10, diagrammatic. *l.*, lunella; *l.f.*, fulcrum or *lamella fulcrans; l i.*, inferior lamella; *l.p.*, parallel lamella; *l.s.*, superior lamella; *l.sp.*, spiral lamella; *p.p.*, principal plica; *p.s.*, sutural plicæ; *u.p.p.*, upper palatal plica.
Figs. 12–14. *Clausilia hyperoptyx* n. sp.
Figs. 15–17. *Clausilia awajiensis* n. sp.
Figs. 18–20. *Clausilia aulacophora* n. sp.

NOTES ON CERTAIN MOLLUSCA OF SOUTHWESTERN ARKANSAS.

BY HENRY A. PILSBRY.

During February of this year, Mr. James H. Ferriss explored for land shells the western tier of counties in Arkansas, from about midway up the western boundary of the State to the southwestern corner. He also collected at Hardy, in the northeastern portion of the State, and in some northeastern counties of Texas. An account of the trip has been given by Mr. Ferriss,[1] with a catalogue of the species collected, accompanied by valuable notes on the localities and habits of the several forms. The following notes on a portion of the species may be regarded as supplemental to his article, which should be consulted for the full list.

Helicina orbiculata tropica (Jan.).

Denison, Tex.; Rocky Comfort and Lanesport, Ark.

Polygyra leporina (Gld.).

Horatio, Chapel Hill, Rocky Comfort and Hardy, Ark.; DeKalb and Mt. Pleasant, Tex. Nowhere in abundance.

This species has especial interest from its intermediate position between the sections *Stenotrema* and typical *Polygyra*. The structure of the basal lip clearly foreshadows what we find in *P. hirsuta uncifera* or *pilula;* while the form of the parietal lamella shows that the upper branch, which makes the parietal V-shaped in typical *Polygyra*, is merely a further development of the callous ridge which runs from the lamella to the outer end of the lip in such species as *P. stenotrema.*

Polygyra dorfeuilliana Lea.

Throughout the western counties of Arkansas, from Polk county south, and in the northeastern counties of Texas, this is an extremely abundant species, and the collection made by Mr. Ferriss contains hundreds of specimens. The very widely umbilicated form, with glossy base, var. *sampsoni*, did not occur, all the specimens being more or less ribbed beneath and varying within wide

[1] *Nautilus*, XIV, July, 1900.

limits in the size of the umbilicus. They are referable to what I called var. *percostata*, but not so strongly sculptured as the types, and in fact pretty well bridge the gap between "*percostata*" and typical *dorfeuilliana*.

Specimens were taken at the following localities:

Hardy, Sharp county, northeastern Arkansas. Typical *dorfeuilliana*, none of the several hundred specimens having the wide umbilicus of var. *sampsoni*. Diam. $7\frac{1}{2}$–9 mm.

Mena, Polk county, Ark. Small specimens, 7 down to 6 mm. diam.; and varying from the typical form with comma-shaped rimation to widely umbilicated, showing over a full whorl below; more or less ribbed there.

Hatton Gap, Polk county. $6\frac{1}{2}$ to $5\frac{2}{3}$ mm.; umbilicus moderate or ample.

Horatio, Chapel Hill, Gilham and Cove, Sevier county. Similar to the last.

Morris Ferry, Little River county, Ark. Similar to the preceding.

Ultima Thule, Sevier county. Diameter varying from 7 to $8\frac{1}{2}$ mm.; umbilicus variable, as in the Mena specimens. In copious supply.

Rocky Comfort, Little River county, Ark. Similar to the preceding lot.

Denison, Tex. Similar to preceding.

It is rather peculiar that *Polygyra jacksoni* occurred during this trip only at Mena, Polk county, Ark. Possibly its southeastern limit does not reach the western counties of Arkansas below Polk.

Polygyra cragini (Call).

Ultima Thule, Sevier county, in southwestern, and Mena, Polk county, in western Arkansas, typical specimens. Also taken at Hardy, Sharp county, in northeastern Arkansas.

Polygyra inflecta (Say).

Mena, Rocky Cove and Hatton Gap, Polk county; Horatio, Sevier county; Morris Ferry, Little River county; all in southwestern Arkansas. Also at Little Rock in central and Hardy in northeastern Arkansas. Most of the specimens from Hatton Gap, Horatio and Hardy are small, often under 10 mm. diam. Those from Mena vary from 10 to 13 mm. This variation is merely individual.

Polygyra binneyana Pilsbry.

The specimens collected fully confirm the specific characters of this fine snail. While rather variable, it does not approach any known species.

The largest examples sent were taken at Gilham, Sevier county, Ark., and measure alt. 14, diam. 26 mm.; the umbilicus is partially overhung by the lip. The smallest seen from this locality is 23 mm. in diameter. All have 5½ whorls. Entirely similar specimens come from Mena, in Polk county; but from the Chastat Mts., near Mena, the shells are smaller, alt. 10, diam. 19½, and alt. 9, diam. 17½ mm.; the smaller ones have not quite 5 whorls. The size approaches that of *Polygyra kiowaensis arkansaensis*, but the aperture, lip and sculpture are as in the typical *binneyana*, and very unlike any form of *kiowaensis*.

Polygyra albolabris alleni (Wetherby).

This Western subspecies extends from Iowa to southwestern Arkansas. About 1885 I "planted" about a quart of living specimens from Des Moines, Ia., on the island of Rock Island, in the Mississippi river, opposite Davenport, Ia., where the species did not exist before. It does not occur in the vicinity of Davenport, nor around Iowa City, Ia.

Ferriss' localities are Hardy, Sharp county; Mena, Polk county, and Little Rock, Ark. The specimens from Hardy are as small as var. *maritima*, 23–24 mm. diam., but in other characters are typical *alleni*. Those from Mena are large, up to 30 mm. diam.; and in some cases the umbilicus is partially open, in apparently mature shells.

A single dead shell from Little Rock is more solid than most *alleni*, with the basal lip broader, somewhat as in an undescribed form from northern Alabama; but I think it only an old *alleni*.

Polygyra appressa (Say).

Finely developed specimens at Hardy, Sharp county, in northeastern Arkansas. They measure 18 to 20 mm. diam. Most specimens have a small upper denticle on the lip (the mark of "var. *a*" of Say), but I regard this as a merely individual variation.

Polygyra appressa perigrapta Pils.

Typical specimens were taken at Little Rock, Ark

Polygyra thyroides (Say).

The variations of this species in the Southwest are extremely perplexing. From the standpoint of the collector in the Ohio or the upper Mississippi valley, the shells are small; but they are as large as most Philadelphia specimens.

It is obvious from an inspection of Mr. Ferriss' shells that *bucculenta* Gld. is scarcely definable as a variety, although the globose, narrowly perforate *clausa*-like shells, such as one lot from Hardy, Ark., seem by themselves quite distinct. Many of the other shells, such as those from Denison and DeKalb, Tex., are practically intermediate; and I can find neither geographic nor conchological boundaries for *bucculenta* well enough defined to warrant its retention.

It remains to notice a small, rather depressed and decidedly reddish form, occurring at numerous localities in western Arkansas, and slightly unlike any *thyroides* I have seen from other localities. Specimens were sent from the following places:

Hardy, Sharp county, in northeastern Arkansas. Three forms collected: (*a*) *P. thyroides*, with flat lip, toothed parietal wall; alt. 12½, diam. 20 mm., or somewhat smaller. (*b*) Similar but red, depressed and glossy, rather openly umbilicate; alt. 11, diam. 19; alt. 10, diam. 16½ mm. (*c*) Typical *bucculenta*, with globose shell, narrow umbilicus, light color and rather rounded lip; alt. 12, diam 17; alt. 11½, diam. 16 mm. Rocky Comfort, Little River county. A form of *thyroides* with reduced or even imperforate umbilicus, the parietal tooth small or wanting; shape normal, and size as in lot "*a*" from Hardy. Also four specimens of the smaller, depressed, ruddy form mentioned above.

Cove, Polk county. Small and very narrowly umbilicated shells, diam. 15–17 mm., varying from yellowish-corneous to reddish. They are too depressed for *bucculenta*.

Ultima Thule, Sevier county. Similar to the shells from Cove: rich reddish.

Mena, Polk county. A single specimen of the small reddish form was taken; diam. barely 15 mm.

DeKalb, Bowie county, Tex. Specimens intermediate between *thyroides* and *bucculenta*.

Denison, Grayson county, Tex. Specimens less globose than typical *bucculenta*, but having the rounded (rather than flattened) lip and narrow umbilicus of that form. They vary from 17 to 20 mm. diameter.

Polygyra labrosa (Bld.).

Little Rock, Ark.

Polygyra stenotrema ('Fér.' Pfr.).

Spur of Chastat Mts., near Mena, Ark.; Hardy, Ark. Size varying from 9 to 10 mm. diam.; form typical.

Polygyra hirsuta uncifera n. var.

Similar to *P. hirsuta* in general form; very densely hirsute throughout, the hairs short, silvery; *parietal lamella more sinuous, recurved in a hook at the outer end;* basal lip formed much as in var. *pilula*, the median sinus oblique, separating two irregular nodules, the edge of the lip projecting above the notch; outer lip bearing a conical tooth.

Alt. $5\frac{1}{2}$–6, diam. 8 mm. (types, Mena).

Alt. 4.7, diam. 7 mm. (Chastat Mts., near Mena).

Alt. 4, diam. 6 mm. (Chastat Mts., near Mena).

Mena and the adjacent Chastat Mts., Polk county, western Arkansas. Types in the collection of the Academy of Natural Sciences of Philadelphia and of James H. Ferriss.

An extraordinary form, in which the parietal lamella is hooked at the distal end, as in *P. maxillata*, and the basal lip is peculiarly modified. The "hook" is evidently homologous with the upper branch of the parietal fold in the typical Polygyras, and this form may fairly be regarded as to some extent a transition form, at least in this one character. The group of small Polygyras of the *plicata-dorfeuilliana* type have evident relationships with *Stenotrema*, having a similar internal "fulcrum," and some species being hairy.

In this connection it might be mentioned that the single West Coast species, *P. germana*, usually referred to the subgenus *Stenotrema*, is in my opinion much more closely allied to the *P. columbiana* group, and might better be grouped therewith. Binney, however, has pointed out its peculiarly intermediate character.

The varieties of *P. hirsuta* now known, *pilula*, *altispira* and *uncifera*, are remarkably distinct; no intergradation with the typical form has yet been observed in any of them. In fact, typical *hirsuta* is much closer to *P. stenotrema* than to the varieties mentioned.

The small series of var. *uncifera* collected by Ferriss show that it has a smaller form on high ground. This peculiarity has been noticed in other species, such as *P. hirsuta* and *P. monodon*, which may have a small and a large form on higher and lower ground respectively, in the same region.

Polygyra monodon (Rack.).

This species was originally described from near Thunder Bay, Lake Huron. This is in Alpena county, Mich. The type, as well figured in the *Linnean Transactions*, was undoubtedly what became known later as "*Helix* (*Stenotrema*) *leai* Ward"—a small, widely umbilicated shell, which many collectors have considered to be a distinct species from the traditional *monodon*, and which is confined to the middle West, north of the Ohio river and west to Iowa.

This state of affairs renders a rearrangement of the nomenclature necessary. *H. leai* will be deleted from the roll of valid species, and its place usurped by *P. monodon*, which name will henceforth be used for the small, glossy, widely umbilicated shells formerly known as *leai*.

The larger, more hirsute form now universally known as *monodon* will become *P. monodon fraterna* (Say). This subspecies is far more widely distributed than the true *monodon*. It varies from as widely umbilicated as *monodon* to quite imperforate. The widely umbilicated forms are chiefly northern, especially in western New York.

In the Little Tennessee river valley the much-depressed, umbilicated subspecies *cincta* Lewis occurs.

In the Southwest, from western Arkansas and Louisiana to southern Texas, several ill-defined races occur. Var. *aliciæ* is a small form, 8–9 mm. diam., with narrow umbilical chink, more or less globose contour and 5½ whorls. Var. *friersoni* is larger, the size of well-developed northern *fraterna*, with 6 whorls and an umbilical chink. Both of these have the umbilical region deeply impressed. The propriety of separating them from var. *fraterna* or from one another is open to question, and requires more study; but it must be said that the series of some hundreds collected by Mr. Ferriss can be assorted without grave difficulty, and the two forms, *aliciæ* and *friersoni*, coexist in numerous localities, just as typical *monodon* ("*leai*") and *fraterna* do in the North.

However, I do not consider either of these varieties to have anything like the standing the several varieties of *P. hirsuta* have, and their discrimination may be an unnecessary refinement.

Then we have a third form of *monodon* which I shall call var. *imperforata*, collected by Mr. Ferriss at Mena, Cove and Rocky Comfort, Ark., apparently living with var. *friersoni*. It has $5\frac{3}{4}$ whorls, an elevated spire, much less swollen, rather flattened base, which is *very little impressed or sunken in the centre*, is *imperforate*, and has scarcely a trace of the flange along the basal lip so prominent in fully adult *friersoni*. The pile is harsh to the touch, and the surface without lustre. Although I may have overdone the naming of *monodon* varieties, I do not see how to avoid distinguishing this race by name. It is by all odds the most distinct of the southwestern varieties, and apparently is confined to the rough, mountainous country. Types from Rocky Comfort, Ark.

The following forms of *monodon* were taken by Ferriss:

Mena, Polk county, Ark. Var. *imperforata* Pils. Rather globose, imperforate shells, $8\frac{1}{3}$ to 10 mm. diam., remarkable for having the umbilical region very little impressed. Whorls $5\frac{1}{2}$ to 6. Pile rather stiff.

Horatio, Sevier county, Ark. Var. *aliciæ*. Two small specimens, diam. 8 mm., with narrow perforation and short, straight parietal tooth, as in typical *monodon*, though this may indicate immaturity; $5\frac{1}{2}$ whorls. The spire is only moderately raised.

Ultima Thule, Sevier county, Ark. Small shells, 8–$8\frac{1}{2}$ mm. diam., with $5\frac{1}{2}$–$5\frac{3}{4}$ whorls, the spire more or less conoid, umbilicus narrow, nearly closed, the umbilical region impressed. The specimens are referable to the form I called var. *aliciæ*.

Cove, Polk county. Three of four specimens taken are the variety *imperforata*, with scarcely impressed umbilical region, mentioned from Mena. The other is an ordinary *friersoni* with partially open umbilicus.

Rocky Comfort, Little River county. Three forms occurred at this place: (*a*) Var. *imperforata*, the imperforate shells with elevated spire, scarcely impressed umbilical region and rather harsh pile mentioned above as occurring at Mena. (*b*) Small specimens such as those described above from Ultima Thule, referable to var. *aliciæ;* 54 specimens. (*c*) Large specimens with deeply impressed umbilical region and 6 whorls, diam. 9–$10\frac{1}{2}$ mm., referable to var. *friersoni*.

DeKalb, Bowie county, northeast Texas. Var. *friersoni*, 5 specimens. Var. *aliciæ*, 20 specimens.

Mt. Pleasant, Titus county, Tex. Var. *aliciæ*, one specimen.

Pupoides marginatus (Say). (*Leucocheila fallax* Auct.).

Cerro Gordo, Sevier county, and Cove, Polk county, Ark.

Bifidaria armifera (Say).

DeKalb, Tex., and Hardy, Ark.

Bifidaria contracta Say.

Cove, Polk county, Ark.

Vitrea simpsoni (Pils.).

Hardy, Mena, Hatton's Gap and Morris Ferry, Ark. The first locality is further east than it has before been reported.

Conulus chersinus trochulus Reinh.

Cerro Gordo and Hatton's Gap, Ark.

Gastrodonta demissa (Binney).

Two southwestern races of this species have received names: var. *brittsi*, an imperforate form, and var. *lamellata*, which has an internal lamina, like *G. gularis*. It must freely be confessed that the abundant series collected by Mr. Ferriss show these forms to intergrade to a perplexing extent, and it is not easy to define them. Both toothed and toothless forms apparently come from the same log; although the fact remains that, except in this particular region, *demissa* is not toothed. Gastrodontas are, however, proverbially difficult to classify; they defy our neat, conventional arrangements of species and subspecies, and proclaim the eternal sway of variation. We name them as we can, and have trouble when the intermediate forms have not become extinct. At all events, the varieties of *demissa* I have erected should not be estimated too highly.

Mena, Polk county, Ark. 16 specimens of the *brittsi* type; the largest 9 mm. diam.; imperforate or barely perforate.

Thirty specimens of the *lamellata* type, the largest $8\frac{1}{2}$ mm. diam.; narrowly perforate; lamella varying from well developed to a heavy callous lump.

Seventeen specimens with no lamella, $9\frac{1}{2}$ mm. diam., 6 alt.; 7 whorls.

Hatton Gap, Polk county. 11 specimens of *lamellata*, the largest 8 mm. diam. Also 33 specimens of *demissa*, up to 9 mm. diam.; perforate.

Cove, Polk county. Both laminate and toothless specimens.

Ultima Thule, Sevier county. 17 specimens of the var. *brittsi.* These approach the typical *G. acerra* in general appearance, but are imperforate. Whorls 7; alt. $8\frac{1}{2}$ to 9, diam. $13\frac{1}{2}$ mm. The var. *lamellata* also occurred at Ultima Thule.

Horatio, Sevier county. Both the lamellate form and toothless *demissa* of all ages.

Chapel Hill, Sevier county. 26 var. *lamellata* and 18 *demissa,* the largest having 7 whorls, alt. 6, diam. 9.8 mm. All perforate.

Gilham, Sevier county. Both *lamellata* and *demissa.*

Pyramidula alternata (Say).

Mena, Polk county; Horatio, Sevier county; Rocky Comfort, Little River county, and Hardy, Sharp county, Ark. Specimens all rather strongly ribbed. The var. *rarinotata* occurred at Denison, Tex., further north than it has hitherto been noticed. The western Arkansas shells are the opposite of the middle Texas variety, being unusually dark and copiously maculated.

Limnæa desidiosa Say.

Hardy, Sharp county, Ark.

Ancylus rivularis Say.

Ancylus haldemani Bgt.

A few specimens of each from Hardy, Sharp county, Ark.

Physa gyrina Say.

Hardy, Sharp county, northeastern Arkansas.

Thysa integra Hald., var.

Hardy, Sharp county, Ark.; Mt. Pleasant, Titus county, Tex. The specimens are small, and of the variety with a dark-brown lip-rib.

Pleurocera elevatum (Say). Fig. 1, upper line.

Spring river, Hardy, Sharp county, northeastern Arkansas. Extremely variable, in color being yellow, banded, or almost black; and varying from nearly smooth to singly or doubly carinated above the sutures, the last whorl with a slight peripheral keel or two or three acute keels, as in the variety *lewisii* Lea. The specimens are unusually beautiful and wholly free from erosion.

Pleurocera subulare (Lea).

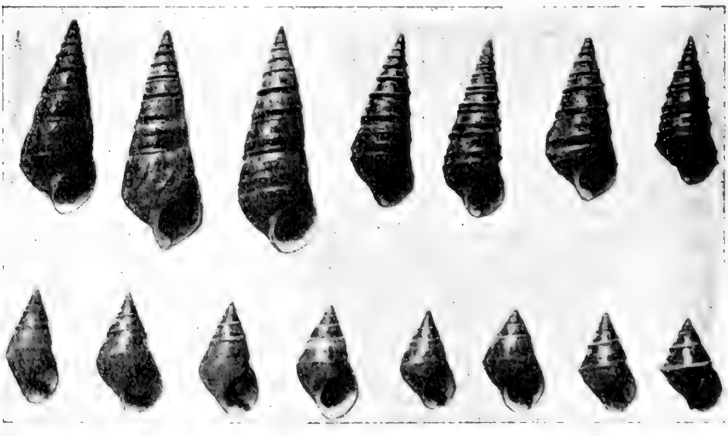
More slender and smoother than *elevatum*, with which it occurs at Hardy. Spring river flows into Black river, a tributary of the White river.

Goniobasis plebeius (Anth.). Fig. 1, lower line.

Spring river, Hardy, Sharp county, northeastern Arkansas. The specimens show the usual variation from almost rounded through angulate to strongly keeled at the periphery; the unicolored examples of the carinated end of the series being indistinguishable from *G. cubicoides* (Anth.), which is a mere synonym. The carina, when present, may either project at the sutures or merely fill them, leaving an even surface. These variations of form occur in the young as well as in adult examples, some half-grown shells being almost rounded at the periphery.

Nearly all the specimens from Hardy are straw-colored, with a blackish band above the periphery and another in the middle of the basal slope; sometimes the upper band or both of them are absent; and in one or two shells the whole surface is dark save for the pale carina. The columella is usually dark-stained at the root, but occasionally white throughout. The apices are not eroded.

The series from Hardy is so interesting in its variations that I reproduce here photographs of the leading forms.



Upper line, *Pleurocera elevatum*. Lower line, *Goniobasis plebeius*.

The vast amount of variation among individuals living side by side, under absolutely identical external conditions, is an inexplicable characteristic of the *Pleuroceridæ*. This variation is generally in the line of retention by the shell of characters of extreme youth or immaturity (carination, costation or other sculptural feature) into mature life, or the early loss of sculpture, leaving a plain, rounded last whorl. This particular phase of variation stands on quite a different basis from that of *Io*, in which the ornate forms are farthest removed from the young stages, the spines of the later whorls being apparently a new and lately acquired character, which has not had time to become impressed upon the young.

DESCRIPTIONS OF A NEW RABBIT FROM THE LIU KIU ISLANDS AND A NEW FLYING SQUIRREL FROM BORNEO.

BY WITMER STONE.

Several mammals collected in the East Indies and adjacent islands have recently been submitted to me for examination for the Wistar Institute of Anatomy.

Two of these prove to be of exceptional interest and are, so far as I can ascertain, undescribed.

The first is a rabbit obtained on the Liu Kiu Islands by Dr. W. H. Furness and Dr. H. M. Hiller, February 26, 1896.

It would naturally be expected that a rabbit from this locality would prove to be allied to the Japanese *Lepus brachyurus*, but curiously enough the two specimens before me represent a species of the genus *Caprolagus*, and are apparently nearest to *C. hispidus* of Assam.

The larger of the two specimens may be regarded as the type (No. 5,314, collection Wistar Institute) of a new species which I propose to name in honor of its discoverer.

Caprolagus furnessi n. sp.

Size approximately that of *Lepus americanus*. Hind foot, tail and ears remarkably short, claws very large and strong, nearly straight on the fore feet, decidedly curved on the hind feet.

Color very dark for a rabbit. Soft under-fur plumbeous, long hair coarse and hispid, brownish black, many with buff annulations or tips, becoming mahogany on the rump and brighter yellowish brown on the feet (except about the base of claws) and tail. The long hairs on both tail and feet retain their bristly character. From the hind neck to the beginning of the mahogany shade on the rump there is a jet-black longitudinal band. Under parts with stiff hairs fewer and mostly pale buff, the gray under-fur more prominent, giving a general plumbeous hue to the pelage.

The cranial characters agree pretty closely with those of *Caprolagus hispidus* as described and figured by Blyth.[1]

Skull strong and solid, incisive foramina short and narrow (length 18 mm.), terminating fully 3 mm. anterior to the anterior margin of alveolus of first premolar. Bony palate correspondingly produced fully as long as broad (length 12.5 mm.). Bony network over the anteorbital foramina entirely coalesced and solid. Nasals very broad and solid, line of juncture with frontals exactly opposite anterior margin of orbit and on line with posterior edge of second premolar. Supraoccipital process very short with no anterior projection, the usual notch in front of it being entirely absent; frontals scarcely constricted, the width behind supraorbital processes being equal to the interorbital width (20 mm.).

Teeth strong and heavy, and no trace whatever of the small posterior upper molar.

In the lower jaw the anterior extension of the mandibles supporting the incisors is somewhat slender, and there is a distinct hump or bulge in the lower contour just anterior to the first premolar.

The measurements of this specimen are as follows:

Total length of flat skin,	550 mm.
Ear,	42 mm.
Hind foot,	97 mm.
Tail vertebræ (approximate),	8 mm.
Length of whiskers,	50 to 65 mm.
Length of skull (occipito-nasal),	88 mm.
Zygomatic breadth (minimum),	40 mm.
Interorbital breadth,	20 mm.
Length of nasals,	31 mm.
Length of upper molar series (alveoli),	15 mm.

Another example (No. 5,315, Wistar Inst. Coll.) is apparently smaller and has the mahogany tints suffused over the whole back, with many of the hairs on the sides and shoulders light yellowish brown, giving it a much brighter richer coloration. The black dorsal stripe in this specimen is not quite so pronounced.

With only the skins and skull at my disposal, I am unable to describe the clavicles in this interesting animal, but from the many

[1] *Journal Asiatic Society of Bengal,* XIV, p. 247.

other peculiarities exhibited by it I regard the genus *Caprolagus* as established by Blyth in 1845 as quite worthy of recognition.

In 1896 Dr. Merriam established the genus *Romerolagus*[2] for a peculiar little rabbit from Mt. Popocatapetl, Mexico, many of the characters being parallel to those of *Caprolagus* as described by Blyth fifty years before. While in no way questioning the validity of *Romerolagus*, we must take exception to Dr. Merriam's statement that "Heretofore the genus *Lepus* has enjoyed the distinction of coincidence in characters with the family to which it belongs." Flower and Lydekker also seem to have totally overlooked *Caprolagus* in making their diagnosis of the family *Leporidæ*. The family characters must certainly be modified and we must recognize three distinct genera:

Lepus;

Caprolagus Blyth, 1845;

Romerolagus Merriam, 1896.

Three species of *Caprolagus* are now known:

C. hispidus (Pearson), *Bengal Sporting Magazine*, August, 1843, p. 131 (*fide* Blyth).

C. netscheri (Schlegel), *Notes Leyden Mus.*, February, 1880, p. 59;

C. furnessi Stone, *antea*.

The other apparent nondescript in the Wistar Institute collection is a flying squirrel obtained by Messrs. Alfred Harrison, Jr., and H. M. Hiller on the Menbuang river, Sarawak, Borneo, January, 1898 (No. 5,298).

Notwithstanding the numerous species of *Sciuropterus* that have been described from this region the present specimen seems to differ from all, so far as I can judge from the descriptions, though lack of material for comparison is much to be regretted.

This species is dedicated to Mr. Harrison, whose researches in Borneo have resulted in most valuable zoölogical collections.

Sciuropterus harrisoni n. sp.

Size and general appearance similar to *S. horsfieldi*, *S. thomsoni*, etc., but distinguished at once by the uniform dull brown of the tail on both the upper and under surfaces.

[2] *Proc. Biol. Soc. Wash.*, Vol. X, pp. 169–174.

The general appearance above is bright rusty red, darker and more inclined to chestnut than in *S. davisoni.*[3] This color extends from the nose to the root of the tail, the dark blackish plumbeous bases to the hair everywhere show through, the rust color being confined to the tips. The sides of the face are paler and there is a black ring around the eye. Flight membranes black, the hairs tipped with white or very pale buff, passing gradually into the rusty color as they approach the body, outer edge of the membranes white. Ears triangular, with a sparse covering of black hairs on the outside. Feet with scattered blackish hairs. Lower surface dull white; cheeks, throat and sides of abdomen tinged with rufous. Under side of membranes dull blackish with pale rufous tips to the hairs.

Tail pale buff or fawn color at the base, below; otherwise entirely uniform dull brown above and below; decidedly distichous and tapering somewhat from root to tip. "Whiskers" long—50 to 70 mm.; one or two short cheek bristles, no tufts at base of ears. Incisors orange.

Length of skin, ...	360 mm.
Length of tail, ...	170 mm.
Hind foot, ...	30 mm.

I wish to acknowledge my indebtedness to the collectors and to Dr. Horace Jayne, Director of the Wistar Institute, for the privilege of examining these specimens.

[3] Figured in *P. Z. S.*, 1886, Pl. VI.

AUGUST 14.

Mr. BENJAMIN SMITH LYMAN in the Chair.

Eight persons present.

A paper entitled, "Lower California Species of Cœlocentrum and Berendtia," by Henry A. Pilsbry, was presented for publication.

The Raubsville Cave.—MR. BENJAMIN SMITH LYMAN, referring to a communication made at a previous meeting by Mr. Lewis Woolman but not reported, remarked that the Carpenter Cave, three-fourths of a mile northwest of Raubsville and three miles south of Easton, Pa., was discovered a few years ago in quarrying limestone near a hilltop about four hundred feet above sea-level and over two hundred feet above the Delaware. It seems to be at the axis of an anticlinal, for at the north side of the quarry the dip is 20° northerly, and some three hundred yards nearly eastward the dip is perhaps 45° southerly, while half a mile eastward, at the Delaware, both north and south dips are very gentle, and the anticlinal sinks easterly. The explored part of the cave, perhaps one hundred and fifty yards east from the entrance, is a mainly straight, east-and-west, nearly vertical, roughly broken fissure, or series of fissures, up to some ten feet in width, with occasional blocks of stone lodged between the walls; and exactly resembles the original, yet unfilled fissures of many ore veins. The water from the small drainage surface above has but slightly deposited stalactites and stalagmites, and the walls are partly bare and angular, according to their inclination. No human traces have been found in the cave; but reported traces of small animals and the excellent ventilation indicate that there must be some natural opening into the cave, though none has yet been found. It is one of the numerous caverns that Lesley[1] has shown to have aided in effecting, by solution rather than by abrasion, the great lowering of the neighboring limestone region that has evidently taken place since glacial times. No undisturbed glacial traces have persisted, or perhaps ever existed hereabouts. Glacial boulders are found four miles southward, but it is not clear they were not waterborne, possibly on ice-cakes, from the great terminal moraine twenty miles to the north.

The following were ordered to be published:—

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[1] *State Geological Report*, D3.

THE STRUCTURE OF THE DIATOM GIRDLE.

BY THOMAS CHALKLEY PALMER AND F. J. KEELEY.

Usually the girdle of the diatom is easily separated from the valve to which it pertains. A strewn mount of cleaned diatoms will show most of the girdles so separated. If any doubt as to the structural distinction between valve and girdle were possible previously, Printz removed it, so far as the large forms of *Navicula* were concerned, by his study of sections.[1] The girdle, therefore, is understood to be, not a part of the valve, but a closed hoop of silica, more or less narrow, wedged into the rim of the valve or otherwise held in place not very firmly. Deby even asserts that in the case of many species old girdles are "caducous" and detach themselves spontaneously. The account[2] which this author gives of the process of multiplication by cell-division—an account agreeing in the main with the views of diatomists in general—implies a rapid and necessary decrease in size as an inevitable result. So also Pfitzer[3] and, following him, most writers on diatoms. The closed hoop structure is taken as typical of the whole family by such recent writers as F. Schuett[4] and George Karsten,[5] the former of whom, discoursing upon the "Zwischenbaender" of O. Mueller, remarks: ". . . . die Zwischenbaender sind . . . . nach *Art der Guertelbaender als geschlossene Ringe* ausgebildet, und erscheinen dann als secundaere Guertelbaender, oder," etc.; and

[1] W. Printz: "Études sur coupes de diatomeés observeés dans les lames minces de la roche de Nykjobing," Brussells, 1880.

[2] J. Deby: "Ce que c'est qu'une Diatomeé?" Soc. B. de Microscopie, Bruxelles, 1877.

[3] E. Pfitzer: "Untersuchungen ueber Bau und Entwickelung der Bacillariaceen," Bonn, 1871. Also, "Die Bacillariaceen," *Encyklopaedie der Naturwissenschaften. Botanik*, II, p. 435, where the matter is thus tersely expressed: ". . . . bei jeder Theilung die groessere der beiden entstehenden Tochterzellen genau eben so lang ist, als die Mutterzelle war, waehrend die andere etwa um die doppelte Dicke des Guertelbandes kuerzer ist."

[4] F. Schuett: "Bacillariaceæ." Engler and Prantl's *Pflanzenfamilien*, I, 1, b., p. 39, 1896.

[5] George Karsten: "Die Diatomeen der Kieler Bucht," *Wissenschaftliche Meeresuntersuchungen*, Vierter Band., 1899.

the latter simply takes the closed ring structure for granted. This structure being admitted, the deduction as to progressive decrease in size is undoubtedly sound. In point of fact, wide variations in size do, in the case of a vast number of species, occur continually. In filamentous forms it would appear that a decrease does occur step by step with the process of reduplication. Yet facts are not wanting that do not agree altogether with the theory. The demonstration has seemed to demonstrate too much. "If the matter is as simple as Mr. Deby has made it out to be," writes Van Heurck, "sexual reproduction would be very frequently observed, which, however, is not the case."[6] Possibly what is meant here is not exclusively sexual reproduction, that is to say conjugation (which does not, in the algæ, wait upon decrease in size), but also rejuvenescence of the cell by auxospore formation.

The scarcity of auxospores in *Melosira* and similar forms, compared with the number theoretically called for, is one of the striking facts in this connection. The details of the process of reduplication were therefore studied exhaustively by Otto Mueller[7] in the case of a single species of the genus. The study culminated in the celebrated "law of Mueller," a statement of the sequence of events in the growth of this particular species, which shows why it is that after forty-three successive reduplications there is but one auxospore in place of the 1,052,100,000,000 which ought to produce themselves according to the theory of plain geometrical subdivision.

Studies of the character of this upon *Melosira arenaria* are not so plentiful that we should desire to do aught but award it the high appreciation which is its just due, and which it has compelled from diatom students in general.

We must, however, be allowed to remark that it has yet to be shown that the sequence of events is the same in all species; and, further, that it is not quite certain, as will appear later, that even the fundamental structure of the silicious parts is the same in all the genera and species of the diatoms.

In all the literature upon diatoms with which we are familiar

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[6] H. Van Heurck: *Treatise on the Diatomaceæ.* English translation by W. E. Baxter, London, 1896.

[7] "Die Zellhaut und des Gesetz der Zelltheilung folge von *Melosira arenaria* Moore," Berlin, 1883.

there is noticeable a curious tendency to neglect the structure of the girdle, to take for granted that it is everywhere the same, and that it is typically a closed hoop.[8] Only in the Lauderiinæ and Rhizosoleniinæ, which include the genera *Lauderia*, *Guinardia*, *Rhizosolenia*, *Dactyliosolin*, and one or two others, is any other structure figured or described; and in those cases a distinction is made by calling the numerous girdles either annulæ or interbands. In short, the girdles here are considered non-typical and peculiar.

Peculiar in certain aspects they may be. But that either these "annulæ" or the "Zwischenbaender" in other genera, differ from the usual girdle in being incomplete hoops is a proposition we dare to call in question. Our theme may be stated thus: *The closed hoop structure is unusual.* With some very important exceptions, the girdle is a two-ended band of silica, with the ends variously and characteristically rounded or otherwise modified, and approximated or overlapping without being joined. The position of the gap or joint is, within limits, constant in a given genus with relation to salient features of the valves. In case of each simple pair of primary girdles, the two gaps are usually at opposite points of the diatom; and in general, in the forms we have studied, the gaps are normally so situated with respect to each other as to "lap joints."

In calling attention to a fact at once so elementary and fundamental, and so in opposition to views generally held, we could desire to present a large number of particulars. But we cannot claim the merit of setting forth at this time the results of any adequate study of the girdle. The field is vast, and the difficulties are various. We content ourselves now with the presentation of certain typical examples, mainly or almost exclusively among the larger forms. It seems, indeed, almost or quite safe to infer the main structure of the girdles of minute species from the main structure of those of larger species in the same genus.

The facts presented are almost all morphological and static, and so, however incomplete in some respects, they have the advantage of being easily verified by any student of the Diatomaceæ. Our observations have been primarily among the Pennatæ, and first of

[8] This is by no means to ignore the "Zwischenband" developments of Otto Mueller and F. Schuett. But, as we have shown, the latter authority at least implies the closed-ring girdle structure. The "Zwischenband" is somewhat apart from our present subject, which confines itself to girdles proper.

all in the genus *Surirella*. It therefore seems necessary to begin with this genus—a genus that partakes of some of the characteristics of both Pennatæ and Centricæ. Especially in the location of the girdle gap would *Surirella* seem to be anything but a typical member of the Pennatæ. Following this we shall consider the Pennatae, and lastly certain typical Centricæ.

SURIRELLA.

It was a study of a pure and very large gathering of *Surirella elegans* Ehrenb. that first drew our attention to the real structure of the girdle. The diatom was found in greatest abundance, practically free from other forms and from inert matter, in a shaded rill of cold water during the month of August. It formed a dark-brown or even blackish patch upon the bottom, about a foot in diameter and more than a fourth of an inch deep. Several ounces of purest material were dipped up and placed in bottles. Some of the gathering remained in good living condition for four months. A part was boiled in strong nitric acid, and mounts were made in balsam. Girdles separated from their valves were plentiful in these preparations. Many girdles were broken into several pieces, but many more were uninjured. Those latter, however, always showed an opening that was not a break. Though separated from their valves, the girdles remained in general bent nearly as when attached. In every case, with absolutely no real exception, the gap was on one of the flat sides of the oval, and mostly not far from a point midway of the length. This was true of all the girdles, of which there were two main types observable. The first of these is the mature girdle, mostly broad and thick; and the second is the young or immature, narrow and thin. The latter kind, in addition to the gap, showed also, at a point nearly opposite, a little stem or *cleat* of silica, in shape somewhat like an hour-glass, extending at right angles from the edge to a distance equal to or greater than the breadth of the girdle itself. This cleat was absent in older, or what may be called primary, girdles. The gathering was, and long remained, rather quiescent as respects reduplication, and successive preparations continued to show the two kinds of girdles with practically no intermediate gradations. These two kinds are represented at *d* and *e*, fig. 1, Pl. XV. It being manifestly impossible to understand the relations of these girdles to each other and to the valves when the elements were in this state of dislocation, preparations were made with parts *in situ* by burning the crude frustules upon cover-glasses and mounting dry and in balsam.

Persistent study of all those preparations, as well as of living frustules and mounts made by other preparers, has, most unfortunately, left many points still obscure. Yet we are able to present the following definitely ascertained facts.

The complete frustule, in this gathering, shows first of all two broad and thick primary girdles, the inner and the outer. Each of these exhibits a gap between its approximated ends, substantially as shown in diagram *c*, fig. 1, Pl. XV.

These gaps are on opposite sides of the diatom in every case observed by us; and while the exact location varies, it is always between the smaller end and the middle point of the length.

Long before there is any other evidence of coming reduplication, two secondary girdles make their appearance, one for each of the primary girdles. One of these extends as a narrow, thin band around the edge of the outer primary, and projects a cleat through the opening in the primary, attaching itself thereby to the outer valve. This outer secondary girdle shows in optical section at the end of the diatom, as if attached to the inner edge of the primary. At the same time, upon the edge of the inner primary girdle appears in like manner a secondary growth, with cleat extending through the opening in the primary to the inner valve. But in optical section, at the end of the diatom, this inner secondary appears as an *outward* thickening, as if attached to the outer edge of the primary. We have, therefore, now four girdles, the two primary and the two secondary, for each pair of valves. Diagrams of these parts, separated and in contact with each other, are included in fig 1, Pl. XV.

That which arrests attention is, that the inner secondary girdle apparently overlaps the inner primary. If these secondary girdles are, by any possibility, destined to become primary girdles in the daughter-cells, the arrangement as described will admit of but two results: either the new valve will attach itself to the new girdle, the old valve remaining as before the inner or smaller valve of the two, or, on the other hand, the new valve may join to the old girdle, which parts from the old valve and is replaced by the new girdle.

But that the secondary girdles do develop and function in either of these ways is what we have been quite unable to prove. It is next to impossible to trace the disposition of parts in a frustule of *Surirella* after the two new valves have formed and before the daughter-cells have parted company. We can only say that we have looked carefully, but hitherto in vain, for any evidence of the growth of new girdles from the young valves of *Surirella elegans* in accordance with orthodox views. In some other genera we have observed facts that seem to indicate that similar secondary girdles, formed before the young valves, broaden and lose their cleats, becoming finally indistinguishable from primary girdles. In the case of *Surirella* we are more in doubt, and we desire to pursue the subject further. As bearing on the doctrine of a necessary decrease in size during successive cell-divisions, the matter is plainly of importance. And in the same connection we would state that among the millions of frustules in our gathering of *S. elegans*, products of a long series of divisions and redivisions, the small ones were few compared with those well toward the maximum of 220 μ. It would certainly seem that, with the expansible girdles which pertain to this species, new valves might be formed as large as the old; and that the quite small frustules, 170 μ long, which are present only to the extent of ten per cent., must owe their existence to some less familiar and simple, but more real, influence than a supposed, but non-existent, stony inexpansibility of the mother-cell girdle.

The girdles of *Surirella elegans* are apparently hyaline, but under favorable conditions transverse striæ are visible. When well resolved, the appearance is similar to that of *Amphipleura pellucida*, but the striæ are more delicate and the resolution much more difficult. Attempts further to resolve into dots were unsuccessful.

Pure gatherings of *S. splendida* Kuetz, less rich than that above described, yet ample, showed essentially the same girdle structure. That is to say, there were primary and secondary girdles, the latter with and the former without cleats, but both with gaps situated as in *S. elegans.*[9]

[9] Many mixed mounts of diatoms were examined, and *Surirella* girdles of several species were recognized. All showed lateral gaps, and many secondary girdles were seen with cleats. In Mueller's type-plate of one hundred forms in styrax, a lateral gap was observed in the form listed as *S. norwegica,* Eul. (II, 3).

S. elegans may stand as a type, not of its own genus only, bu apparently also of the Surirelloideæ. *Cymatopleura solia* W. Sm., according to our too few observations, has girdles with gaps situated one on each side of the diatom, not far from the place of greatest constriction midway of the length. As for *Campylodiscus*, the remaining genus, we have been unable to find any preparations showing girdles in a condition admitting of study.

NITZSCHIA.

We have not been fortunate enough to identify satisfactorily any large variety of girdles in this genus. Such girdles as are *in situ* show nothing of importance except occasionally certain apparent lines running out at a sharp angle from the termination of the valve on the girdle face—such as have been figured frequently (*e.g.*, *Nitzschia linearis*, in Van Heurck, Pl. 16, fig. 542). Dislocated girdles, however, were found plentifully in a gathering of *N. sigmoidea*. As in *Surirella*, the girdles are of two kinds. The first is, when in place, in contact with its valve along its whole length. The second is narrower, and connected with the valve only at one point—the cleat. Both have one end open, the other end closed. The free ends of a girdle are uniformly beveled in a characteristic way, so as to form two sharp points. These points meet each other at the end of the diatom. The inner girdle of a simple pair has its opening at the end opposite to the opening in the outer. The cleat on the secondary girdle is situated at the opening in the primary, and partly closes it without at any time fusing it into a solid, unbroken band. Fig. 5, *a* and *b*, Pl. XV, illustrate these two forms of girdle in this species very well, except that breadth is less in proportion to length than these drawings would indicate.

NAVICULA.

Among the vast number of species of this genus we have paid attention mostly to the Pinnularia group, such as *Navicula viridis*, *nobilis* and *major*. Pure gatherings of these large forms have not been at our command. But though nowhere in great abundance, some are to be found in almost all good fresh-water gatherings. The girdles are easily assigned to their proper species as a rule, because even when quite detached they generally still retain approximately their original shapes. Even in fossil deposits it is not difficult to recognize many *Navicula* girdles as belonging to this or that particular form also represented therein by valves.

In these large forms the girdles, when viewed as they stand upon their edges—that is, in valve view, but with valve removed—show each one a closed end and an end more or less widely opened. When the exact shape is retained, the free ends, which are much thinned or drawn out, approach each other closely or perhaps overlap a very little in some cases. As a rule, however, some little distortion occurs during the preparation of the slide. A diagram of the edge-view is given in fig. 2*a*, Pl. XV.

When seen flatwise, or in girdle view, the ends are found to be narrowed in the other direction also. When the heat used in mounting has been particularly high, it often happens that girdles lying on their sides are softened, and the preparation will then sometimes show both the free ends nearly or quite in the same place, and not superposed. The appearance then is somewhat as in fig. 2*b*, Pl. XV. The terminations of the band of silica appear always of nearly this same shape in the large Naviculæ. The joint which is formed by them is uniformly at the end of the diatom; and, as may be expected, the joint or gap in the outer girdle is at one end of the diatom, while that in the inner girdle is at the other end. Secondary girdles, homologous with those described above for *Surirella*, we have seen but in a single doubtful case; and anything resembling a cleat, either *in situ* or detached from the valve, is equally hard to find. Richer gatherings will probably be necessary before the secondary girdles, if such exist in *Navicula*, can be described.

The terminal gap or joint of these large forms is typical of the girdle structure of the whole vast genus. *N. gibba* Kg., *N. Bombus* Ehr., and many others, some in nearly pure gatherings, yield girdles with gaps situated at the ends. It is, indeed, very striking to see how uniformly the dislocated girdles of all species, even the smallest, are open at one end and closed at the other. Girdles *in situ*, unless happily broken at the right place, do not show the gap satisfactorily; and even a pair of girdles, one within the other, with valves removed, often cling together so tightly that the gaps are not obvious, and the observer might think he had here a completely closed single hoop. But a real case of a single girdle with both ends closed has not, among either large or small forms of this genus, been noted by us.

STAURONEIS.

The girdles of *S. Phœnicentron* Ehr. are very thin and narrow, and the free ends forming the gap, which is situated at the end of the frustule, have a less constant and definite shape than in the case of most diatoms. Owing to their tenuity, and consequent proneness to soften and become distorted, these girdles are not easily identified in mixed gatherings. From an examination of some pure gatherings we are able to state that the gaps in inner and outer girdles are at opposite ends of the diatom, and that exceedingly minute cleats are often present on secondary girdles. These cleats are merely little rod-like projections at right angles to the edges of the girdles.

NAVICULOIDEÆ and ACHNANTHOIDEÆ.

Terminal gaps in the girdles of the following have been observed with uniformity: *Pleurosigma angulatum* W. Sm., *Pl. Spencerii* Bailey, *Pl. Balticum* W. Sm., *Pl. elongatum* W. Sm., *Pl. strigosum* W. Sm., *Van Heurckia rhomboides* Breb., *Gomphonema geminatum* (Lyngb.) Ag., *Rhoicosphenia curvatum* (Kuetz) Grun. In the case of *Pleurosigma*, the termination of the free end of the girdle is somewhat like that in species of *Nitzschia*, but less sharply pointed, and more rounded on the side of the termination away from the valve. In the above genera we have not seen any very definite cleats.

Cymbella, Amphora, Amphiprora and *Mastogloia* remain uninvestigated. *Epithemia* has claimed our attention without yielding any clear understanding of its girdle structure. *Achnanthes brevipes* Ag. and *Cocconeis Pediculus* Ehr. yield girdles in which terminal gaps can generally be distinctly seen.

RHABDONEMA.

Among the crowd of genera and species of the Fragilarioideæ, *Rhabdonema adriaticum* Kuetz. is the form that most clearly shows the essential structure of the girdle. This structure seems, in addition, typical of the whole group, with the exception, apparently, of some species of *Synedra*. Practically the same arrangement—apart from the interposition of the *Zwischenbaender*—is found with clearness in *Eunotia*, and indicated sufficiently in *Meridion, Diatoma* and *Fragilaria*.

Two girdles of *R. adriaticum* are shown in fig. 3, Pl. XV. One bears a thin band which joins it throughout its length to the valve or *Zwischenband.* The other is more narrow, and connects with the valve only by the very distinct cleat. Intergradations are observable in rich gatherings which show a gradual increase of breadth, starting from the cleat and extending toward the open end. The ends are rounded, and half-inclined to be spatulate on the side removed from the valve, but come to a point on the side next the valve. The cleat is of considerable breadth, comparatively heavy, and calculated, from its shape, to fit snugly on the inner edge of the valve at the end. A few specimens, only partly dislocated during mounting, showed the usual alternation of parts—that is, the outer girdle of a pair is open at one end of the diatom, the inner girdle of the same pair is open at the other end.

EUNOTIA.

E. major Rab. was studied at some length, both mounted in filaments and mounted after disruption and separation of parts. The mounted filament yields but unsatisfactory results. The features of importance being at the ends of the cells, and the parts being here so overlapped and confusing, an optical section of the end of the cell, especially of one in course of division, will show "a mass of things, but nothing distinctly." Nevertheless, a rapidly growing filament does afford some evidence that prevalent ideas as to what goes on during cell-division of diatoms are not altogether unmixed with error. We desire to return to this subject at no distant date. For our present purpose, we simply show, in fig. 4, Pl. XV, two separated girdles of this species. We have been able to discover no other kind of girdle than these, and such as are of an intermediate character, either in this species or in others of the genus. Filamentous and non-filamentous, all species examined yield only girdles open at one end and closed at the other.

MELOSIRA.

The fresh-water species of this genus are mostly small, and the girdles are, previous to the formation of new valves, excessively tenuous—so much so that any structure is only to be made out with the greatest difficulty. *M. Roeseana* Rab., however, occasionally shows a typical structure, which is also dimly seen in certain specimens of *M. varians* Ag. The long, tubular "connective" which separates the old valves, and within which new valves grow, is made up of numerous imbricated hoops. Each of these hoops is incomplete. The openings in them are situated with respect to each other somewhat irregularly. The species *M. Borreri* Grev., being much larger, reveals a distinct structure. The arrangement of the hoops is essentially like that in *Lauderia annulata* Cleve.[10] These bands or hoops, when separated, show openings; and in a few cases, in the species *M. Roeseana*, delicate cleats extending to the valves have been seen. These cleats are much like those in *Biddulphia,* which are described below. After the formation of the new valves within this system of rings, the tube seems to increase in thickness, and to become more or less firmly united with the outer surfaces or edges of the valves into a stiff and stout construction not easily separated again. So the filamentous state is conserved. But the openings or joints in the rings can still be made out, with proper management. The tube composed by these rings is, therefore, originally somewhat expansible. If it becomes non-yielding, that is after the formation of the new valves ; so that, if these latter are smaller, as they undoubtedly are, this fact also has possibly another explanation. Numerous published figures indicate the rings composing the tube in *Melosira* and its relatives, but the openings and cleats have not been figured so far as we can find.

We have not investigated the girdles of the other genera of Melosirinæ nor those of the Sceletoneminæ.

COSCINODISCUS.

Particularly distinct structures are to be found in the girdles of this genus. In fig. 7, Pl. XV, is shown diagrammatically a pair of girdles of *C. subtilis* Grun. with two secondary girdles in place. In fig. 8, Pl. XV, is given an inner primary, with two secondaries adhering. These two figures will sufficiently elucidate the arrangement and relation of parts in this species. We have here the openings in all the girdles and stem-like cleats joining the secondary girdles to the valves. It is worthy of note that here, at least, whatever the import may be, the secondary girdles both

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[10] See Van Heurck, *Treatise on the Diatomaceæ*, p. 418. Figure in the text.

overlie the inner primary. Here again, however, our information is incomplete. It is a question whether these secondary girdles are destined to serve the yet unformed valves of the daughter-cells, or whether they are nearly constant features of the mature mother-cell, and designed simply to strengthen the whole structure. We desire to pursue this inquiry further.

A somewhat similar structure is that in *C. robustus* Grev. (at least as to the primary girdle), but more pronounced owing to the greater thickness of the girdle, as will be noted in figs. 1 and 2 of Pl. XVI, which show photographically both views of the opening in the primary girdle. Here the cellular structure of the girdle, which is similar to but much finer than that of the valve, has comparatively broad hyaline margins continuous through the gap. We have observed secondary girdles with cleats in this same species, but not in a shape to indicate clearly their relations with primary girdles.

The structure and arrangement as given will probably explain the form described by J. Brun[11] under the name of *Coscinodiscus crassus cum Placentæ;* also the appearance, according to J. Rattray,[12] of certain specimens of *C. robustus* from Santa Monica, Cal., wherein a striated border (of the valve) was "surrounded by a second more sharply defined but narrower band, with a slightly convex surface; . . . . at one place this band is interrupted and somewhat more convex on the two sides of the break. This gives it the appearance of an elastic spring enveloping the valve."

Our material representing *C. robustus* is from Sendai, Japan, and while rich in girdles, it has failed to afford one that was completely closed.

ACTINOCYCLUS.

We have studied the girdles of *A. Ehrenbergii* Ralfs. from Florida. The structure is essentially the same as that of *Coscinodiscus subtilis* as given in figs. 7 and 8 of Pl. XV. In addition, we have seen at least one secondary girdle apparently developing in a most interesting and curious manner into a girdle of full width. More observation is needed here before we feel warranted in

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[11] J. Brun: *Diatomées Especes Nouvelles Marines*, p. 21.

[12] J. Rattray: *A revision of the genus Coscinodiscus* Ehr. Edinburgh, 1890.

drawing any final conclusion; but the single example referred to would seem to indicate only one possibility, namely, that the secondary girdles do indeed eventually become indistinguishable from the primary.

AULACODISCUS.

In this genus the girdles are composed of hoops, imbricated as in *Melosira*, *Lauderia*, etc. The arrangement of the hoops and the location of the gaps are shown photographically in figs. 4 and 5 of Pl. XVI, where the first figure is of the upper side of a semi-frustule of *A. Kittonii*, and the second is of the lower side of the same specimen. The girdle is in this case composed of four hoops, but the number varies from two to six or even more in different individuals. The opening of the hoop next the valve is on the lower side, that of the next is on the upper side, the third on the lower, the fourth on the upper. The cleats, which may be anticipated here on all except the first hoop, have not been seen.

BIDDULPHIA.

The typical species, *B. lævis* Ehr., so abundant along the coasts, has a complicated system of hoops. Two oft-recurring shapes are shown in fig. 4, Pl. XVI. The cleat on the narrower hoop passes through the gap in the wide hoop and attaches itself to the valve within the sulcus. In fig. 3, Pl. XVI, is shown a frustule with three hoops in the outer girdle. In fig. 6, Pl. XV, is given diagrammatically, but with essential faithfulness, a frustule with two valves and four approximately equal girdles. No cleats could be discovered in the specimen from which this figure was constructed. The arrangement shown would certainly indicate the possibility that secondary girdles may function as primaries in the daughter-cells.

As to the location of the girdle gaps, it is worth remarking that in this and neighboring species the gaps and cleats are always situated almost vertically under the knobs of the valves—that is to say, at the ends of the oval diatom, not on the flat sides as in *Surirella*.

Diatoms With Closed Girdles.

Apparent or real exceptions to the open-girdle structure are noted as follows:

Synedra superba Kuetz. Whether the girdle is or is not closed at both ends in this species remains quite doubtful. Certainly there is much appearance of complete closure in many specimens examined by us. In any case, the girdle is furnished with a stout hook-shaped cleat at one end, and generally at the other end with either precisely the same thing or else with two hooks only separable from each other with difficulty.

Arachnoidiscus Ehrenbergii Bailey. Such girdles of this species as we have examined have been narrow and comparatively thick. They are attached to the under side of the valve by an inward-bent rim of great tenuity, quite continuous all around the circle. No manipulation we could bring to bear has made any opening evident in either rim or girdle, and the girdles usually show as perfect and complete circles.

Triceratium favus Ehr. The girdles are attached by a rim like that in *Arachnoidiscus.* They are broader, however, and of a thickness that would make any opening or gap very obvious. Considering the close relationship now thought to obtain between *Triceratium* and *Biddulphia,* we confidently expected to find a similarity in girdle structure. Our material, though not in endless profusion, has not been exactly meagre. Yet we end by saying not only that we have not found any girdle gaps in *Triceratium,* but also that we do not believe any will be found. This is the more curious, since it would appear from published figures that *Lithodesmium* has possibly a complicated system of open girdles. But we have not examined the latter, and cannot state the facts as to this matter. It may be that the closed hoop structure is a characteristic of all the Triceratiinæ.

Terpsinœ musica Ehr. seems to have closed girdles. Being a large form, any opening ought to be seen with ease. If such exists, it is in the form of a very narrow slit at the end of the diatom, and so invisible in the specimens as usually mounted.

Isthmia nervosa Kuetz. This very large diatom has completely closed girdles. These are all the exceptions to the general rule that we have detected. Their importance is undeniable. Others among the Centricæ may quite possibly be found; though, if our present classification is not overrated as an expression of natural relationships, the probabilities are all in favor of the open-girdle structure in most of the genera intervening between *Melosira* and *Biddulphia.* As to the Pennatæ, terminal gaps may be expected in nearly all genera.

We desire to thank Messrs. J. E. Schultz, Lewis Woolman and C. S. Boyer for diatom material, and the last-named gentleman for certain references to the literature of diatoms.

EXPLANATION OF PLATES.

Plate XV.

Fig. 1. *Surirella elegans* Ehr. *a*, inner primary girdle; *b*, outer primary girdle; *a′*, inner secondary girdle; *b′*, outer secondary girdle; *c*, arrangement of parts *in situ*; *d*, separated primary girdle; *e*, separated secondary girdle with cleat.

Fig. 2. *Pinnularia* sp. *a*, girdle on edge; *b*, girdle on flat side, distorted.

Fig. 3. *Rhabdonema adriaticum* Kuetz. *a*, primary girdle; *a′*, secondary girdle.

Fig. 4. *Eunotia major* Rab. *a*, primary girdle; *a′*, secondary girdle.

Fig. 5. *Nitzschia sigmoidea* Ehr. *a*, primary girdle; *b*, secondary girdle.

Fig. 6. *Biddulphia lævis* Ehr. Two valves and four girdles, the front of outer girdles broken away to show gaps on the farther side.

Fig. 7. *Coscinodiscus subtilis* Grun. A pair of primary girdles, with two secondaries in place.

Fig. 8. *Coscinodiscus subtilis* Grun. An inner primary girdle, with two secondaries adhering.

Plate XVI.

Fig. 1. Valve view of girdle of *Coscinodiscus robustus* Grev. × 350.

Fig. 2. Girdle view of girdle of *Coscinodiscus robustus* Grev. × 350.

Fig. 3. *Biddulphia lævis* Ehr. × 425. Showing three hoops in outer girdle.

Fig. 4. *Biddulphia lævis* Ehr. A primary and a secondary girdle, the latter with cleat. × 200.

Figs. 5 and 6. *Aulacodiscus Kittonii* Arnott. × 370. A semi-frustule, mounted on its girdle, and photographed first on the side in contact with the cover-glass (fig. 5), then on the far side (fig. 6).

Photographed with Tolles $\frac{1}{4}$ 1.20 N. A.

THE MUSCULUS CRUCIFORMIS OF THE ORDER TELLINACEA.

BY H. VON IHERING.

During the winter of 1876–1877, I spent my time in studying the animals of the Pelecypoda in the rich collection of the Museum of Copenhagen, which were with great liberality placed at my disposal. Among the numerous still unpublished observations then made, there is one which I believe may be useful now, as it seems that no other zoölogist has hitherto observed and published the same.

All the members of the Tellinacea (Dall) have at the base of the siphons in the connected ventral parts of the margins of the mantle a singular muscle, formed by two crossing muscles which are inserted in the valves in the region of the angle formed by the mantle-impression and the sinus, or between it and the borders of the shell. Our fig. 1 shows their positions in *Sanguinolaria sanguinolenta* (Gm.). One of the two branches perforates the other, both being united into a cross-shaped muscle, which functionally may serve as a secondary adductor. I have examined this muscle in the following species: *Macoma lucerna* Hanley and *calcarea* Ch., *Tellina interrupta* Wood and *striata* Ch., *Soletellina violacea* Lam., *Sanguinolaria sanguinolenta* Gm., *Psammobia ferroensis* Ch., *Asaphis coccinea* Mart., *Donax cuneatus* L., *Semele reticulata* L., *Iphigenia brasiliana* Lam., *Tagelus gibbus* Spengler.

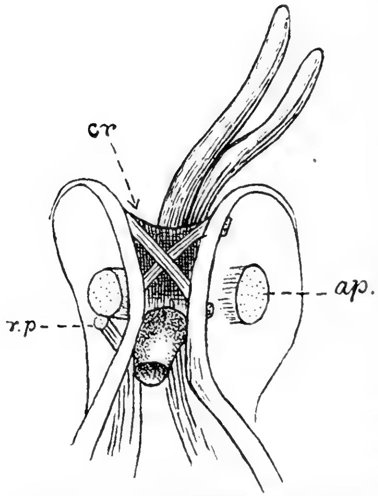

Fig. 1. Siphonal apparatus of *Sanguinolaria sanguinolenta* (Gm.). *ap*, posterior adductor; *rp*, posterior retractor; *cr*, cruciform muscle.

In all these different forms the general arrangement is the same, but the development of the muscles, their insertions, etc., offer great variability. In *Tagelus* the muscle is very small and included in the mantel-edges, not producing separate scars of insertion. Somewhat stronger are the muscles in *Psammobia* and *Donax,* but as a rule they produce also no distinct scars of insertion. *Iphigenia* has the muscles strong but short. In the true *Tellina* and in *Macoma* the branches are slender and very long, and always the scars of insertion are quite well developed, as shown by our fig. 2.

Sometimes the insertion is different in relation to the distance of the scars in both valves, and sometimes one of the muscular branches is subdivided, producing thus two scars.

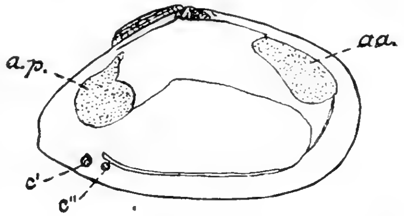

Fig. 2. *Tellina striata* Ch. *aa,* anterior adductor; *ap,* posterior adductor; *c'* and *c''*, scars of the insertions of the cruciform muscle.

All these differences are of secondary value. There can be, however, no doubt that the Tellinidæ offer the best and most typical development of the apparatus, and *Tagelus* the most rudimentary one. The conditions of the muscle in the genera *Solecurtus* and others apparently related to *Tagelus,* should be examined. Evidently the cruciform muscle is a special development of fibres of the mantel-edge which only secondarily have been isolated from these margins. This is, as I believe, the true origin also of the adductor muscles, which in their earliest state were situated in the mantel-edge and secondarily isolated and removed from it. The cruciform muscle forms a new and important character of the super-family Tellinaceæ, confirming the views of Prof. W. H. Dall.

THE FLORA OF THE EDGEHILL RIDGE NEAR WILLOW GROVE AND ITS ECOLOGY.

BY ALEXANDER MAC ELWEE.

The village of Willow Grove, Montgomery county, Pa., is situated near the eastern edge of the Chester Valley limestone formation, and just at the northern base of one of the highest points of the Potsdam sandstone, commonly known as the Edgehill ridge. This ridge is part of an almost continuous belt of sandstone, quartzite and conglomerate rocks, which extends from the Delaware river near Trenton almost to the Schuylkill river. The section of the belt studied extends from the village of Willow Grove southeast about one mile, then southwest for about five miles, terminating at a point one mile southwest of the village of Edgehill. The average elevation of this ridge is about 400 feet. This elevated region is an important factor in determining the flow of the streams in its neighborhood. Sand Run, rising about a half-mile east of Rubicam, drains the valley between this ridge and the hills of the same formation on the north and unites with the Wissahickon on the west side of Fort Hill. Various little streams starting on the south side at Laverock, Edgehill, Weldon and Abington, unite a short distance above Jenkintown and form the main volume of Tacony creek. The southeast, east and northeast sides are drained by the Pennypack creek and its tributaries, Paul's Brook, Terwood Run and other minor streams. Numerous good roads traverse the region in different directions, and many fine views of the surrounding country may be obtained.

The flora of this ridge is very interesting, owing to its difference from that of the surrounding country. It is a flora peculiar to many barren districts on the Atlantic seaboard which contain numerouspecies and v arieties.

The plants of this region resolve themselves into three societies or associations of species. These are as follows:

1. Sunshine plants:
    (*a*) Roadside,
    (*b*) Dry open woods,
    (*c*) Introduced annuals of the cultivated fields.
2. Shade plants.
3. Bog plants.

1. Sunshine Plants.—The old road leading over the hill near Willow Grove is an excellent place for the study of this society. A great variety of plants are found here in bloom, from the first early violets of spring until the last asters and golden-rods of autumn. The varied colors and scents of the Virginia goats-beard, golden ragweed, clumps of pink azaleas, lousewort, blue-eyed grass, fragrant pennyroyal, bracken ferns and kindred plants make the road gay in early summer. Later, the many forms of sedges, grasses, tick-seeds, and compositæ interest the lover of plants. It is interesting to note the number of young trees of rock oak, red oak, tulip poplar, sassafras, mocker-nut, hickory and others which are springing up among the belt of blackberries skirting the road. Wagons passing at long intervals just manage to keep the track open and prevent the forest from reclaiming its own. The following is a select list of plants of this society:

Pteris aquilina,
Agrostis alba,
Danthonia spicata,
Panicum pubescens,
Panicum sphærocarpon,
Carex virescens,
Sisyrinchium graminoides,
Rubus Canadensis,
Rubus villosus,
Baptisia tinctoria,
Lespedeza hirta,
Ascyrum hypericoides,
Helianthemum majus,
Viola communis,
Viola dentata,
Viola emarginata,
Viola fimbriatula,
Viola sagitatta,
Viola villosa,
Chamænerion angutifolium,
Lysimachia nummularia,
Sabbatia angularis,
Pedicularis Canadensis,
Campanula rapunculoides,
Adopogon Virginicum,
Aster ericoides,
Aster lateriflorus,
Bidens comosa,
Eupatorium aromaticum,
Gnaphalium obtusifolium,
Hieracium Gronovii,
Hieracium scabrum,
Solidago bicolor,
Solidago nemoralis.

(*b*) The dry open woods contain a society of plants, some of which are frequently met with along the road. Huckleberry Hill, so named by me from the variety and abundance of these plants found there, may be taken as a type locality. The species of plants are few and comprise the following:

Carex nigro-marginata,
Scleria pauciflora,
Hypoxys hirsuta,
Pogonia verticillata,
Comptonia peregrina,
Quercus Marylandica,
Quercus minor,
Rubus hispidus,
Cracca Virginiana,
Linum striatum,
Linum Virginianum,
Gaylussacia resinosa,
Gaylussacia frondosa,
Vaccinium atrococcum,
Vaccinium vacillans,
Vaccinium stamineum,
Kalmia augustifolia,
Kalmia latifolia,
Dasystoma flava,
Gerardia tenuifolia,
Aster patens,
Aster undulatus,
Aster undulatus triangularis,
Chrysopsis mariana,
Sericocarpus asteroides.

(*c*) The weeds of the cultivated fields will form the basis of later study.

2. Shade or Forest Plants.—The woods of the hill consist principally of second-growth rock-chestnut oak, with a sprinkling of white and red oak. Beech trees are also quite numerous, and in the thicker portions are a few tulip trees conspicuous by their tall, straight, light-colored trunks. Along the outskirts are juniper, sassafras, white and shellbark hickory, cherries and dogwood.

The undergrowth consists of arrow-wood, young beeches and high bush huckleberries, while clambering up and over the trees are tangled masses of frost-grape and briar. At the highest point of the hill the woods have been cut over in recent years, hence the timber is very thin and averages about twelve feet in height. Further north, nearer the village, the timber is heavier and is at its best in the woods on the northeast side of the road. All these woods give shelter to herbaceous plants according to their density and depth of vegetable mould. The following plants, among others, may be found:

Adiantum pedatum,
Panicum Porterianum,
Smilax herbacea,
Polygonatum biflorum,
Cypripedium acaule,
Populus grandidentata,
Agrimonia hirsuta,
Aronia nigra,
Geranium maculatum,
Viola pubescens,
Viola sororia,
Sanicula Canadensis,
Deringa Canadensis,
Chimaphila maculata,
Chimaphila umbellata,
Pyrola rotundifolia,
Monotropa uniflora,
Hypopitys Hypopitys,
Pieris mariana,
Lycopus Virginicus,
Chelone glabra,
Galium triflorum,
Galium lanceolatum,
Viburnum acerifolium,
Aster divaricatus,
Aster Lowrieanus,
Aster Lowrieanus lancifolius,
Aster macrophyllus pinguifolius,
Nabalus trifoliatus.

3. Bog Plants.—This society of plants is very interesting, not in its size, but in its peculiar flora. The little bog of this region is in the centre of a three-acre field. The trees in it consist mainly of sweet bay, *Magnolia Virginiana*, willows and alders. The rills from the base of the hill all centre here. At different times in the year the following plants may be found in bloom:

Panicum sphagnicolum,
Panicum longifolium,
[1] *Agrostis altissima*,
Dulichium arundinaceum,
Eleocharis tuberculosa,
Rhyncospora alba,
Rhyncospora glomerata,
Eriophorum Virginianum,
Carex Atlantica,
[1] *Carex alata*,
Juncus marginatus,
Aletris farinosa,
Xyris flexuosa,
Pogonia ophioglossoides,
Limnodorum tuberosum,
Drosera rotundifolia,
Polygala cruciata,
Bartonia tenella,
Aster Novæ-Belgi,
Eupatorium verbenæfolium.

Some of the above plants are frequently met with in bogs here and there throughout the State, but almost all are common to the pine-barren regions of lower New Jersey. How they got into this little bog is an interesting question which is hard to solve.

[1] Collected by Mr. C. F. Saunders.

In addition to the above, the following plants are also found in this bog:

Paspalum læve,	*Viola primulæfolia,*
Carex interior,	*Oxypolis rigida,*
Scleria Torreyana,	*Gentiana saponaria,*
Juncus scirpoides,	*Asclepias rubra,*
Juncus dichotomus,	*Scutelaria integrifolia,*
Alsine uliginosa,	*Campanula aparinoides,*
Viola cucullata,	*Senecio balsamitæ,*
Viola blanda,	*Vernonia Noveæ-boracensis.*

The study of this flora has given rise to numerous questions regarding the origin and distribution of many species, some of which I shall endeavor to explain. The factors which influence the flora are soil, light, heat, water, wind, plants and animals.

(1) *Soil.*—The soil of this region, excepting the denser woods, is of a light brown or gray color, open and porous in texture and usually strewn on the surface with numerous pieces of the native rock. From its porous nature it cannot retain water, hence the plants have adapted themselves to this condition and usually have long roots. The absence of annuals in this region is striking. Out of a total of about 120 species, collected by me in 1899, but few were annuals. My collecting was confined mainly to those places where the indigenous flora is not influenced by the operations of man. Annuals are characterized by a fibrous root system, which is usually not very extensive. They are not, therefore, adapted for existence in this porous soil. Two of the annuals referred to, *Bidens comosa* and *Erechtites hieracifolia,* were collected along roadsides, where they were partially protected from the sun and received a fair share of moisture in the rich soil of such locations. Another annual, *Gerardia tenuifolia,* of the dry woods, has small and very narrow leaves, and is thus fitted for existence under these conditions.

(2) *Light and Heat.*—The effect of these two factors on the distribution of plants is very marked. The elevations in this limited area do not peceptibly influence the prevailing temperature; but as the amount of light regulates, to a greater or less extent, the degree of heat or temperature, we will consider the two together.

Light has a marked effect on the area and texture of leaves; while it reaches its minimum in dense woods, it attains its maximum in the open and exposed locations. Between these two extremes there are many variations and each has its peculiar plants. In the minimum condition—that is, in dense woods—plants are characterized by broad, thin leaves; for instance, note the leaves of May-apple, *Podophyllum peltatum;* Indian turnip, *Arisæma triphyllum; Panicum Porterianum; Aster Lowrieanus; Aster macrophyllus*, and others, and compare these with the same or allied species growing in the sunlight. The first two, May-apple and Indian turnip, decided woodland plants, when growing in the open where woods have been recently cut off, are smaller in height and area of leafage. In the sunlight the leaves of most grasses and sedges are narrow, many of them are erect or placed edgewise, so as to receive a minimum of light. *Aster ericoides, Solidago bicolor, Euthamia Caroliniana, Helianthemum majus*, and others have all comparatively small leaves. Leaves of many plants in sunlight have protective coverings of hair or scales to prevent a too rapid evaporation of moisture. Others, particularly plants belonging to the *Leguminosæ*, have the power of changing their position when the light is too strong. On a cloudy day such leaves assume the usual position, but if the day is bright and the sun strong they turn on edge, close up or turn directly away from the sun.

While we notice that plants in the shade develop large leaves and long stems and that those in the sun are retarded in their development, we also note a tendency toward an optimum condition. Shade plants along edge of woods or around clearings in dense forests develop to a remarkable degree and have a strong directive tendency toward the light. Sun plants, on the other hand, dispute the ground with them, and an intense struggle for supremacy takes place. This battle-ground of the plants is common along roads in wooded districts. It is in this disputed territory of intermingling individual plants that differentiation begins and gives place to a variety of forms of species. As we recede from it to either extreme of light we encounter the well-marked species, specialized for adaptation to their particular surroundings.

(3) *Water.*—Water or moisture considered as food of plants has an important bearing on the development of plant life. On

this ridge its presence is not at once very evident. Rock-chestnut oak, post oak, black oak and beech, trees of rocky, sterile regions, are everywhere found. We have reason to believe that much moisture ascends through the porous subsoil by capillarity, enough at least to reach the plants peculiar to this soil. The moisture necessary to support the woodland plants is conserved through the aid of the thick covering of vegetable mould.

No streams cross the ridge, but, as described above, many take their rise along its base. There is a little bog at the southern base of the hill at Willow Grove, where Terwood Run takes its rise. The moisture here seems to ooze out from the base of the sandstone on to the loamy soil of the flanking formation on the south.

In studying the plants of this bog, I have been impressed with the comparatively smaller area of the leafage, and have come to the conclusion that abundant moisture does not necessarily imply an increased growth of leaves. A glance at the accompanying table will show the striking difference in this respect between typical plants of the woods and those of the bog.

FOREST PLANTS.	CM.	SQ. CM.
Agrimonia hirsuta	7 x 3.5	24.5
Phryma Leptostachya ...	11 x 7	77
Viola pubescens	8 x 8	64
Galium triflorum	3.5 x 1	3.5
Chimaphila maculata ...	3 x 1.5	4.5
Pyrola rotundifolia	4.5 x 4.5	20.25
Galium lanceolatum	3.5 x 1.5	5.75
Aralia nudicaulis	13 x 7.5	97.5
Smilax herbacea	7 x 5	35
Deringa Canadensis	11 x 7	77
Sanicula Canadensis	7 x 3	21
Panicum Porterianum ..	8 x 2	16
Nabalus trifoliatus	10 x 7	70
Viburnum acerifolium ..	8 x 8	64
Lycopus Virginicus	8 x 3	24
Chelone glabra	9 x 3.5	31.5
Aster Lowrieanus	7 x 3.5	24.5
Aster macrophyllus	16 x 12	192
Podophyllum peltatum ...	15 x 10	150
Arisæma triphyllum	10 x 5	50
Sanguinaria Canadensis.	12 x 7	84
Total area		1136
Average of 21 species..		54.1

BOG PLANTS.	CM.	SQ. CM
Magnolia Virginiana ...	11 x 5	55
Dulichium arundinaceum	5 x .2	1
Aletris farinosa	13 x 1	13
Drosera rotundifolia	.5 x .4	2
Asclepias rubra	13 x 4.5	52.5
Scutellaria integrifolia ...	2.5 x .6	1.5
Campanula aparinoides .	2 x .5	1
Limnodorum tuberosum .	15 x .5	7.5
Oxypolis rigidus	4 x .3	1.2
Eupatorium verbenæfolium	7 x 2.5	17.5
Aster Novæ-Belgi	4 x .5	2
Polygala cruciata	2 x .3	.6
Gyrostachys cernua	15 x 1.5	22.5
Eriophorum Virginicum .	30 x .3	9
Scleria Torreyana	12 x .2	2.4
Xyris flexuosa	21 x .1	2.1
Panicum sphagnicolum .	4 x .4	1.6
Rhyncospora glomerata ..	12 x .1	1.2
Eleocharis tuberculosa ...	10 x .02	.2
Gentiana saponaria	4 x 1	4
Alsine uliginosa	1 x .4	.4
Total area		198.2
Average of 21 species ..		9.4

In making these measurements, I took the average-sized leaf—in the case of pinnate leaves, one leaflet—and multiplied its length by its breadth in centimeters. The result, though not the exact area of the leaf, is approximate enough to show comparative values.

The average area of the leaves of the swamp plant is 9.4 sq. cm., while that of the forest plant is 54.1 sq. cm., or a ratio of nearly 1 to 6.

Conversely, this also proves that the large leaves of the woodland plants are the result of a lack of light, as noted above, and not a lack of moisture, since this element is usually present in such localities.

It can also be shown by comparing typical bog plants with typical dry-soil plants, that the size of the leaves is not dependent upon the amount of moisture.

Here are a few plants of each class:

Bog Plants (Hyprophytes).	Dry-Soil Plants (Xerophytes).
Pogonia ophioglossoides,	*Pogonia verticillata,*
Panicum sphagnicolum,	*Panicum nitidum,*
Scleria Torreyana,	*Scleria pauciflora,*
Aster Novæ-Belgi,	*Aster ericoides,*
Juncus marginatus,	*Juncus buffonius,*
Viola cucullata,	*Viola communis,*
Asclepias rubra,	*Asclepias syriacus,*
Carex interior.	*Carex virescens.*

There is practically no difference in the size or structure of the leaves of the two groups. Many other plants of either group not related to each other might be quoted as having features common to both, but I have only chosen in the above list the allied species. As a rule, the root system of the bog plant is extensive, but it is not more so than that of the dry-soil plant. The roots of the dry-ground plants have further and deeper to go in order to get sufficient moisture, hence their system is more extensive and much greater than that of the bog plant. A familiar instance of this outside of the region under discussion is that of the root systems of the sand-binding plants of the coast sand dunes, plants which live under rigorous xerophytic conditions.

This difference of root systems constitutes the only difference between the bog plants and the dry-soil plants of the Willow Grove hill. In the first, the food is abundant and close at hand, and the system compact; in the other, the food is scarce, and the system extended. I have therefore concluded that the swamp plants are nothing more or less than xerophytes in moist surroundings, or *vice versa*.

(4) *Wind.*—Wind is an important factor in distributing plants. Seeds of many of the plants of this region are provided with wings or hairs by means of which they are blown considerable distances.

(5) *Plants.*—The rich vegetable mould of the woods and other places support plants which cannot exist where this factor is absent. In the woods north of the road on top of the Willow Grove hill, the vegetation is well developed. In the deeper recesses may be found the colorless and leafless saprophytes, *Monotropa uniflora, Hypopitys Hypopitys, Aphyllon uniflora* and *Leptamnium Virginianum,* also the plants in table above. The change of this flora as a result of the removal of vegetable mould may be seen a little southeast of the above point on Huckleberry Hill. Here the woods have been cut off, the slope is steep and the elements have done their work too well. Vegetation is scant, and stunted second-growth trees and shrubs give but little shade to the few clumps of wiry grasses, sedges, huckleberries and a few other flowering plants. Sphagnum moss in the bog supports small plants like *Drosera rotundifolia* and *Polygala cruciata.*

(6) *Animals.*—The distribution of plants is effected by insects in aiding cross-fertilization and by birds, squirrels and other animals in distributing seeds selected as food.

A summary of my observations shows that there is a distinct ridge having a peculiar geological structure and a flora different from that of the surrounding country; that perennials as a rule are only fitted to exist in the porous soil; that the large thin leaves of the wood plants are the result of a lack of light and not of nourishment; that variation of species commences in the optimum condition of light, and that the distinct forms are found in the extremes of this element; that the abundant moisture of the bog does not tend to develop much vegetable growth, and that the difference of structure of swamp plants and dry-soil plants is slight or none at all; that all the factors of soil, light, heat, water, wind, plants and animals regulate the distribution of the plants into three well-marked societies, the first two depending on the amount of light and the third on the amount of available moisture.

SEPTEBMER 4.

Mr. CHARLES MORRIS in the Chair.

Seven persons present.

Papers under the following titles were presented for publication:

"Contributions to the Ichthyology of the Tropical Pacific," by Henry W. Fowler.

"Sonorella, a New Genus of Helices," by Henry A. Pilsbry.

SEPTEMBER 11.

Mr. BENJAMIN SMITH LYMAN in the Chair.

Six persons present.

A paper entitled "The Genesis of Mid-Pacific Faunas," by Henry A. Pilsbry, was presented for publication.

SEPTEMBER 18.

Mr. CHARLES MORRIS in the Chair.

Ten persons present.

A paper entitled "A Partial Revision of the Pupæ of the United States," by Henry A. Pilsbry and Edward G. Vanatta, was presented for publication.

SEPTEMBER 25.

The President, SAMUEL G. DIXON, M.D., in the Chair.

Fifteen persons present.

Papers under the following titles were presented for publication:

"Note on Some Post-Larval Changes in the Vertebral Articulations of Spelerpes and Other Salamanders," by J. Percy Moore.

"An Ecological Study of the New Jersey Strand Flora," by John W. Harshberger, Ph.D.

The following were elected members:

Charles B. Lamborn, Lowndes Taylor, Helen Taylor and Emily Hinds Thomas.

The following were ordered to be printed:

CONTRIBUTIONS TO THE ICHTHYOLOGY OF THE TROPICAL PACIFIC.

BY HENRY W. FOWLER.

I. THE SANDWICH ISLANDS.

Among the more important collections of fishes presented to the Academy of Natural Sciences of Philadelphia during the earlier days of its existence, was one made by the celebrated naturalist and traveller, Dr. John K. Townsend, in the tropical Pacific.

In the year 1834 it seems that an expedition was formed under the auspices of a Captain Wyeth, who intended to travel over the United States to establish trading posts along the Pacific coast. Dr. Townsend joined the expedition at the suggestion of Mr. Thomas Nuttall, the distinguished botanist, who was also a member of the party. After proceeding to Fort Vancouver, they embarked for the Sandwich Islands, arriving in Honolulu, January 5th, 1835, and after visiting the various islands returned to the Columbia river in April. On the first of October, 1835, Nuttall left Townsend, who remained in the West till November, 1836, when he again left the Columbia for the Sandwich Islands, making Oahu in December, and after making a second tour of the islands, he proceeded to Tahiti.

For detailed information concerning the route, reference should be made to the account which he published in 1839, entitled "Narrative of a Journey across the Rocky Mountains to the Columbia River, and a visit to the Sandwich Islands, Chili, etc."

Subsequently Dr. William H. Jones, of the United States Navy, was enabled to make collections in various branches of zoölogy while in the tropical Pacific, among which was one of fishes, which has found its way into the Academy.

Dr. Benjamin Sharp, who visited the Sandwich Islands in 1893, made collections, mostly of invertebrates, among which was a small collection of fishes which he purchased in the markets of Honolulu during October or November.

All the specimens are alcoholic, except a number in the Townsend and Nuttall collections which are dry preparations.

LEPTOCEPHALIDÆ.

1. **Leptocephalus** sp.?

No. 1,042. Thomas Nuttall. A larval specimen.

OPHICHTHYIDÆ.

2. **Leiuranus semicinctus** (Lay and Bennett).

Ophisurus semicinctus Lay and Bennett, Zool. Capt. Beechey's Voyage, 1839, p. 66, Pl. XX, fig. 4.

Nos. 16,477 and 16,478.

3. **Myrichthys magnificus** (Abbott). Plate XVIII, fig. 3.

Pisoödonophis magnifica Abbott, Proc. Acad. Nat. Sci. Phila., 1860, p. 476.

Nos. 1,013 and 1,014. Dr. J. K. Townsend.

Types of Abbott's *Pisoödonophis magnifica.*

MURÆNIDÆ.

4. **Lycodontis eurosta** (Abbott). Plate XVIII, fig. 4.

Thyrsoidea eurosta Abbott, Proc. Acad. Nat. Sci. Phila., 1860, p. 478.

No. 984. Dr. J. K. Townsend.

Type of Abbott's *Thyrsoidea eurosta.*

5. **Lycodontis acutirostris** (Abbott). Plate XVIII, fig. 5.

Muræna acutirostris Abbott, Proc. Acad. Nat. Sci. Phila., 1860, p. 476.

No. 998. Dr. J. K. Townsend.

Type of *Muræna acutirostris* Abbott.

6. **Lycodontis kaupi** (Abbott). Plate XVIII, fig. 6.

Thyrsoidea Kaupii Abbott, Proc. Acad. Nat. Sci. Phila., 1860, p. 477.

No. 916. Dr. J. K. Townsend.

Type of *Thyrsoidea Kaupii* Abbott.

7. **Lycodontis pseudothyrsoidea** (Bleeker).

Muræna pseudothyrsoidea Bleeker, Natuurk, Tijdsch. voor Nederl. Indie, Jaarg. III, 1852, p. 778.

No. 996. Dr. J. K. Townsend.

No. 16,476. Dr. W. H. Jones.

8. **Lycodontis parvibranchialis** sp. nov. Plate XVIII, fig. 1.

No. 16,483. Type.

The form of the body is elongate and compressed, and resembles that of the preceding species. Mouth closing, but when closed the lips do not conceal the sharp teeth completely, as some of these are always visible laterally; lateral teeth of the upper jaw in 2 rows till posterior to the eyes at least, those in the inner row somewhat the larger and occasionally a canine-like form is assumed; about 9 large, fang-like teeth in the anterior portion of the upper jaw, which has but 1 row of bordering teeth; the teeth in the lower jaw in 2 rows which are close together and rather irregular; this is the case in the upper jaw directly below the eye, and there are also enlarged fang-like teeth in the anterior part of the mandible like those above, vomerine teeth in a single series, the median being slightly larger than the others. The neck has the swollen appearance of most of the Morays, and is thicker than the body. The branchial apertures, which are very small, inconspicuous, and which might easily be overlooked, have the cleft of the mouth contained in the space between themselves and the tip of the snout about 3 times. The eyes are rather large, contained in the snout more than once their diameter, situated laterally, directly above the jaws, and nearly midway between the tip of the snout and the corners of the mouth. The anterior nostrils are placed in fleshy tubes, the posterior pair are situated in the antero-interorbital space, and midway between the eyes and the tip of the snout are also a pair of nostril-like pores. The depth of the head in the ocular region is greater than its width in the same region, its general shape is moderately attenuated and compressed laterally. The interorbital space is about equal to the diameter of the eye and is nearly level. The D., whose origin is at a point anterior to the branchial aperture, though not median in position in the space between the latter point and the corner of the mouth, is of moderate height and, like the A., is continuous with the caudal. The P. are absent. The vent is situated about an eye-diameter in advance of the origin of the A. Lateral line absent. The general color of the body is a dark, rich brown, variegated with about 4 rows of longitudinal whitish spots, all of which are not larger than the pupil of the eye. The space intervening between the whitish spots is marked with blackish blotches of a similar size as the white ones, but not so sharply defined.

One small specimen.

9. Echidna zonata sp. nov. Plate XVIII, fig. 2.

No. 16,484. Type.

Form of the body elongate, compressed, especially the caudal region. The branchial aperture about equal to the eye, and with the cleft of the mouth contained in the space between the foremost point and the tip of the snout 3 times. The snout is bluntly obtuse, though slightly compressed laterally, and it projects beyond the lower jaw. Eyes placed directly above the mouth, laterally, and slightly posterior to its centre, so that they are contained in the snout at least $1\frac{1}{2}$ times. Anterior nares in tubes near the tip of the snout, posterior nares situated superior to the eye and in the interorbital space, and with the nostril-like pores as in the preceding species. The eyes are covered with thin skin, and are not equal to the interorbital space which is convex. Teeth obtuse, molar like, in 2 series laterally in the lower jaw; anterior teeth in both jaws enlarged, vomerine teeth in a single series. Mouth capable of being completely closed, so that no teeth are then visible. Neck not much greater in depth than the rest of the body. There are no P. Origin of the D. midway between the tip of the snout and the branchial aperture, the fin itself of moderate height, and like the A., confluent with the caudal. Anus midway in the ventral region of the body and directly in front of the origin of the A. The general color of the body is a very pale brownish-white, pure white on both jaws anterior to the eyes and the extremity of the caudal. Upon the light ground color of the body are large, rich umber blotches, which are clearly and evenly defined and which extend upon the D. and A. fins, but do not cross the abdominal region. Length about 5 inches.

10. Echidna polyzona (Richardson).

Muræna polyzona Richardson, Zool. Voy. Sulphur; Ichth., I, 1844, p. 112, Pl. LV, figs. 11 and 12.

No. 16,485.

Head anterior to the eyes, white. On the anterior half of the body the white rings which encircle the trunk widen considerably, and all the region anterior to the vent is whitish; there are 27 white rings, if the snout and tip of the caudal are counted. The tail is a little longer than the body.

ELOPIDÆ.

11. Elops saurus Linnæus.

Elops saurus Linnæus, Syst. Nat., Ed. XII, 1766, p. 518.

No. 1,181. Dr. W. H. Jones.

ENGRAULIDIDÆ.

12. Stolephorus purpureus sp. nov. Plate XIX, fig. 1.

Nos. 23,329 and 23,330. Types. Dr. W. H. Jones.

This species is close to the *Stolephorus ischanus* of Jordan and Gilbert.

Form of the body elongate and compressed, the greatest depth of the body contained in its length without the caudal nearly 6 times and the head in the same $3\frac{1}{2}$ times. Head laterally compressed. Eyes lateral, anterior to the centre of the head, in which they are contained $3\frac{1}{2}$ times, and about equal to the snout. Mouth large, the maxillaries with their distal portion produced backwards beyond the posterior margin of the eye equal to an eye diameter and with their lower edges with minute teeth. Teeth in the lower jaw. Gill-rakers numerous. The D. is inserted a little behind the base of the V., and nearer the tip of the snout than the tip of the caudal or as in *Stolephorus ischanus* midway between the anterior margin of the eye and the base of the caudal. Radii of D. 11 and 15; of A. 13 ? and 16. The origin of the A. is at a point posterior to the base of the last D. ray. The P. are short but reach beyond the centre of the space between their bases and the bases of the V. Scales apparently not firm or closely adhering to the body, very few remaining on these examples. A broad silvery lateral bar from the upper part of the head passes to the caudal and widens posteriorly as in *Stolephorus commersonianus* Lacépède. Color of the head silvery and the silvery lateral band and remaining scales shot with delicate purple. The caudal is faintly spotted with brownish dots. Total length of both specimens about $2\frac{3}{8}$ inches.

SYNODONTIDÆ.

13. Synodus sharpi sp. nov. Plate XIX, fig. 2.

Nos. 16,084 to 16,086. Types. Dr. W. H. Jones.

This species is near *Synodus evermanni* of Jordan and Bollman. Form of the body elongate, the depth contained in the total length without the caudal $6\frac{2}{3}$ to 7 times, and the head in the same about 4 times. Head blunt, strongly compressed above and with the interorbital space concave and equal to the diameter of the eye. Eyes superior and anterior in the head in which they are contained $4\frac{1}{2}$ to 5 times. The nares are placed about midway between the tip of the snout and the anterior margin of the eye, the snout itself greater than the eye. Jaws equal, the teeth large and the space between the tip of the snout and the posterior extremity of the maxillary about $\frac{2}{3}$ the length of the head. The P. short, rounded and not equal to $\frac{1}{2}$ the length of the head. The V. large, radii 10, inserted anterior to the tip of the P., the innermost rays the longest, and when depressed reaching beyond the base of the last D. ray. Origin of the D. more posterior to the tips of the P. than the origins of the V. are anterior, the anterior rays of the fin reaching the tips of the posterior when depressed, the radii 10, and the origin also nearer the adipose fin than the tip of the snout. The origin of the A. nearer the origin of the V. than the tip of the caudal. Radii of A. 9, without the first rudiment. Base of the V. with a long flap. Caudal forked and with acute points. Lateral line distinct, straight, but without any distinct keel. Scales about 52. The general color is brownish, darker above, and spotted or indistinctly marbled with darker brown. Along the sides are **9** large, well-defined dark brown blotches which are disposed at regular intervals. All the fins and also the mandible are barred with brown. Total length of the specimens $3\frac{3}{16}$, $2\frac{1}{2}$ and $1\frac{15}{16}$ inches.

Named for Dr. Benjamin Sharp.

14. Saurida tumbil (Bloch).

Salmo tumbil Bloch, Ichthyologie, Vol. 4. pt. 11, 1797, p. 100, Pl. 430.

Nos. 7,956 and 7,957. Dr. J. K. Townsend.

MYCTOPHIDÆ.

15. Rhinoscopelus coruscans (Richardson).

Myctophum coruscans Richardson, Voyage of the Erebus and Terror; Ichth., 1844–48, p. 40, Pl. 27, figs. 1, 2, 3 and 4.

Nos. 7,972 to 7,975. Near the Sandwich Islands. Dr. W. H. Jones.

16. Myctophum sp.?

No. 14,897. Lat. 21° N.?, Long. 151° W. Dr. W. H. Jones.

HEMIRAMPHIDÆ.

17. Hyporhamphus sp.?

Nos. 7,507 and 23,338. Near the Sandwich Islands. Dr. W. H. Jones.

18. Hemiramphus depauperatus Lay and Bennett. Plate XIX, fig. 3.

Hemirhamphus depauperatus Lay and Bennett, Zool. Capt. Beechey's Voyage, 1839, p. 66.

Nos. 7,530 to 7,532. Thomas Nuttall and Dr. J. K. Townsend.

Form of the body elongate, strongly compressed, the greatest depth contained in the total without the beak and caudal $7\frac{1}{3}$ to $7\frac{1}{2}$ times, and the head including the beak is contained in the entire length of the fish not 3 times. The greatest depth of the head which is in the occipital region is about $\frac{1}{2}$ its length without the beak, and the latter equals about $\frac{3}{4}$ the length of the projecting beak. The eye is situated in the upper anterior part of the head and is contained in the space between its anterior margin and the tip of the upper jaw $1\frac{1}{2}$ times, in the length of the head from the latter point to the margin of the opercles 4 times, in the greatest depth of the head about twice, and once in the flat interorbital space. In all these measurements of the eye the eye is measured horizontally, as its shape is that of a somewhat contracted ellipse, and the pupil is also the same shape, and larger than the nasal aperture, which is placed anterior to the eye and superior in position. The internasal region is equal to the vertical diameter of the eye. The rostral flap is produced considerably anterior to the tip of the upper jaw. Gill-rakers numerous, strong, the longest about equal to the pupil of the eye, but the last are not as large as the others. Branchiostegal radii about 12, and in all the examples those on the left ceratohyal overlap those on the right. Top of the head with pores and somewhat laterally and above the præoperculum rugose tracts are seen. Origin of the P. superior, on a level with the upper margin of the eye, and but little behind the posterior margin of the branchial-aperture, about equal to the head in length (without beak), and much longer than the base of the D., its length contained in the space between its origin and that of the V. twice. Radii of P. I. 10. The origins of the V. nearer the tip of the P. than the base of the caudal and nearer the latter than the branchial-aperture, before the origin of the D. and reaching more than half-way in the space between their own bases and that of the A. Radii of V. 6, rather short and flattened, and the innermost the strongest. Nearly $\frac{1}{3}$ of the D. is anterior to the origin of the A., whose base is about $\frac{2}{3}$ the length of that of the D. The radii of the D. differ from the number given by Lay and Bennett, as there are 14 in all 3 of these examples, and there are also a few small scales at the bases of several of the foremost. As most of the rays of the fins have been more or less damaged, it is not possible to give a comparison of the length of the rays of the D., yet I do not think that the second, if any longer at all than the third, was very much so, and in 2 of the examples the last ray, which is better preserved than some of the others, is longer than the shorter rays of the fin and which immediately precede it. The radii of the A. vary from 12 to 14, the first the shortest, and the second and third the longest. Caudal deeply forked, the lower lobe the longest and the rays strengthened as in many of the other species. The rudimentary caudal rays are flattened and the lower are much larger than the upper. Lateral line present, running inferiorly along the ventral region to the lower rays of the caudal and its course traversing about 60 scales. As so many of the scales have been lost and the specimens have been in alcohol so many years, any traces of the color in life would naturally be supposed to have disappeared, yet there is a bright silvery lustre about the head, and the eyes are yellowish. Total length 13¾ inches, the beak measuring mostly 2½ inches.

EXOCŒTIDÆ.

19. Parexocœtus mesogaster (Bloch).

Exocœtus mesogaster Bloch, Ichthyologie, Vol. 4, pt. 12, 1797, p. 12, Pl. 399.

No. 7,482. Dr. J. K. Townsend.

20. Exocœtus volitans Linnæus.

Exocœtus volitans Linnæus, Syst. Nat., Ed. X, 1758, p. 316.

No. 7,457. Dr. W. H. Jones.

AULOSTOMIDÆ.

21. Aulostomus chinensis (Linnæus).

Fistularia chinensis Linnæus, Syst. Nat., Ed. XII, 1766, p. 515.

No. 9,763. Oahu. Dr. W. H. Jones.

MUGILIDÆ.

22. Mugil kelaartii Günther.

Mugil kelaartii Günther, Cat. Fish, Brit. Mus., III, 1861, p. 429.

Nos. 9,804 and 9,805. Dr. W. H. Jones.

Scales about 33; D. VI, I, 8; A. III, 9; P. extending to the eleventh scale of the lateral line and to the origin of the D. and shorter than the head; base of the A. not quite as long as the longest D. ray, both fins scaly; 19 scales between the tip of the snout and the origin of the D.; adipose eyelids broad, and the maxillary is entirely hidden; caudal emarginate and scaly; total length 7 to $7\frac{1}{16}$ inches.

SPHYRÆNIDÆ.

23. **Sphyræna commersonii** Cuvier and Valenciennes.

Sphyræna Commersonii Cuvier and Valenciennes, Hist. Nat. Poiss., III, 1829, p. 260.

No. 11,459. Dr. W. H. Jones.

POLYNEMIDÆ.

24. **Polydactylus pfeifferi** (Bleeker).

Polynemus Pfeifferi Bleeker, Natuurk. Tijdsch. voor Nederl. Indie, Deel IV, (New Series I) 1853, p. 249.

Nos. 11,504 to 11,507. Dr. W. H. Jones.

HOLOCENTRIDÆ.

25. **Myripristis murdjan** (Forskål).

Sciæna murdjan Forskål, Descript. Animal., 1775, p. 48.

No. 17,122. (Dried skin.) Dr. J. K. Townsend.

No. 22,947. Honolulu. Dr. Benjamin Sharp.

26. **Holocentrus diadema** Lacépède.

Holocentrus diadema Lacépède, Hist. Nat. Poiss., III, 1801, Pl. 32, fig. 4; IV, 1801, pp. 372 and 374.

No. 17,125. (Dried skin.) Dr. J. K. Townsend.

27. **Holocentrus diploxiphus** Günther.

Holocentrum diploxiphus Günther, Proc. Zool. Soc. London, 1871, p. 660.

Nos. 17,124 and 17,126. (Dried skins.) Dr. J. K. Townsend.

CARANGIDÆ.

28. **Trachurops crumenophthalmus** (Bloch).

Scomber crumenophthalmus Bloch, Ichthyologie, Vol. 4, pt. 10, 1797, p. 65, Pl. 343.

Nos. 11,280 and 11,281. Dr. W. H. Jones.

29. **Caranx latus** Agassiz.

Caranx latus Agassiz, Genera et species Pisci. Brasiliam, 1829, p. 105, tab. LVI*b*., fig. 1.

Nos. 22,948 and 22,949. Honolulu. Dr. Benjamin Sharp.

EQUULIDÆ.

30. **Equula** sp.?

No. 15,231. Dr. W. H. Jones.

KUHLIDÆ.

31. **Kuhlia malo** (Cuvier and Valenciennes).

Dules malo Cuvier and Valenciennes, Hist. Nat. Poiss., VII, 1831, p. 360.

No. 17,099. (Dried skin.) Dr. J. K. Townsend.
Nos. 22,922 and 22,923. Dr. Benjamin Sharp.

CHEILODIPTERIDÆ.

32. **Apogon** sp.?

Nos. 13,434 to 13,437. Dr. J. K. Townsend.

SERRANIDÆ.

33. **Epinephelus fuscoguttatus** (Forskål).

Perca summara, var. *Fusco-guttata*, Forskål, Descript. Animal, 1775, p. 42.

No. 13,463. Dr. J. K. Townsend.

LUTIANIDÆ.

34. **Aprion microlepis** (Bleeker).

Chætopterus microlepis Bleeker, Versl. Mededeel. Konink. Akad. Wetensch., Tweede Reeks, Derde Deel, 1869, p. 80.

No. 13,290. Dr. J. K. Townsend.

SPARIDÆ.

35. **Sparosomus unicolor** (Quoy and Gaimard).

Chrysophrys unicolor Quoy and Gaimard, Voyage de l'Uranie, Zool., 1824, p. 299.

No. 12,326. Dr. J. K. Townsend.

CIRRHITIDÆ.

36. **Cirrhites forsteri** (Bloch and Schneider).

Grammistes Forsteri Bloch and Schneider, Syst. Ichth., 1801, p. 191.

No. 12,220. Dr. J. K. Townsend.
No. 17,253. (Dried skin.) Thomas Nuttall.
No. 17,254. (Dried skin.) Dr. J. K. Townsend.
Nos. 22,944 to 22,946. Honolulu. Dr. Benjamin Sharp.

POMACENTRIDÆ.

37. Tetradrachmum trimaculatum (Rüppell).

Pomacentrus trimaculatus Rüppell, Atlas zu der Reise im Nördl. Afrika, 1828, p. 39, taf. 8, fig. 3.

Nos. 9,615 to 9,618. Thomas Nuttall.

No. 9,619. Oahu. Dr. W. H. Jones.

38. Eupomacentrus nigricans (Lacépède).

Holocentrus nigricans Lacépède, Hist. Nat. Poiss., IV, 1801, pp. 332, 367 and 370.

Nos. 9,661 and 9,662. Oahu. Dr. W. H. Jones.

Form of the body short, much compressed, and the greatest depth contained in the total length, without caudal, about $1\frac{1}{4}$ times. The head is small, contained in the body, without caudal, $3\frac{4}{7}$ times and in the greatest depth of the body a little over twice. Eye placed superior and anterior to the centre of the head in which it is contained 3 times. The eye is also a little smaller than the interorbital space, which is strongly convex and contained itself $2\frac{4}{5}$ times in the head. Nostrils placed anterior to the eye to which they are nearer than the tip of the snout, though they are a little below the level of the pupil. The orbitals are broad, though none attain a breadth equal to the diameter of the eye, those situated postero-inferiorly with the lower margin with very distinct denticulations and equal to at least $\frac{2}{3}$ the breadth of the præorbitals. Lips and jaws naked, without any scales. Mouth small, reaching as far as the anterior margin of the eye. Teeth compressed and in a single band-like series. The præoperculum slopes forward, the posterior margin denticulate and the lower margin smooth, and the angle would be formed anterior to the posterior margin of the eye in the vertical and also a little below the base of the uppermost P. rays. The operculum is furnished superiorly with 2 small spinous processes along the posterior edge. The profile-line of the head from the snout to the origin of the D. is convex, though compressed in the occipital region. The origin of the D. is at a point directly over that of the P. and both are posterior to the posterior opercular margins; radii XIII, 17, the median branched rays produced, much higher than the spinous part of the fin, the base of the posterior ray more posterior in position than the same of the A. and with the result that the tip of the former approaches nearer the tip of the caudal than the latter. Upper part of the base of the P. nearly level with the mouth, radii 20, not extending so far posteriorly as the V. and about equal to the length of the head. Origin of the V. posterior to the same of the P., radii I, 5, and the first ray with a filament-like point which reaches the anus. Origin of the A. below that of the soft D., radii II, 14, the soft part of the fin similar to the soft D., and the first spine greatly inferior to the second in size. Body covered with scales, except the lips, jaws and the edges of the D., A. and caudal, and also the greater part of the P. and all of the V. The P. without scaly flap, though several of the scales above its base are enlarged, and the scales on the base of the fin itself minute. The V. are furnished with scaly flaps and there is also one between their bases. The scales along the base of the unpaired fins, with the exception of those at the base of the spinous D., which are as large as those on the sides of the body, are all very small and extend over the greater part of the fins. There is a line of demarcation between the bases of these fins showing where the fin-rays articulate with the interneural and interhæmal spines. Caudal deeply emarginate and the upper lobe a little longer than the lower. The lateral line is strongly arched and not extending as far posteriorly as the last A. ray. Scales about 32, tubes 20. The caudal peduncle is rather strong and much compressed, and its depth is more than ½ the length of the head. In alcohol these specimens are dark brownish with the bases of the soft D. and A., and also the caudal, spotted. The P. shows faint traces of spots or blotches. Entire length about 4¼ inches.

39. Abudefduf sordidus (Forskål).

Chætodon sordidus Forskål, Descript. Animal., 1775, p. 62.

No. 9,606. Dr. J. K. Townsend.

No. 9,613. Oahu. Dr. W. H. Jones.

No. 17,214. (Dried skin.) Dr. J. K. Townsend.

40. Abudefduf sexfasciatus (Lacépède).

Labrus sexfasciatus Lacépède, Hist. Nat. Poiss., III, 1801, pp. 430 and 477, Pl. 19, fig. 2.

Nos. 9,604 and 9,605. Dr. J. K. Townsend.

No. 15,228. Oahu. Dr. W. H. Jones.

41. Abudefduf limbatus (Cuvier and Valenciennes).

Glyphisodon limbatus Cuvier and Valenciennes, Hist. Nat. Poiss., V, 1830, p. 357.

No. 17,215. (Dry skin.) Dr. J. K. Townsend.

The form of the body somewhat ellipsoid, compressed, the snout not conspicuously or abruptly blunt and with the greatest depth of the body contained in its length without the caudal twice. The head is contained in the body without caudal $3\frac{8}{15}$ times, and the head is about equal to $\frac{1}{2}$ the greatest depth of the body. The eye is superior and anterior in position, a little over 3 in the head and its diameter greater than the snout. Nostril very near the front margin of the eye and slightly inferior to its centre. Orbitals broad, none equal to the eye, the anterior the deepest and about equal to $\frac{2}{3}$ the eye and the margin of the præoperculum is distant from the posterior margin of the eye about the same. Mouth small, most likely reaching to the front of the eye when closed. The orbitals are furnished with a single series of scales below the eyes, but they do not reach as far as the anterior margin of the eye. The margin of the præoperculum is inclined forwards and the angle would form below the posterior margin of the eye in the vertical. There are four series of scales on the cheeks. The snout, lips and chin are naked. Teeth long, narrow, in a single series and with the apical portion slightly serrate. Origins of both the V. and P. in advance of the D., the former furnished with a scaly flap and the P. with the scales enlarged above its base. The basal third of the P. covered with minute scales, the radii of the fin about 20, the radii of the V. I, 4, the first soft ray produced (the tip of which is broken) and reaching for about $\frac{2}{3}$ the distance from its base to the origin of the A., and entirely destitute of scales. The spinous D. much longer than the soft D., but not equal to the latter in height, radii XII, 18, the first spine the shortest, the next longer and all the rest still longer and about equal. The base of the D. is covered with scales, those on the spinous D. larger and entirely covering the basal half of that portion of the fin, while those on the soft D. are rather minute. Origin of the A. below the last D. spine, radii II, 13, the soft part of the fin similar to the soft D. and also covered with minute scales though there are some large ones anteriorly. Caudal peduncle broad and compressed. Last ray of D. not reaching as far posteriorly as the last A. ray. Caudal deeply emarginate, the upper lobe the longest and the basal part covered with minute scales. Lateral line not parallel with the dorsal outline of the back, puncturing 21 scales and stopping considerably short of the terminal branched D. rays in the vertical. Scales, about 30, in a lateral series to the base of the caudal, and 3 scales between the lateral line and the profile-line of the back at the articulations of the interneural and D. rays. Total length $4\frac{1}{2}$ inches.

LABRIDÆ.

42. Anampses cæruleopunctatus Rüppell.

Anampses cæruleopunctatus Rüppell, Atlas zu der Reise im Nördl. Afrika, 1828, p. 42, taf. 10, fig. 1.

Nos. 9,622 and 9,623. Dr. J. K. Townsend.

43. Anampses cuvieri Quoy and Gaimard.

Anampses Cuvier Quoy and Gaimard, Voyage de l'Uranie, Zool., 1824, p. 276, Pl. 55, fig. 1.

No. 9,624. Dr. J. K. Townsend.

Nos. 17,197, 17,198 and 17,212. (Dried skins.) Dr. J. K. Townsend.

Form of the body oblong, compressed, the greatest depth contained in the total length exclusive of the caudal about $2\frac{4}{7}$ times and the head in the same, excluding the opercular flap $3\frac{1}{2}$ times. The head has a rhomboid appearance, due to the produced opercular flap which is not as long as the diameter of the eye. The eye is situated in the upper anterior part of the head in which it is contained, exclusive of the opercular flap, a trifle over 4 times, in the snout about $1\frac{1}{2}$ times, and in the interorbital space the same. The angle formed by the snout would not be a right one. The upper profile is concave in front of the interorbital space, then straight to the occiput after which it is convex to the origin of the D. The nostrils are placed anterior to the eye and not an eye diameter distant, the anterior a little lower than the posterior pair which are placed about midway in the space between the anterior pair and the anterior margin of the eye. The præorbital greater than the diameter of the eye, and the infraorbitals barely $\frac{1}{2}$ the diameter of the eye, both are unevenly striated. Mouth protractile, capable of considerable distension, furnished with 4 conspicuous projecting compressed teeth which are turned forwards and provided with a grinding edge; there are two teeth in each jaw, the lower pair are closer together than the upper and fit in between the latter when the jaws are closed. The corners of the closed mouth fall a little posterior to the anterior nostrils in the vertical. The lips are well developed and fleshy. The præoperculum, operculum, suboperculum and the interoperculum striated. The entire head is naked, the snout, interorbital and cranial regions have the skin finely roughened, the cheeks smooth. The angle of the præoperculum, which would be an obtuse one, falls below the posterior margin of the eye. Branchial aperture moderate, gill-membranes united to the isthmus, gill-slits small and the gill-rakers also small and short. Pseudobranchiæ developed. Origin of the D. in advance of that of the P., which is in advance of the origin of the V., about over the posterior margin of the operculum (the flap excluded). The D. spines are firm, the first the shortest, the next larger, and the third longer and together with the others about equal, though none are as high as the highest soft rays. The P. shorter than the head, though longer than the V., which are attenuated, having their first rays reaching the anus, and they have the basal portion of the innermost ray connected with the body by a membrane. The origin of the A. falls below the first ray of the soft D., and also the tip of the P. which reaches that far posteriorly. The A. spines are much shorter than any of the rays of the fin, and they are graduated from the first, which is the smallest, to the third. The soft A. rays of nearly equal height, though the terminal one is the shortest and not situated as far posteriorly as the last soft D. ray, yet both reach the base of the caudal. No scales along the bases of any of the fins except some at the base of the caudal, which are very fine. The lateral line is not absolutely parallel with the dorsal outline of the back, traversing about 20 scales in the form of single tubes, when it decurves and runs along the sides of the caudal peduncle to the base of the caudal. Each scale is furnished with a small rounded whitish spot. The D. and A., together with the head, are also furnished with similar spots, and on the former there are several longitudinal lines. All the spots of the dorsal region of the body much smaller than those on the sides and the scales being also smaller they appear to form longitudinal bands. The measurements, fin formulæ, scales, etc., as follows:

	No. 9,624.	No. 17,197.	No. 17,198.	No. 17,212.
Total length..........	$5\frac{15}{16}$ in.	$4\frac{7}{16}$ in.	$7\frac{3}{8}$ in.	$8\frac{1}{2}$ in.
Scales	29?	29	27	28
Radii of D.	IX, 12	IX, 12	IX, 12	IX, 12
Radii of A.	III, 12	III, 12	III, 12	III, 12
Radii of P.	I, 12	I, 12	I, 12	I, 12
Radii of V.	5	5	5	5

44. Stethojulis albovittata (Lacépède).

Labrus albovittatus Lacépède, Hist. Nat. Poiss., III, 1801, pp. 443 and 509.

Nos. 9,415 and 9,418. Dr. J. K. Townsend.

45. Stethojulis axillaris (Quoy and Gaimard).

Julis axillaris Quoy and Gaimard, Voyage de l'Uranie, Zool., 1824, p. 272.

Nos. 9,407 to 9,414. Oahu. Dr. W. H. Jones.

Nos. 9,419 to 9,420. Dr. J. K. Townsend.

46. Macropharyngodon geoffroyi (Quoy and Gaimard).

Julis Geoffroy Quoy and Gaimard, Voyage de l'Uranie, Zool., 1824, p. 270.

No. 17,196. (Dried skin.) Dr. J. K. Townsend.

47. Hemipteronotus copei sp. nov. Plate XX, fig. I.

No. 521. Type. Oahu. Dr. W. H. Jones.

Form of the body elongated, much compressed, deepest in the pectoral region, from which it diminishes backwards to the caudal. The greatest depth is contained in the total length, without caudal, 3 times. The head is elevated, $3\frac{5}{6}$ times in the total length, without caudal, much compressed, snout not produced and the anterior profile very parabolic though slightly convex. Lower profile line of the head a very slightly inclined oblique line. The eye is situated in the upper part of the head, nearly median in its length, about once its diameter from the occiput, contained in the greatest depth of the head about $6\frac{1}{2}$ times, contained in the space between its anterior margin and the tip of the upper jaw 3 times, contained in the total length of the head $6\frac{1}{4}$ times and it is also equal to the interorbital space. The interorbital space is convex and greatly produced. The nares are small, both very close together, the anterior pair about an eye diameter from the anterior margin of the eye. The præorbital is very long and broad, the infraorbitals narrow and about equal to half an eye diameter. Mouth narrow, the distal extremity of the maxillary below the anterior margin of the eye in the vertical. Teeth strong, the outer lateral teeth larger than the others except the canines which are in two pairs on the anterior portions of the jaws, those in the lower jaw closer together than the upper pair and fitting in between the latter when the mouth is closed. The lips are large and fleshy, those on the sides of the lower jaw forming 2 thin flaps. Mouth below the upper basal portion of the P. The angle of the præoperculum is a very obtuse one, and would form very little posterior to the posterior margin of the eye. The opercular bones, which shield the branchial aperture, have their lower and posterior margins furnished with membraneous flaps. The gill-membranes are very thick and tough, though they are not connected with the isthmus. Gill-rakers moderate. Pseudobranchiæ developed. The head is naked, except a series of 6 scales, which descend obliquely forwards from the postorbitals, though not extending anterior to the centre of the eye in the vertical. There are also 2 scales, anterior and superior, on the upper margin of the operculum. The origin of the D. is at a point a trifle posterior to the median vertical keel of the præoperculum. The first radii of the D. are developed as 2 pungent spines, the tip of the first ending in a short filament, and about the same height as the spines which succeed them and which are rather strong and firm and not at all pungent. The branched rays of the D. are longer than the spines and the terminal ray, when depressed, reaches the base of the caudal. D. II, VII, 12. Origin of the A. below the first D. ray and the terminal ray is produced like the same of the D., so that when it is depressed it also reaches the base of the caudal. Spines of the A. short, graduated from the first to the third, which is the longest, and the radii of the fin III, 12. Base of the last A. ray slightly posterior to that of the soft D. The P. is contained $1\frac{3}{4}$ times in the head, radii of the fin I, 11, and their origins are below the centre of the body and above the origin of the V. Innermost ventral ray joined to the body by a membrane and the tips of the fin do not reach the origin of the A. though they extend beyond the tips of the P. The lateral line with 24 single tubes, the greater portion parallel with the dorsal outline of the back from which it is distant a scale's breadth, interrupted after traversing 20 scales, then appearing on the caudal peduncle in a medio-lateral position and continuing to the base of the caudal. There are 26 scales in a lateral series from the operculum to the base of the caudal. Caudal rounded. A narrow bluish band from the lower anterior portion of the eye running downwards to behind the corner of the mouth, parallel with this are other vertical lines running from the eye and the upper part of the head, one on the præoperculum is broad and the opercles are furnished with narrow lines on their posterior portion. General color dull brownish, the fins immaculate. Total length $7\frac{1}{8}$ inches.

Named for Prof. E. D. Cope.

48. Thalassoma aneitensis (Günther).

Julis aneitensis Günther, Cat. Fish. Brit. Mus., IV, 1862, p. 183.

Nos. 9,431 to 9,434. Oahu. Dr. W. H. Jones.

49. Thalassoma hebraica (Lacépède).

Labrus Hebraicus Lacépède, Hist. Nat. Poiss., III, 1801, pp. 455 and 526, Pl. 29, fig. 3.

No. 9,426. Dr. J. K. Townsend.

No. 17,201. (Dry skin.) Dr. J. K. Townsend.

50. Thalassoma purpurea (Forskål).

Scarus purpureus Forskål, Descript. Animal., 1775, p. 27.

Nos. 17,199 and 17,202. (Dried skins.) Dr. J. K. Townsend.

No. 17,200 (Dry skin.) Thomas Nuttall.

51. Halichœres sp.?

No. 17,195. Dr. J. K. Townsend.

52. Gomphosus tricolor Quoy and Gaimard.

Gomphosus tricolor Quoy and Gaimard, Voyage de l'Uranie, Zool., 1824, p. 280, Pl. 55, fig. 2.

No. 9,406. Dr. J. K. Townsend.

No. 17,213. (Dry skin.) Dr. J. K. Townsend.

53. Gomphosus varius Lacépède.

Gomphosus varius Lacépède, Hist. Nat. Poiss., III, 1801, pp. 100 and 104, Pl. 5, fig. 2.

Nos. 9,404 and 9,405. Dr. J. K. Townsend.

54. Coris gaimardi (Quoy and Gaimard).

Julis Gaimard Quoy and Gaimard, Voyage de l'Uranie, Zool., 1824, p. 265, Pl. 54, fig. 1.

No. 9,330. Dr. J. K. Townsend.

No. 17,203. (Dried skin.) Thomas Nuttall.

55. Coris aygula Lacépède.

Coris aygula Lacépède, Hist. Nat. Poiss., III, 1801, p. 96, Pl. 4, fig. 1.

Nos. 9,331 and 9,332. Dr. J. K. Townsend.

No. 17,207. (Dried skin.) Dr. J. K. Townsend.

The form of the body is elongate, the depth is contained in the total length about $4\frac{7}{8}$ times and the head in the same $4\frac{1}{2}$ times. The anterior profile of the head is in the form of an isosceles triangle. The eye is placed anterior and superior in the head, about equal to the præorbital, which is broad and contained in the head about $4\frac{2}{3}$ times and is also about equal to the interorbital space. The depth of the head is contained $1\frac{2}{5}$ in its length, and the P. about the same. Nostrils small and anterior to the eye. Four canines in the anterior part of each jaw, the two median lower ones fitting in between the upper pair, both of these median pairs inclined and considerably larger than the others, which are nearly vertical. Remaining teeth diminish in size as they approach the corners of the mouth. Lips rather thick. The head is furnished with pores on the præoperculum and there is also a rather imperfect circumorbital system. The posterior margin of the operculum is produced into a fleshy flap which is a trifle less than the diameter of the eye. The origin of the D. falls a little behind the origins of the P. and V. Radii of D. IX, 12, the spines much shorter than the rays, the first the shortest and the last spine the longest, soft rays equal and the terminal like the same of the A. reach to the base of the caudal. Origin of the A. nearly below the last D. spine, the radii III, 12, the first spine the shortest and the third the longest, but more equal to the soft rays. The V. not so long as the P., radii of the former I, 5, and of the latter I, 11. Scales in the posteriorly decurved lateral line about 50. Scales of the occipital region small. Caudal rounded. Opercular flap with a black posterior marginal spot. Base of the soft D. with brownish spots and the bases of the terminal rays with a distinct blackish ocellus. Total length of the alcoholic specimens about $5\frac{1}{2}$ inches.

56. Coris flavovittata (Bennett).

Julis flavo-vittatus Bennett, Zoological Journal, IV, 1829, p. 36.

No. 9,333. Dr. J. K. Townsend.

No. 17,208. (Dried skin.) Dr. J. K. Townsend.

57. Cheilio inermis (Forskål).

Labrus inermis Forskål, Descript. Animal., 1775, p. 34.

No. 9,311. Dr. J. K. Townsend.

Nos. 9,312–14. Oahu. Dr. W. H. Jones.

SCARIDÆ.

58. Scarichthys auritus (Cuvier and Valenciennes).

Scarus auritus Cuvier and Valenciennes, Hist. Nat. Poiss., XIV, 1839, p. 161.

No. 436. Dr. J. K. Townsend.

59. Cryptotomus sandwicensis (Cuvier and Valenciennes).

Callyodon sandwicensis Cuvier and Valenciennes, Hist. Nat. Poiss., XIV, 1839, p. 219.

Nos. 9,316 and 9,317. Dr. J. K. Townsend.

60. Scarus oviceps Cuvier and Valenciennes.

Scarus oviceps Cuvier and Valenciennes, Hist. Nat. Poiss., XIV, 1839, p. 181.

Nos. 9,277 and 9,278. Dr. J. K. Townsend.

CHÆTODONTIDÆ.

61. Forcipiger longirostris (Cuvier and Valenciennes).

Chætodon longirostris Cuvier and Valenciennes, Hist. Nat. Poiss., VII, 1831, p. 67, Pl. 175.

No. 23,324. (Dry Skin.) Dr. J. K. Townsend.

62. Chætodon miliaris Quoy and Gaimard.

Chætodon miliaris Quoy and Gaimard, Voyage de l'Uranie, Zool., 1824, p. 380, Pl. 62, fig. 6.

Nos. 12,299 and 12,300. Oahu. Dr. W. H. Jones.

No. 17,257. (Dry skin.) Thomas Nuttall.

No. 17,258. (Dry skin.) Dr. J. K. Townsend.

63. Chætodon setifer Bloch.

Chætodon setifer Bloch, Ichthyologie, Vol. 4, pt. 12, 1797, p. 99, Pl. 426, fig. 1.

No. 12,295. Dr. J. K. Townsend.

64. Chætodon biocellatus Cuvier and Valenciennes.

Chætodon biocellatus Cuvier and Valenciennes, Hist. Nat. Poiss., VII, 1831, p. 48.

No. 12,296. Oahu. Dr. W. H. Jones.

No. 17,263. (Dry skin.) Dr. J. K. Townsend.

65. Chætodon unimaculatus Bloch.

Chætodon unimaculatus Bloch, Ichthyologie, Vol. 2, pt. 6, 1788, p. 54, Pl. 201, fig. 1.

No. 17,176. (Dry skin.) Dr. J. K. Townsend.

66. Chætodon quadrimaculatus Gray.

Chætodon 4-maculatus Gray, Zoological Miscellany, 1831–42, p. 33.
Chætodon quadrimaculatus Günther, Cat. Fish. Brit. Mus., II, 1860, p. 12.

Nos. 12,297 and 12,298. Oahu. Dr. W. H. Jones.

No. 17,175. (Dry skin.) Dr. J. K. Townsend.

67. **Chætodon ornatissimus** Cuvier and Valenciennes.

Chætodon ornatissimus Cuvier and Valenciennes, Hist. Nat. Poiss., VII, 1831, p. 22.

No. 17,259. (Dry skin.) Dr. J. K. Townsend.

68. **Chætodon tau-nigrum** Cuvier and Valenciennes.

Chætodon tau-nigrum Cuvier and Valenciennes, Hist. Nat. Poiss., VII, 1831, p. 29.

No. 12,292. Dr. J. K. Townsend.

ZANCLIDÆ.

69. **Zanclus cornutus** (Linnæus).

Chætodon cornutus Linnæus, Syst. Nat., Ed. X, 1758, p. 273.

Nos. 11,059 and 11,060. Dr. W. H. Jones.
No. 17,174. (Dry skin.) Dr. J. K. Townsend.

TEUTHIDIDÆ.

70. **Monoceros unicornis** (Forskål).

Chætodon unicornis Forskål, Descript. Animal., 1775, p. 63.

Nos. 9,768 and 9,769. Oahu. Dr. W. H. Jones.
Nos. 10,337 to 10,339. Dr. J. K. Townsend.
No. 17,285. (Dry skin.) Dr. J. K. Townsend.
No. 17,286. (Dry skin.) Thomas Nuttall.

71. **Teuthis triostegus** (Linnæus).

Chætodon triostegus Linnæus, Syst. Nat., Ed. X, 1758, fig. 270.

Nos. 10,295 and 10,296. Dr. J. K. Townsend.
Nos. 10,297 to 10,313. Oahu. Dr. W. H. Jones.
No. 17,277. (Dry skin.) Thomas Nuttall.

72. **Teuthis guttatus** (Bloch and Schneider).

Acanthurus Guttatus Bloch and Schneider, Syst. Ichth., 1801, p. 215.

No. 17,279. (Dy skin.) Dr. J. K. Townsend.

73. **Teuthis annularis** (Cuvier and Valenciennes).

Acanthurus annularis Cuvier and Valenciennes, Hist. Nat. Poiss., X, 1835, p. 153.

Nos. 10,327 to 10,331. Oahu. Dr. W. H. Jones.
Nos. 10,333 to 10,336. Dr. J. K. Townsend.

74. **Teuthis achilles** (Shaw).

Acanthurus Achilles Shaw, General Zoology, IV, 1803, p. 383.

Nos. 10,319 to 10,321. Dr. J. K. Townsend.
No. 17,280. Dr. J. K. Townsend.

BALISTIDÆ.

75. Balistapus bursa (Bloch and Schneider).

Balistes Bursa Bloch and Schneider, Syst. Ichth., 1801, p. 476.

No. 16,473. Dr. W. H. Jones.

76. Balistapus rectangulus (Bloch and Schneider).

Balistes Rectangulus Bloch and Schneider, Syst. Ichth., 1801, p. 465.

No. 790. Dr. J. K. Townsend.

77. Canthidermis oculatus (Gray).

Balistes oculatus Gray, Illustrations of Indian Zool., I, 1830–32, Pl. 90, figs. 1 and 1*a*.

Nos. 802 and 803. Dr. J K. Townsend.

MONACANTHIDÆ.

78. Cantherines sandwichiensis (Quoy and Gaimard).

Balistes sandwichiensis Quoy and Gaimard, Voyage de l'Uranie, Zool., 1824, p. 214.

No. 1,032. Dr. J. K. Townsend.

79. Monacanthus spilosoma Lay and Bennet.

Monacanthus Spilosoma Lay and Bennett, Zool. Capt. Beechey's Voyage, 1839, p. 70, Pl. XX, fig. 4.

No. 17,309. (Dried skin.) Dr. J. K. Townsend.

TETRAODONTIDÆ.

80. Spheroides florealis (Cope). Plate XX, fig. 4.

Tetrodon florealis Cope, Trans. Amer. Philos. Soc., (new ser.) XIV, 1871, p. 479.

Nos. 1,109 and 1,110. Types of *Tetrodon florealis* Cope. Dr. J. K. Townsend.

No. 17,336. (Dried skin.) Dr. J. K. Townsend.

MOLIDÆ.

81. Ranzania makua Jenkins.

Ranzania makua Jenkins, Proc. Cal. Acad. Sci., (2) V, 1895, Colored frontispiece, p. 779.

No. 17,369. (Fine dried skin.) Dr. J. K. Townsend.

It is interesting to observe that this specimen was taken nearly sixty years before the one described by Dr. Jenkins, and even yet it shows well-preserved traces of its once brilliant colors. The markings of the head are especially distinct, and are in the form of somewhat irregular crescents, with the convex side bending anteriorly. Three of these markings radiate from the inferior margin of the eye, though there is 1 anterior to these and more horizontal, and they all become more vertical posteriorly. There are also 2 broad vertical bars between the eye and the P. On the sides of the head below and somewhat posterior to the eyes and anterior to the base of the P. are a number of blackish spots which are distributed over the bands. P. 13; D. 19; A. 20; Caudal 22. Total length of the body without the caudal $18\frac{5}{8}$ inches.

SCORPÆNIDÆ.

82. Sebastopsis guamensis (Quoy and Gaimard).

Scorpæna guamensis Quoy and Gaimard, Voyage de l'Uranie, Zool., 1824, p. 326.

No. 12,207. Dr. J. K. Townsend.

83. Sebastopistes strongia (Cuvier and Valenciennes).

Scorpæna strongia Cuvier and Valenciennes, Hist. Nat. Poiss., IV, 1829, p. 237.

No. 12,206. Dr. J. K. Townsend.

This poorly preserved specimen has the following fin formula: D. XII, 10; A. III, 5; P. 16; V. I, 5.

84. Scorpænenopsis diabolus (Cuvier and Valenciennes).

Scorpæna diabolus Cuvier and Valenciennes, Hist. Nat. Poiss., IV, 1829, p. 229.

No. 17,165. (Dried skin.) Dr. J. K. Townsend.

CARACANTHIDÆ.

85. Caracanthus maculatus (Gray). Plate XX, fig. 5.

Micropus maculatus Gray, Zoological Miscellany, 1831–42, p. 20.

No. 23,048. Honolulu. Dr. Benjamin Sharp.

Head and body greatly compressed, the greatest depth of the latter about $1\frac{1}{2}$ in its length without the caudal. Upper profile of the head somewhat parabolic. Eye over once in the snout, greater than the interorbital space and about $3\frac{1}{2}$ in the head without the opercular flap. Head $2\frac{1}{2}$ in the body without the caudal. Nares well developed, the posterior pair the largest. Mouth rather broad, horizontal, when closed the jaws are equal and also furnished with small teeth. Lips moderately developed. The maxillary, which is very oblique, extends posteriorly for $\frac{2}{3}$ of the diameter of the eye. The preorbital is armed with a broad sharp spine projecting obliquely downwards parallel with the maxillary. The interoperculum is armed with a spine and the præoperculum has 5 curved spines along its posterior margin, the lower the largest. On the upper posterior part of the operculum are 2 broad flattened spines. The top of the head and the interorbital space is villosely osseous and over the eyes are 2 larger ossifications. The branchial aperture is moderate, lateral in position, and the gill-membranes are joined to the isthmus which is large and fleshy. Gill-rakers moderate, most numerous posteriorly. Pseudobranchiæ well developed. No slit after the last gill-arch. Origin of the D. over the tips of the opercular spines, a little before that of the P., and the fin is divided, the spinous portion with VIII spines and the soft portion with 12 rays the last of which is adnate, along its posterior margin to the caudal peduncle by a membrane. The third D. spine is the longest and the second is longer than the seventh and eighth, while the soft rays are more even, those anteriorly the longest, and the rays gradually become shorter posteriorly. P. with VIII simple and 5 branched rays. V. more or less rudimentary radii I, 3. A. spines II, isolated from the soft rays of the fin which are 12, and the last is adnate to the caudal peduncle by a membrane. The 2 spines of the A. are a little posterior to the origin of the soft D. The lateral line is conspicuous and runs from above the branchial aperture to the base of the caudal. Body naked, papillose. Caudal small and rounded. Color in alcohol brownish, much darker above and with numerous small round whitish spots. Total length $1\frac{1}{2}$ inches.

CEPHALACANTHIDÆ.

86. Cephalacanthus orientalis (Cuvier and Valenciennes).

Dactylopterus orientalis Cuvier and Valenciennes, Hist. Nat. Poiss., IV, 1829, p. 98, Pl. 76.

No. 11,643. Dr. J. K. Townsend.
No. 17,067. (Dried skin.) Dr. J. K. Townsend.
Nos. 23,351 and 23,352. Dr. W. H. Jones.

GOBIIDÆ.

87. Eleotris fuscus (Bloch and Schneider).

Pœcilia Fusca Bloch and Schneider, Syst. Ichth., 1801, p. 453.

Nos. 22,924 to 22,943. Honolulu. Dr. Benjamin Sharp.

88. Gobius albopunctatus Cuvier and Valenciennes.

Gobius albopunctatus Cuvier and Valenciennes, Hist. Nat. Poiss., XII, 1837, p. 43.

No. 10,703. Dr. J. K. Townsend.

89. Gobius papuensis Cuvier and Valenciennes.

Gobius Papuensis Cuvier and Valenciennes, Hist. Nat. Poiss., XII, 1837, p. 80.

No. 23,350. Dr. Benjamin Sharp.

90. Gobius sp.?

Nos. 23,345 to 23,348. Dr. J. K. Townsend.

More than one species may be included here, but the specimens are so poorly preserved that I have not attempted to identify them.

91. Awaous genivittatus (Cuvier and Valenciennes).

Gobius genivittatus Cuvier and Valenciennes, Hist. Nat. Poiss., XII, 1837, p. 48.

No. 10,746 and 10,747. Dr. J. K. Townsend.

92. Awaous crassilabris (Günther).

Gobius crassilabris Günther, Cat. Fish. Brit. Mus., III, 1861, p. 63.

Nos. 10,744 and 10,745. Dr. J. K. Townsend.

ECHENEIDIDÆ.

93. Remora albescens (Temminck and Schlegel).

Echeneis albescens Temminck and Schlegel, Fauna Japonica, Poiss., 1842, p. 272, Pl. 120, fig. 3.

No. 11,413. Thomas Nuttall.

BLENNIDÆ.

94. Petroskirtes filamentosus (Cuvier and Valenciennes).

Blennechis filamentosus Cuvier and Valenciennes, Hist. Nat. Poiss., XI, 1836, p. 206, Pls. 325, 326, lower fig.

No. 16,666. Dr. W. H. Jones.

95. Salarias edentulus (Bloch and Schneider).

Blennius Edentulus Bloch and Schneider, Syst. Ichth., 1801, p. 172.

No. 10,489. Dr. W. H. Jones.

96. Salarias gibbifrons Quoy and Gaimard.

Salarias gibbifrons Quoy and Gaimard, Voyage de l'Uranie, Zool., 1824, p. 253.

No. 10,492. Dr. J. K. Townsend.

In this specimen the A. is marked with a number of spots.

97. Salarias variolosus Cuvier and Valenciennes.

Salarias variolosus Cuvier and Valenciennes, Hist. Nat. Poiss., XI, 1836, p. 235.

No. 10,493. Dr. W. H. Jones.

? No. 10,494. Thomas Nuttall.

Nuttall's specimen is very badly preserved.

98. Salarias brevis Kner.

Salarias brevis Kner, Sitzungb. Akad. Wissensch. Wien., LVIII, 1868, p. 334, taf. 6, fig. 18.

No. 10,495. Dr. J. K. Townsend.

BROTULIDÆ.

99. Brotula townsendi sp. nov. Plate XX, fig. 3.

No. 8,981. Type. Dr. J. K. Townsend.

Form of the body elongate, the greatest depth a trifle over 5 in the total length. The head is compressed, and including the opercular flap is contained in the total length about 5 times. The eyes are anterior and high in the head, small, contained in the head with opercular flap nearly 8 times, in the interorbital space $1\frac{1}{2}$ times and nearly 2 in the snout. Mouth rather large and prominent and with the lower jaw projecting. Lips large, thick and fleshy, there are 4 superior buccal barbels of about equal length and 6 inferior mandibular ones which are longer than the former. The anterior nares which are near the posterior pair are furnished with a pair of barbels which are also larger than the rest of the upper ones. The anterior nares are about an eye diameter from the eyes, and their aperture is smaller than that of the posterior pair. Teeth of the jaws, vomer and palatines, small and in many series forming broad and well-defined patches. The maxillary is oblique, very broad at the distal extremity, reaching beyond the posterior margin of the eye, and its width at that point is equal to the length of the snout. The supplemental maxillary is well developed thus accounting for its broad distal extremity. The maxillaries themselves are more or less partly concealed by the orbital flap of skin. The branchial aperture is large, the gill-membranes joined to each other and crossing the isthmus but not joined to it. No pseudobranchiæ. Gill-rakers as long as the eye and a slit after the last gill-arch. On the superior and anterior part of the operculum is a partly erectile spine directed backwards, which is about as long as the eye. The V., which are bifid, are jugular in position, and their origin is not quite an eye diameter posterior to the distal extremity of the maxillary, and their tips extend posteriorly as far as the tips of the P., which is about half-way between the base of the P. and the anus. The origin of the P. is anterior to that of the D., and the fin is contained nearly twice in the head. The D., A. and caudal are continuous, the latter terminating in a point. D. A. and caudal 176 ? Body covered with small cycloid scales, about 96 in the lateral line. The lateral line is dorsal in position and nearly parallel with the dorsal outline of the body throughout its whole course. General color uniform brownish. Total length 5 inches.

Named for Dr. J. K. Townsend.

ANTENNARIDÆ.

100. Antennarius commersonii (Lacépède).

Lophius commersonii Lacépède, Hist. Nat. Poiss., I, 1801, p. 327.

Nos. 10,648 and 10,649. Thomas Nuttall and Dr. J. K. Townsend.

101. Antennarius sp.?

No. 10,647. Dr. J. K. Townsend.

Specimen badly preserved.

II. Tahiti.

The collections illustrating the ichthyology of this region, in the Academy, are those made by Dr. J. K. Townsend and Mr. Andrew Garrett. Dr. Townsend's collection was made while on his second Pacific expedition, and after the visit to the Sandwich Islands.

CLUPEIDÆ.

1. Sardinella atricauda (Günther).

Clupea atricauda Günther, Cat. Fish. Brit Mus., VII, 1868, p. 426.

Nos. 14,504 to 14,506. Andrew Garrett.

SYNGNATHIDÆ.

2. Doryrhamphus brachyurus (Bleeker).

Syngnathus brachyurus Bleeker, Verhandel. Batavia. Genootsch. Kunst. Wetensch., Deel XXV, 1853, p. 16.

Nos. 14,848 to 14,868. Andrew Garrett.

Dumeril has placed *Dorichthys mille-punctatus* of Kaup in the synonymy of this species (*Hist. Nat. Poiss.*, 1870, p. 575).

SPHYRÆNIDÆ.

3. **Sphyræna commersonii** Cuvier and Valenciennes.

Sphyræna Commersonii Cuvier and Valenciennes, Hist. Nat. Poiss., III, 1829, p. 260.

No. 11,466. Dr. J. K. Townsend.

HOLOCENTRIDÆ.

4. **Holocentrus diploxiphus** Günther.

Holocentrum diploxiphus Günther, Proc. Zool. Soc. London, 1871, p. 660.

No. 14,140. Dr. J. K. Townsend.

MULLIDÆ.

5. **Upeneoides vittatus** (Forskål).

Mullus vittatus Forskål, Descript. Animal., 1775, p. 31.

Nos. 12,473 and 12,476. Dr. J. K. Townsend.

6. **Upeneus trifasciatus** (Lacépède).

Mullus trifasciatus Lacépède, Hist. Nat. Poiss., III, 1801, pp. 383 and 404, Pl. 15, fig. 1.

No. 12,475. Dr. J. K. Townsend.

7. **Upeneus pleurospilos** Bleeker.

Upeneus pleurospilos Bleeker, Natuurk. Tijdsch. voor Nederl. Indie, Deel IV, (New Series I) 1853, p. 110.

No. 12,474. Dr. J. K. Townsend.

KUHLIDÆ.

8. **Kuhlia marginata** (Cuvier and Valenciennes).

Dules marginatus Cuvier and Valenciennes, Hist. Nat. Poiss., III, 1829, p. 87, Pl. 52.

Nos. 16,008 to 16,010. Andrew Garrett.

9. **Kuhlia malo** (Cuvier and Valenciennes).

Dules malo Cuvier and Valenciennes, Hist. Nat. Poiss., VII, 1831, p. 360.

No. 12,647. Dr. J. K. Townsend.

POMACENTRIDÆ.

10. **Tetradrachmum aruanus** (Linnæus).

Chætodon aruanus Linnæus, Syst. Nat., Ed. X, 1758, p. 275.

Nos. 9,620 and 9,621. Andrew Garrett.

LABRIDÆ.

11. **Pseudocheilinus hexatænia** (Bleeker).

Cheilinus hexatænia Bleeker, Acta. Societ. Scient. Indo Neerlandicæ, Vol. II, 1857, p. 84.

Nos. 9,667 to 9,673. Andrew Garrett.

SCORPÆNIDÆ.

12. **Sebastopsis guamensis** (Quoy and Gaimard).

Scorpæna guamensis Quoy and Gaimard, Voyage de l'Uranie, Zool., 1824, p. 326.

Nos. 12,192 to 12,198. Andrew Garrett.

Body moderately elongate, robust, greatest depth in the region of the P. and about 3 in the total length, excluding caudal. Head $2\frac{1}{2}$ in the body without the caudal, broad, somewhat conical, and furnished with sharp spines, as the preocular, supraocular, postocular, tympanic, parietal, nuchal, preopercular and opercular, all of which are present and many are furnished with small filaments. Top of the head without occipital depression and the interorbital space concave, not equal to the diameter of the eye. Eye large, about $3\frac{1}{2}$ in the head and nearly once in the snout. Snout very protractile and with a depression between the premaxillaries into which the slightly knobbed symphysis of the mandible fits when the mouth is closed. Maxillaries broad distally and extending posteriorly for nearly $\frac{2}{3}$ the eye diameter. Villiform teeth on the premaxillaries, dentaries and vomer, but none on the palatines. Gill-rakers small, short and moderate in number. No slit after the last gill-arch. Pseudobranchiæ well developed. The gill-membranes are not broadly connected across the isthmus. Branchiostegal radii strong, becoming larger, longer and more robust as they ascend the ceratohyals which are rather broad. The jaws are equal. Opercular flap scaly below like the rest of the operculum and præoperculum, also the region below the eyes and on the top of the head. The branchial aperture is very large and with a distinct depression. There is a small spine above the P. near the opercular flap. Origin of the D. about over that of the P., and both before the posterior edge of the opercular flap. Base of the D. very long, the base of the terminal ray more posterior than that of the terminal A. ray, and with its posterior margin joined to the caudal peduncle by a membrane. The rays of the soft D. exceed the length of the longest D. spine. The P.

has an exceedingly broad base, inclining somewhat anteriorly, radii of the fin very long, much longer than the V., whose origin is posterior to that of the P., and its tips reach beyond the anus and nearly to the origin of the A. The inner V. ray is joined to the body by a membrane at its base and the tips of the fins do not reach the anus. The origin of the A. falls below that of the soft D., the first spine is the shortest and the second the longest, though not equal to the longest soft rays. The caudal is small and rounded, and the median rays somewhat the longest. Color in alcohol mostly of a rich brown, beautifully variegated with darker marblings and spots. A broad light band across the soft D., caudal peduncle and soft A. All the fins irregularly and somewhat narrowly barred with darker brownish. A large blackish spot about the size of the eye upon the upper part of the operculum. Scales mostly ctenoid, except those of the thoracic region, which are cycloid, and together with the ctenoid scales of the head, those along the bases of the D., A. and P. much smaller than those on the rest of the body. The lateral line descends from above the gill-opening to the centre of the base of the caudal in nearly a straight line, not traversing the caudal peduncle medio-laterally. There are about 38 to 42 scales in the lateral line. Radii of the D. mostly XIII, 9, only seldom XIV, 9 or XIII, 10. Radii of P. mostly 19, occasionally 18. Raddii of V. I, 5. Radii of A. III, 5. The entire length of the specimens ranges from $1\frac{13}{16}$ to $3\frac{5}{8}$ inches.

13. Pterois radiata Cuvier and Valenciennes.

Pterois radiata Cuvier and Valenciennes, Hist. Nat. Poiss., IV, 1829, p. 271.

No. 11,807. Andrew Garrett.

CARACANTHIDÆ.

14. Caracanthus maculatus (Gray).

Micropus maculatus Gray, Zoological Miscellany, 1831–42, p. 20.

No. 12,199. Andrew Garrett.

This specimen is very much like the one obtained by Dr. Sharp at Honolulu, but differs a little in the larger eye, and the coloration is also different, but this is due, I think, to the method of preservation as Dr. Sharp's specimen was discolored by being placed in a copper can.

GOBIIDÆ.

15. **Eleotris fuscus** (Bloch and Schneider).

Pœcilia Fusca Bloch and Schneider, Syst. Ichth., 1801, p. 453.

Nos. 11,006 to 11,025. Andrew Garrett.

16. **Gobius ornatus** Rüppell.

Gobius ornatus Rüppell, Atlas zu der Reise im Nördl. Afrika, 1828, p. 135.

No. 10,668. Andrew Garrett.

PSEUDOCHROMIDÆ.

17. **Pseudochromis polyacanthus** Bleeker.

Pseudochromis polyacanthus Bleeker, Natuurk. Tijdsch. voor Nederl. Indie, Deel X (New Series) 1856, p. 375.

No. 14,647. Andrew Garrett.

FIERASFERIDÆ.

18. **Fierasfer homei** (Richardson).

Oxybeles homei Richardson, Voyage of the Erebus and Terror, Ichth., 1844–48, p. 74, Pl. 44, figs. 7 to 18.

Nos. 8,933 to 8,937. Andrew Garrett.

19. **Fierasfer parvipinnis** Kaup. Plate XIX, fig. 5.

Fierasfer parvipinnis Kaup, Cat. of Apod. Fish., 1856, p. 160, Pl. 16, fig. 2.

No. 8,938. Andrew Garrett.

A fine specimen with the very elongate tapering body peculiar to the genus, in which the greatest depth, which is a little posterior to the P., is contained $11\frac{1}{2}$ times. The head is contained in the body 9 times, its greatest depth contained in its own length $1\frac{3}{5}$ times, though its breadth is a trifle greater than its greatest depth. The eyes are circular, anterior and superior, greater than the snout and contained in the length of the head about 6 times. Top of the head broad, nearly flat, or only very slightly convex, the cheeks swollen, and the interorbital space equal to $1\frac{1}{2}$ eye diameters. The snout is obtuse, blunt and with the jaws equal when closed. Teeth in the jaws pluriserial, well developed. Vomerine and palatine teeth larger and more conical than those of the jaws, especially the former. Maxillaries oblique, the distal extremity expanded and posterior to the posterior margin of the eye. Branchial aperture large, the gill-membranes free from the isthmus, but forming a fold which passes over it. Branchiostegals robust. Pseudobranchiæ absent. Gill-rakers in moderate number and nearly as long as the eye. Nares small. The operculum is prolonged posteriorly into a little flap. Genito-anal apertures anterior to the origin of the very short P., which is contained in the length of the head 4 times. Both the D. and A. are very little developed, so that I am unable to locate the origin of the former, but that of the latter falls a short distance behind the base of the P. The body is completely naked and the lateral line is distinct and straight from above the branchial aperture to the tip of the caudal. The color in alcohol is at present a rich light brown with very minute dark spots or dots, and there also appears to have been marblings of another darker color than the ground color, but not so dark as the dots. The cheeks are also somewhat darker than the ground color. Total length 7 inches.

III. Samoa.

The following specimens were collected many years ago by Dr. H. C. Caldwell, by whom they were presented to the Academy.

ANGUILLIDÆ.

1. Anguilla bengalensis (Gray).

Muræna Bengalensis Gray, Illustrations of Indian Zoology, I, 1832, Pl. 95, fig. 5 (after Ham. Buch. MS.).

No. 1.087.

This specimen is labeled as the type of *Anguilla planirostris* Abbott MS.

MURÆNIDÆ.

2. Echidna nebulosa (Ahl).

Muræna nebulosa Ahl. De Muræna et Ophichtho, 1789, p. 5, Pl. 1, fig. 2.

No. 966.

MUGILIDÆ.

3. Mugil caldwelli sp. nov. Plate XIX, fig. 4.

No. 9,841. Type.

Form of the body oblong, the greatest depth $4\frac{2}{5}$ in the total length, head about the same, but much longer than deep. The eye is situated in the anterior part of the head and above the centre of its depth, contained once in the snout, $3\frac{3}{5}$ in the head, and $1\frac{2}{3}$ times in the interorbital space which is evenly though shallowly convex and also contained in the head $2\frac{1}{4}$ times. The eye is furnished with an adipose eyelid the posterior portion of which is broader than the anterior portion and also covers the greater part of the iris. The nostrils are placed superiorly, both pairs closer together than the width of the interorbital space, and when viewed laterally the anterior is half an eye diameter anterior and superior to the centre of the eye and is rounded. The posterior nostrils are slit-like, superior to the anterior and nearer the front margin of the eye than the centre of the space between the anterior pair and the anterior margin of the eye. Mouth very protractile, lips moderately thin and the symphysis of the mandible is elevated and fits into a depression in the centre of the roof of the upper jaw when the mouth is closed. The depth of the mouth, that is the space between the symphysis of the mandible and the corner of the mouth, is more than $\frac{1}{2}$ the width of the breadth between both corners of the same. The angle made by the mandibulary bones would be an obtuse one. The maxillaries are completely hidden when the mouth is closed. The corners of the mouth are a trifle posterior to the posterior nostrils. The præorbital is small, scaleless and with the lower margin denticulate. Head covered with scales, except the jaws, and the opercles at present are also nude, but they were most likely scaled during life. Gill-rakers long and well developed. Pseudobranchiæ well developed. Origin of the P. above the centre of the body, though the base of the fin is not as high as the upper margin of the eye, directly behind the branchial aperture, shorter than the head and extending posteriorly a trifle beyond the origin of the spinous D. Radii of P. I, 15. The origin of the V. is about half-way between the origin of the P. and its tip, and it reaches posteriorly beyond the centre of the space between their bases and the anus. The anus is directly below the tip of the second D. spine, when the fin is depressed. Radii of V. I, 5, the innermost rays joined to each other and to the body by a membrane at their bases and there is also a large arrow-shaped scale between their bases. The P. are also furnished with a scale at their bases. The soft D. differs from that of any other species of *Mugil* known to me by having 5 rays, and they all appear to be branched rays, as there is no anterior spine present in this fin. The origin of the soft D. is over the fourth or fifth soft A. ray. The spinous D with IV spines, the first 3 large and well developed, the third thin and shorter than the second and fourth is about $\frac{2}{3}$ the length of the second, which is the longest. There are 2 elongated scales at the base of the spinous D., which lie on the back. Origin of the A. posterior to the anus, radii III, 9, the anterior rays the longest and the terminal longer than the median. The A. is covered with small scales, especially anteriorly, the scales extending on the fins as far as the tip of the third spine, which is the longest, the first being the shortest. The soft D. appears to have had the basal portion covered with scales. Caudal very deeply emarginate, the lobes pointed and the basal portion scaled. Caudal peduncle compressed and equal to the interorbital space. As the scales on the anterior part of the body have been removed, I shall count the scales from the upper posterior margin of the operculum to the base of the caudal, yet they are in places removed so that the count is approximate—34. The color is a dull silvery, without any conspicuous markings. Total length $5\frac{1}{8}$ inches.

I have named this species for Dr. Caldwell, who collected the type.

HOLOCENTRIDÆ.

4. **Holocentrus diadema** Lacépède.

Holocentrus diadema Lacépède, Hist. Nat. Poiss., III, 1801, Pl. 32, fig. 4, IV, 1801, pp. 372 and 374.

Nos. 14,139 and 14,140.

5. **Holocentrus spinifer** (Forskål).

Sciæna spinifera Forskål, Descript. Animal., 1775, p. 49.

No. 14,142.

6. **Holocentrus sammara** (Forskål).

Sciæna sammara Forskål, Descript. Animal., 1775, p. 48.

No. 14,141.

MULLIDÆ.

7. **Upeneus indicus** (Shaw).

Mullus Indicus Shaw, General Zoölogy, IV, 1803, p. 614.

Nos. 12,471 and 12,472.

EQUULIDÆ.

8. **Equula fasciata** (Lacépède).

Clupea fasciata Lacépède, Hist. Nat. Poiss., V, 1802, pp. 425, 460 and 463.

No. 11,064.

KUHLIDÆ.

9. **Kuhlia rupestris** (Lacépède).

Centropomus rupestris Lacépède, Hist. Nat. Poiss., IV, 1801, pp. 252 and 273.

No. 12,648.

SERRANIDÆ.

10. **Epinephelus merra** Bloch.

Epinephelus merra Bloch, Ausl. Fische, VII, 1793, p. 17, fig. 329.

No. 13,456.

LUTIANIDÆ.

11. **Genyoroge marginata** (Cuvier and Valenciennes).

Diacope marginata Cuvier and Valenciennes, Hist. Nat. Poiss., II, 1828, p. 320.

No. 13,288.

POMACENTRIDÆ.

12. **Eupomacentrus lividus** (Bloch and Schneider).

Chætodon Lividus Bloch and Schneider, Syst. Ichth., 1801, p. 235.

No. 9,651 and (?) 9,652.

Of the latter, which is in bad preservation, I am not positive of the identification.

LABRIDÆ.

13. **Hemigymnus melapterus** (Bloch).

Labrus melapterus Bloch, Ichthyologie, Vol. 3, pt. 8, 1797, p. 111, Pl. 285.

Nos. 9,591 and 9,653.

SCARIDÆ.

14. **Scarus viridus** Bloch.

Scarus viridus Bloch, Ichthyologie, Vol. 3, pt. 7, 1797, p. 20, Pl. 222.

No. 9,274.

15. **Scarus globiceps** Cuvier and Valenciennes.

Scarus globiceps Cuvier and Valenciennes, Hist. Nat. Poiss., XIV, 1839, p. 179.

Nos. 9,279 and 9,280.

16. **Scarus** sp.?

No. 9,275.

CHÆTODONTIDÆ.

17. Chætodon setifer Bloch.

Chætodon setifer Bloch, Ichthyologie, Vol. 4, pt. 12, 1797, p. 99, Pl. 426, fig. 1.

No. 12,294.

18. Chætodon vagabundus Linnæus.

Chætodon vagabundus Linnæus, Syst. Nat., Ed. X, 1758, p. 276.

No. 12,293.

BALISTIDÆ.

19. Balistapus aculeatus (Linnæus).

Balistes aculeatus Linnæus, Syst. Nat., Ed. X, 1758, p. 328.

Nos. 801 and 23,349.

These two specimens represent the *Balistes diva* Cope MS., but are undoubtedly the young of the above.

TETRAODONTIDÆ.

20. Ovoides immaculatus (Bloch and Schneider).

Tetrodon Immaculatus Bloch and Schneider, Syst. Ichth., 1801, p. 507 (after Lacépède).

No. 1,117.

The writer would like to call attention to errors in the *Proc. Acad. Nat. Sci. Phila.*, 1899, p. 496, where *Arothron* is spelled *Arathron* and *Arothron reticularis* (Bloch and Schneider) is referred to as *Arathron reticulatis* (Günther). The species should all be referred to the present genus, *Ovoides*, then they would stand:

Ovoides nigropunctatus (Bloch and Schneider).

Tetrodon Nigropunctatus Bloch and Schneid. Syst. Ichth., 1801, p. 507.
Ovoides reticularis (Bloch and Schneider).
Tetrodon Reticularis Bloch and Schneider, Syst. Ichth., 1801, p. 506.

21. Ovoides ophryas (Cope). Pl. XX, fig. 2.

Arothron ophryas Cope, Trans. Amer. Philos. Soc., (New Series) XIV, 1871, p. 479.

No. 651. Type of *Arothron ophryas* Cope.

ECHENEIDIDÆ.

22. Echeneis naucrates Linnæus.

Echeneis naucrates Linnæus, Syst. Nat., Ed. X, 1758, p. 261.

No. 11,423.

SOME ARACHNIDA FROM ALABAMA.

BY NATHAN BANKS.

The following spiders and allied Arachnids were collected in Alabama, for the most part, by Prof. Carl F. Baker and his students. Some, however, were gathered by Prof. Baker's predecessor, Dr. L. M. Underwood. A few very interesting ones were taken by the late Mr. Hugo Soltau near Mobile. When no locality is given the specimens come from the vicinity of Auburn. The following students assisted in making the collections: Messrs. Allen, Dixon, Dobbin, Eppes, Farley, Houghton, McCalla, Minge, Ransom, Shevers, Stewart and Warwick from Auburn, and Hudnion from Opelika. All the localities are in the southern portion of the State; collections in the hilly northern part would doubtless add many forms to the list, while on the Gulf coast a few semi-tropical forms would be found.

The Arachnid fauna of Alabama is of much interest to the modern student since this State was one of the collecting grounds of Prof. Hentz, the father of American Arachnology. A number of species described by Hentz have been unknown to later naturalists, and the systematic position of some of them in much doubt. In this collection several of these forms appear which enables me to place them in their proper position.

Perhaps the most interesting of these species is the one described by Hentz as *Katadysas pumilus*. Hentz believed this spider to be intermediate between the two great divisions of the Araneida—those with four lung-slits and vertically moving fangs, and those with two lung-slits and laterally moving fangs. *Katadysas* was reputed to have but two lung-slits, yet with vertically moving fangs. The general appearance of Hentz' figure led several writers to believe that *Katadysas* was a *Zora* or near that genus. In this collection there is one specimen of *Katadysas pumilus* which proves to belong to the genus *Zora*, a genus new to our country.

Of scarcely less interest was the scorpion, of which Prof. Baker sent me many specimens. This scorpion proves to be quite different from the ordinary scorpion of the Southern States, long known as *Centrurus carolinianus* Beauv. This species is the form described by C. L. Koch as *Vejovis carolinus*. I had no idea that there were two scorpions common in the Southern States, and its discovery was of much concern to me. In looking up the literature on the subject, however, I found that what was evidently the same species had been recorded by Mr. J. P. Stelle in 1870, in the *American Entomologist*, as occurring in Tennessee. This species is abundantly different from our common *Centrurus*, belonging to another family and exhibiting many minor points of difference.

A few other interesting species may be mentioned: *Myrmecophila foliata* Atk., which proves to be the same as *Mygale fluviatilis* Hentz; *Anyphæna piscatoria* Hentz, one of the lost species, easily recognized by the peculiar shape of the male palpus; *Dolomedes albineus* Hentz, a pale species of the genus, and *Lycosa missouriensis*, a curious species which I described several years ago from one Missouri specimen, is represented by many examples.

Mr. Soltau sent several small forms that add interest to the list; one, a new genus of *Dictynidæ*, is remarkable on account of its near approach to certain six-eyed forms.

Except in the small *Theridiidæ*, where the woodland species have not been well collected, this collection gives one a fair idea of the spider fauna of the region. Most of the species are widely distributed in the Atlantic States, very few but are found in more northern regions. A few forms are more common in regions to the south; such are *Anyphæna striata*, *Gaucelmus angustinus*, *Argyrodes nephilæ*, *Prostheclina aurata* and *Lyssomanes viridis*. Altogether one hundred and thirty-three spiders are recorded and twelve other Arachnids—a total of one hundred and forty-five species. The *Epeiridæ* leads with twenty-four species; then follow the *Lycosidæ* and the *Attidæ*. Twenty families are represented, seven by but one species. One hundred of the spiders were described by Hentz; three are described as new.

THERAPHOSIDÆ.

Pachylomerus carolinensis Hentz.

One female.

Myrmeciophila fluviatilis Hentz.

M. foliata Atkinson.

Several specimens.

FILISTATIDÆ.

Filistata capitata Hentz.

Many specimens; also Opelika.

DYSDERIDÆ.

Ariadne bicolor Hentz.

One specimen.

PHOLCIDÆ.

Pholcus phalangioides Fuess.

Several specimens. September.

Spermophora meridionalis Hentz.

A few specimens.

DRASSIDÆ.

Sergiolus variegatus Hentz.

Several examples, one from Mobile.

Prosthesima atra Hentz.

A few. October.

Prosthesima ecclesiastica Hentz.

Several specimens. October.

Prosthesima decepta n. sp.

Length ♀ 7.5 to 8 mm.; tibia plus patella IV, 3 mm. Cephalothorax yellow-brown, rather darker on head, mandibles red-brown, legs brownish yellow, sternum pale reddish brown, abdomen above and below dark gray, spinnerets yellowish. Cephalothorax as long as tibia plus patella IV, much narrowed in front; posterior eye-row slightly procurved, P. M. E. largest, oval and oblique, not half their diameter apart at their posterior ends, much farther from the P. S. E., A. M. E. nearly their diameter apart, closer to the equal A. S. E., S. E. quite widely separated; mandibles stout, vertical; legs of usual length, no spines under tibiæ I and II, a pair under metatarsus II, none under metatarsus I, posterior pairs with many spines, none above; sternum plainly longer than broad, truncate at base, broadest in middle, pointed at the tip; abdomen once and one-half as long as broad, truncate at base, depressed; the epigynum shows a broad area, traversed by a rather narrow pale septum, and a dark ridge on each side.

Several specimens. Resembles *P. insularis* Banks, but the epigynum is quite different and the P. M. E. are larger and closer together.

Gnaphosa sericata Koch.

Herpyllus bicolor Hentz.

Many specimens, some from Opelika.

CLUBIONIDÆ.

Clubiona abottii Koch.

A few small specimens.

Chiracanthium inclusa Hentz.

Many examples. October.

Chiracanthium albens Hentz.

One young specimen.

Phrurolithus alarius Hentz.

One from Mobile.

Thargalia bivittatus Keys.

Young specimens from Mobile.

Anyphæna striata Becker.

One male of this rare species. Readily known by small size and dark color, as well as by structure of palpus.

Anyphæna piscatoria Hentz.

Two males are evidently this species, which is easily recognized in this sex by the very long process to the tarsus of the palpus. One is from Opelika.

Gayenna celer Hentz.

Anyphæna incerta Keys.

One young specimen from Opelika.

ZOROPSIDÆ.

Zora pumilis Hentz.

Katadysas pumilis Hentz.

One immature specimen. It has the characteristic appearance of the other species of the genus.

AGALENIDÆ.

Agalena nævia Hentz.

Various specimens, some of the form described by Becker as *A. hentzi*, which I do not think is specifically different. September.

Tegenaria derhami Scop.

Several examples.

Cœlotes medicinalis Hentz.

One specimen.

THERIDIIDÆ.

Theridium tepidariorum Koch.

Great numbers of specimens. There is considerable variation in color and markings, and the males vary in size and length of legs.

Gaucelmus angustinus Keys.

One female.

Theridula sphærula Hentz.

A few specimens. October.

Teutana triangulosa Walck.

Numerous examples, some from Opelika. September.

Lathrodectes mactans Koch.

Many specimens. September.

Lithyphantes fulvus Keys.

One female.

Crustulina guttata Rossi.

One from Mobile.

Mysmena bulbifera Banks.

One specimen. March.

Argyrodes trigonum Hentz.

A few specimens. September.

Argyrodes nephilæ Cambr.

One specimen. October.

Argyrodes cancellata Hentz.

Two from Mobile.

Spiropalpus spiralis Emer.

One example.

Linyphia communis Hentz.

Several specimens. September.

Bathyphantes maculata n. sp.

Cephalothorax black on sides and above in the middle, leaving an irregular pale yellowish area each side, eyes on black spots, with a black line extending back from each P. S. E.; mandibles dark on base, pale on apex; legs pale, a dark band on middle of the tibiæ, and frequently a spot above on middle of femora; sternum black, a narrow black band on apex of each coxa; abdomen black, a pale space at base and three chevrons behind, four spots on each upper side, the posterior ones often connected to the chevrons, toward the base on each side is a long pale spot, and two smaller near the spinnerets; venter black. Head rather high; the P. M. E. less than their diameter apart, scarcely as far from the P. S. E.; A. M. E. smaller, hardly their diameter apart, farther from the larger A. S. E.; legs long and slender; abdomen high and convex, rounded at the base, pointed behind; epigynum shows a finger bent in, and holes each side much as in *B. zebra*. Length ♀ 1.8 mm.

Two specimens from Mobile. Differs from *B. zebra* in larger size, markings, etc.

DICTYNIDÆ.

Dictyna sublata Hentz.

Many specimens. October.

Dictyna volucripes Keys.

A few examples. October.

Dictyna foliacea Hentz.

D. volupis Keys.

Several specimens.

DICTYOLATHYS n. gen.

Much like *Dictyna*, but apparently six-eyed, three in a group each side; but the A. M. E. are present, although very small, and situate close to and a little higher than the A. S. E. Head not much elevated; legs of moderate length, not spined, but very hairy; accessory spinning organs like *Dictyna*.

Dictyolathys maculata n. sp.

Cephalothorax, legs, mandibles and sternum pale, rather yellowish, eyes on black spots; abdomen whitish, with a basal black mark and four rows of transverse dark marks, the submedian pairs being more or less connected, the lateral rows extending obliquely down on the sides, the hind ones converging to the spinnerets, venter with a few median black dots, region of epigynum reddish. P. M. E. are more than their diameter apart, close to the equal P. S. E; A. S. E. of about equal size; A. M. E. very small and close to and slightly higher than the A. S. E.; sternum broad, sides rounded; abdomen rather truncate at base, moderately broad; genital region semicircular, showing a dark mark on each outer lower side, with a narrow median septum, and each side at base an oval opening. Length 1.4 mm.

Several specimens from Mobile; also from Meridian, Miss.

ULOBORIDÆ.

Uloborus plumipes Lucas.

A few specimens. September.

EPEIRIDÆ.

Gasteracantha cancer Hentz.

Several specimens.

Acrosoma spinea Hentz.

A few specimens.

Acrosoma rugosa Hentz.

A few examples of several color varieties.

Mahadeva verrucosa Hentz.

One female.

Ordgarius cornigerus Hentz.

One female from Mobile.

Argiope aurantia Lucas.

Epeira riparia Hentz.

Several specimens.

Argiope transversa Emer.

Many examples.

Epeira scutulata Hentz.

A few, mostly young specimens.

Epeira insularis Hentz.

Many specimens.

Epeira trifolium Hentz.

One specimen.

Epeira domiciliorum Hentz.

Several examples, some very dark.

Epeira thaddeus Hentz.

A few examples.

Epeira prompta Hentz.

E. parvula Keys.

Many specimens, representing many color varieties.

Epeira globosa Keys.

A few specimens. October. It is curious that Hentz did not find this species, which he certainly would recognize as distinct.

Epeira displicata Hentz.

Several specimens.

Epeira trivittata Keys.

A few examples.

Epeira labyrinthea Hentz.

A few specimens.

Epeira vulgaris Hentz.

E. volucripes Keys.

A few young specimens.

Abottia gibberosa Hentz.

Several examples. October.

Abottia placida Hentz.

A few specimens.

Argyrœpeira hortorum Hentz.

Many specimens.

Plectana stellata Hentz.

A few, mostly young specimens.

Cyclosa conica Pallas.

Many examples. September.

Larinia directa Hentz.

A few specimens. October.

TETRAGNATHIDÆ.

Tetragnatha grallator Hentz.

A few specimens.

Tetragnatha laboriosa Hentz.

More common than the preceding species. October. Also Opelika.

THOMISIDÆ.

Xysticus gulosus Keys.

A few specimens.

Xysticus quadrilineatus Keys.

Several examples. October.

Xysticus nervosus Banks.

Several specimens. October.

Xysticus maculatus Keys.

One specimen, probably this species. October.

Synema parvula Hentz.

An immature specimen.

Oxyptila monroensis Keys.

One female from Mobile.

Coriarachne versicolor Keys.

A few specimens. October.

Runcinia aleatoria Hentz.

Several specimens.

Misumena vatia Clerk.

Two females. May.

Misumena rosea Keys.

Many specimens. October.

Misumena georgiana Keys.

A few examples. October.

Tmarsus caudatus Hentz.

Several specimens. October.

Tibellus duttoni Hentz.

A few specimens. October.

Thanatus rubicundus Keys.

Several examples. October.

Philodromus rufus Walck.

A number of young specimens.

Philodromus aureolus Walck.

Three females.

Philodromus vulgaris Hentz.

Many specimens.

Philodromus laticeps Keys.

One immature specimen; the species is quite rare, but very distinct.

Philodromus infuscatus Keys.

One male.

LYCOSIDÆ.

Pisaurina undata Hentz.

Several specimens; also from Opelika.

Dolomedes sexpunctatus Hentz.

Many specimens, mostly young.

Dolomedes scriptus Hentz.

Three specimens.

Dolomedes albineus Hentz.

A few specimens of this rare species.

Dolomedes urinator Hentz.

Several examples.

Lycosa scutulata Hentz.

Many specimens. October.

Lycosa punctulata Hentz.

A few specimens. October.

Lycosa carolinensis Hentz.

Several specimens.

Lycosa missouriensis Banks.

Many specimens of this very distinct and pretty species. September.

Lycosa fatifera Hentz.

L. tigrina McCook.
L. vulpina Emer.

A few specimens.

Lycosa erratica Hentz.

Many specimens, most of them small and with the black venter with a large median yellow area. Also from Opelika. March, October.

Lycosa ocreata Hentz.

L. rufa Keys.

Many specimens, both of pale and dark varieties. Also from Opelika.

Lycosa lenta Hentz.

L. ruricola Hentz.

Many specimens. Quite readily known by the generally pale color and black venter; there is much variation in size.

Lycosa babingtoni Blackw.

L. nidicola Emer.

Smaller than *L. lenta ;* darker above, with three pale stripes on cephalothorax, the median one extending between M. E. Several specimens; also from Opelika.

Lycosa riparia Hentz.

One female. This has the pale median stripe like *L. babingtoni*, but with banded legs.

Lycosa sp.

One female; dark; legs dark; venter dark, but not black; somewhat like *L. floridana* Banks.

Lycosa sp.

One male; pale, resembles *L. ocreata* Hentz, but there are no stiff hairs on the anterior tibiæ.

Trochosa cinerea Fabr.

A few specimens.

Allocosa funerea Hentz.

Several specimens. March, October.

Pardosa milvina Hentz.

Many specimens.

Pardosa minima Keys.

Several examples. October. Also from Opelika.

OXYOPIDÆ.

Oxyopes salticus Hentz.

Many specimens. October.

Oxyopes scalaris Hentz.

A few specimens. October.

Peucetia viridans Hentz.

Many specimens.

PODOPHTHALMIDÆ.

Thanatidius dubius Hentz.

One specimen.

CTENIDÆ.

Ctenus punctulatus Hentz.

Several specimens; also from Opelika.

ATTIDÆ.

Phidippus mystaceus Hentz.

One example.

Phidippus audax Hentz.

Attus tripunctatus Hentz.

Many specimens. September, October.

Phidippus rufus Hentz.

Several specimens.

Phidippus insolens Hentz.

A few specimens.

Phidippus cardinalis Hentz.

Three specimens. October.

Phidippus obscurus Peck.

One female.

Dendryphantes octavus Hentz.

Many specimens. October.

Dendryphantes retarius Hentz.

A few examples. October.

Icius palmarum Hentz.

A few specimens. October.

Icius mitratus Hentz.

A few specimens. October.

Icius elegans Hentz.

One example.

Cyrba tæniola Hentz.

Many specimens. February, October.

Marptusa familiaris Hentz.

Many specimens. September, October.

Habrocestum cœcatum Hentz.

Two specimens.

Habrocestum cristatum Hentz.

A few examples; also from Opelika.

Prostheclina aurata Hentz.

P. cambridgei Peck.

Several specimens.

Saitis pulex Hentz.

Many specimens, mostly young.

Zygoballus parvus Hentz.

A few examples. October.

Homalattus cyaneus Hentz.

One female. October.

LYSSOMANIDÆ.

Lyssomanes viridis Hentz.

Two specimens. October.

PHALANGIDA.

Liobunum vittatum Say.

Several specimens.

Liobunum politum Weed.

One specimen.

Liobunum hyemale Weed.

Two specimens.

Liobunum flavum Banks.

One specimen.

Liobunum speciosum n. sp.

The female shows two pale lines extending from the eye-tubercle to the anterior margin; the male has black trochanters.

Color of female brown; a dark central mark on the cephalothorax, with two pale lines extending from the eye-tubercle to the front margin; eye-tubercle dark brown; palpi pale; legs pale, patellæ light brown, tips of tibiæ brown; venter pale; dorsum of abdomen with a vase-mark margined with clear pale yellow, the mark extending to near tip of body; sides of cephalothorax brown, widest behind, and enclosing a yellow dot. Male nearly uniform reddish yellow above, pale beneath; palpi paler; trochanters black as well as the bases of the femora, rest of legs pale, except light brown patellæ and tips of the tibiæ; eye-tubercle black.

Legs long and slender, eye-tubercle with a few spinules above. Body of female not very slender, of male broad and short, finely granulate, the skin rather hard. Femur I of female twice as long as body; of male two and one-half times as long as body.

A few specimens. September. Separated from *L. bicolor* by pale color, absence of the tubercles mentioned by Wood, markings of the female, etc.

Cynorta sayi Simon.

Several specimens, some in December.

SCORPIONIDA.

Vejovis carolinus Koch. *Die Arachniden*, vol. 10, p. 7.

Body nearly uniform light reddish brown, palpi same color, legs and venter paler, under side of tail dark like the upper side, cephalothorax with pale spots. Cephalothorax longer than broad behind, with a median sulcus throughout, anterior margin emarginate, about one-half as long as posterior margin, surface with groups and rows of granules, these are dark, elsewhere the surface is pale. Median eyes at anterior third, three small side-eyes in a curved row, the third smaller than the others; abdominal segments with granules most numerous on the posterior portion, and a row of larger ones along the hind margin, and a faint median ridge indicated on the middle of the segments, last segment with four granulate ridges, the side pair not reaching the hind margin, the submedian pair outline a broad area, slightly wider in front than behind; tail short, stout, the first four segments short, each a little longer than the preceding one, the fifth nearly twice as long as the fourth; the first segment has three granulate ridges on its sides, the second and third segments have the intermediate ridge arising from near the middle of the upper ridge, while on the fourth segment the intermediate ridge is wanting; all have a ridge each side above, in the fourth terminating much before the tip; the fifth has a ridge each side above, an upper lateral one on the basal part and a lower lateral one for the whole length; on the lower side the first four segments have a low submedian ridge each side, and the fifth has a median ridge; the bulb is nearly smooth above, granulate below, leaving a submedian smooth space each side, the sting is black at tip, of moderate length and curved, no spine below. The palpi are short, about the length of the cephalothorax and abdomen; femur four-sided, broader than high, scarcely broader in the middle than at either end, a granulate ridge at each angle; tibia about as long as femur, broader than high, broader in the middle, being swollen on the inner side, four-sided, with a granulate ridge on each angle and one on the middle of the inner side; hand scarcely as long as tibia, swollen, with seven faint ridges and granules near some of them; fingers rather longer than hand, paler, gently curved, finely denticulate, and with five pairs of larger teeth at about equal distances apart. Sternum five-sided, broad in front; thirteen teeth in each comb; each ventral segment paler on posterior part. Length, 36 mm.

Many specimens. Easily separated from *Centrurus carolinianus* by darker nearly uniform color, by broader five-sided sternum, by absence of spine under the sting, by broader central area of last abdominal segment, by stouter hands and shorter fingers, by lateral eyes farther from anterior margin, by shorter second joint of tail, and by fewer number of teeth in the comb.

PSEUDOSCORPIONIDA.

Chelifer cancroides Linn.

Several specimens crawling over moss in February.

Chelifer muricatus Say.

One specimen.

ACARINA.

Bdella oblonga Say.

One under stones, January; another from Mobile.

Gamasus spinipes Say.

Two specimens of this large and well-marked species.

Gamasus sp.

Many specimens of a small pale species, probably new; abundant in greenhouses in January.

THE PINE BARRENS OF NEW JERSEY.

BY C. F. SAUNDERS.

Lying between the New Jersey Southern Railroad and Barnegat Bay and north of Mullica river there is an area of about four hundred square miles of wilderness, traversed by no railroad and practically uninhabited. This region, which is the very heart of the Pine Barrens of southern New Jersey, is so inaccessible that, so far as I can learn, it has been visited of late years by only an occasional botanist, although its outer borders, at such places as Atsion, Hammonton, Tuckerton, Whitings, Woodmansie, and the Upper or West Plains, have been visited more frequently.

A forty-mile trip in midsummer across the Pine Barrens has drawbacks enough to make even the most enthusiastic flower-lover think twice before entering upon it. The sands are heavy, the flies and ticks and mosquitoes are numerous, the heat is excessive, springs are few and far between, and forest fires are apt to be at their devastating work in the very place to be visited. However, we decided to chance these things, and on the evening of July 3, 1899, found ourselves landed at an old-fashioned hotel at Tuckerton, and bargaining with a resident South Jerseyman—half farmer, half sportsman, and altogether a pioneersman, to use his own expression—for a team to take us across to Atsion with board and lodging *en route,* and the next morning bright and early we were jogging along the road that leads from Tuckerton northwest toward the Lower Plains.

Mile after mile of oak and pine barrens were passed without sign of human habitation, and when five miles were registered we came to the spot which is marked upon the maps as Munyon Field. Here, in old times, had been a house, and a family had lived here, scratching some sort of a living from the sand and fattening hogs on the abundant mast which strewed the ground under the little chinquapin oaks. Now no vestige of human occupation remains save a little clearing which is rapidly filling up with wildings from the surrounding forest, prominent among them that characteristic primrose of the Pine Barrens, *Oenothera sinuata* L. Two or three miles more of similar wilderness and the forest growth thinned out and dwindled down to dwarf proportions as we emerged upon the rolling heathlike expanse of the East or Lower Plains. These plains are about nine miles northwest of Tuckerton and lie south of the East Branch of the Wading river. The West or Upper Plains, which are reached most easily from Woodmansie, lie north of the said branch of the Wading river, and are of less extent than the Lower Plains. The latter possess an area (according to Pinchot's report) of about 7,700 acres, or, roughly, five miles long by two and one-half miles across. Nothing could be more restful to the eye than this rolling expanse of green plain melting away in every direction into the misty distance, the white sand gleaming out here and there like white caps on an emerald sea. The flora appears to be identical with that of the Upper Plains, which have more than once been the objective point of visits by members of the Academy. The luxuriant vines of the bearberry (*Arctostaphylos uva-ursi*) lay sprawling everywhere in the sun, their dry, astringent berries not yet tinged with the crimson that makes them so conspicuous in winter; the pyxie, trailing arbutus, hudsonia, laurel, tephrosia and leiophyllum were so abundant that the whole place must have been like a garden in the spring. *Corema Conradii* is on the Lower Plains as well as on the Upper, a characteristic plant, growing in masses of sallow green. On July 3 we found it in mature fruit—in fact, past its prime, so that the dry little drupes easily shattered off after being transferred to the press.

The same growth of stunted scrub and blackjack oaks and pitch pine covers these Lower Plains as covers the Upper. The average height of these curious little trees, which are abundantly fruited with acorns and cones, is hardly over three feet. Occasionally a clump six feet high or so occurs, and we noted a sassafras or two about six feet high, but for considerable stretches one may walk with his knees in the tree tops. Gifford Pinchot, in his account of the Plains, appended to the last annual report of the New Jersey State Geologist, calls attention to the fact that while the pine is chiefly of coppice growth—that is consisting of sprouts from stumps or from creeping branches of trees which have been killed back by fire—many of the small specimens which appear like sprouts will, if examined, be found to be in reality seedlings with stems and branches creeping on the ground. The prostrate seedlings, he states, exhibit a remarkable similarity to the forms assumed by trees near the timber line on high mountains, and it is a fair inference that the very harsh and exposed situations in which they grow on these South Jersey plains has had an effect analogous to that of great elevation.

About half-way across the Lower Plains, where the road dips down into a little hollow in the bosom of the hills, we found a good-sized pond with sphagnum border, and bearing on its waters several floating islands of sphagnum supporting luxuriant growths of *Cassandra calyculata*, Eriocaulon, sedges, sundews, etc. This, our driver told us, was called Watering Place Pond, and was well known to old hunters, who in former days had killed many a deer on its margin. *Castalia odorata*, *Pogonia ophioglossoides*, *Limodorum tuberosum*, *Azalea viscosa*, *Drosera filiformis* and *intermedia*, *Polygala Nuttallii* and *lutea*, *Proserpinaca pectinacea*, *Hypoxis erecta*, *Lysimachia stricta* were in bloom. *Carex Walteriana*—a graceful southern sedge, which finds its northern limit in the southern New Jersey Pine Barren swamps, luxuriated along with *Woodwardia Virginica*, in the shallow water of the pond's margin, and on the dryer banks the dwarf huckleberry, *Gaylussacia dumosa*—called by our driver, grouseberry—was abundant. The fruit of the other *Gaylussacia* common throughout this region—*G. resinosa*—the same authority invariably spoke of as hog huckleberries, or more familiarly "hoggies." The swamp blueberry (*Vaccinium corymbosum*) also grew by this pond, its luscious fruit just maturing and tempting one to forget home and linger forever by the loaded bushes, as the lotos tempted the companions of old Ulysses.

After leaving the Plains, the old road wound now through dry sandy pine woods, bare of conspicuous flowers, save, perhaps, for the ever-present *Melampyrum lineare* and the yellow banners of *Baptisia tinctoria*—now through damp savanna lands, where we had as roadside companions the thread-leaved sundew's purple flowers, the orange heads of *Polygala lutea*, the magenta blossoms of the grass pink and the snake-mouth Pogonia. *Lophiola Americana* was just coming into blossom, and nothing could be more exquisite than the beauty of its white flannelly corymbs in a condition of half bud, half bloom. The expanded blossoms of this characteristic plant of the damp barrens, though individually small, are wonderfully rich in color, with orange anthers and rich reddish-brown sepals crested with lines of golden wool. In some places the bearberry formed a veritable carpet. The gathering of this plant for shipment to the cities, where it has been more or less extensively employed in medicine, used to be a considerable industry in southern New Jersey. A reminiscence of this oldtime trade still lingers in one of the common names of the plant down there, viz., *uvursy*—the shop name of the bearberry being *uva-ursi.* In a savanna through which we passed just before reaching the east branch of the Wading river we were greeted with the sight of *Abama Americana* in the height of bloom, studding the grass as thick as buttercups. This beautiful little plant, which bears a spike of fragrant yellow blossoms, and is no less beautiful in fruit, when the whole plant, stem and capsules, is suffused with a vermilion glow, is interesting as being found nowhere else in the world except in the wet pine barrens of southern New Jersey. In this same savanna we were delighted to find another most interesting plant, *Tofieldia racemosa,* a liliaceous herb covered with a rough, glutinous pubescence, that makes it anything but pleasant to handle. This species is truly a southerner, and, though the books give its northern limit as southern New Jersey, is credited in Britton's *Catalogue* to only one locality in that State—namely, near Manchester. There it is very scarce and not recently reported, so that our discovery of it would seem to be worthy of note.

Crossing the east branch of the Wading river, and passing through a cedar swamp which was still fragrant (July 4) with the perfume of the blossoms of *Magnolia Virginiana,* we came out upon some cultivated fields and a farmhouse—the first sign of human life that we had met with since leaving Tuckerton eight or nine hours before. It was interesting to note the establishment here in this little cultivated spot in the wilderness, of such familiar weeds as the ox-eyed daisy, English plantain, sheep sorrel, rabbit's-foot clover and *Plantago aristata,* as well as the white hoarhound, *Marrubium vulgare.* A mile or so west of this place and at least four miles from the Plains, we came again upon *Corema Conradii,* this time growing in pine woods, though by no means so abundant as on the Plains.

That evening we pitched our camp on the banks of the Wading river, at a crossing called Allen's Bridge, and while our driver was engaged in preparing supper, we made a sortie across the river and, where the sphagnum was sprinkled with plants of *Drosera filiformis*, with *Lycopodium Carolinianum* growing hard by, we discovered *Schizaea pusilla* in fair abundance. The plants were scarcely fully developed yet, many of them indeed just uncoiling. A number of fertile fronds of the previous year still persisted, but brown and dead and with spore-cases empty. It may not be generally known that this little fern, as well as its relative, *Lygodium palmatum*, is evergreen, at least so far as the sterile fronds are concerned, and a very good time to search for it is in mild midwinter, when, the snow being off the ground and the earth rather bare of green vegetation, the tiny corkscrew fronds are comparatively conspicuous. Growing in the water along the shore of the river at Allen's Bridge, *Juncus militaris* was abundant—a stately rush, which is of especial interest as possessing two sorts of leaves, one of the usual rushlike kind, and the other submerged, borne in dense fascicles, and developing threadlike, knotted blades a foot or more in length—in fact, one would be inclined to regard them as roots, instead of leaves. Near here, also, *Rhyncospora Torreyana* was collected—a beak rush peculiar to the pine barren swamps of the coast between New Jersey and South Carolina, and one of rare beauty.

On the edge of a cedar swamp near Calico—a half-day's travel further west—we again found *Schizaea pusilla* at home, but sparingly, and growing in the same locality, like so many little black-headed pins stuck in the sand, were plants of the tiny *Utricularia cleistogama*. Not far from here we came upon the rarity of an inhabited house. There was an old stone-lined well in the shady yard, and as we leaned on the curbing while the bucket was bringing us up a drink, we were greeted with a beautiful sight of scores of fern plants clinging in the cool damp crevices of the stones far down in the well. *Phegopteris Dryopteris*, *Asplenium filixfoemina*, *Asplenium platyneuron*, and one of the varieties of *Dryopteris spinulosa* were collected. These are not at all Pine Barren species; indeed, *Phegopteris Dryopteris* is a typical mountain form, and as far as New Jersey is concerned, Britton's *Catalogue* gives for it but two stations, both of which are in northern counties of the State, more than a hundred miles away. How it and its companions happened to get in that old well in the heart of the Pine Barrens is an interesting mystery.

From Calico to Batsto, where we had planned to pass the night, our road (which, by the way, was no easy one to follow) led through "Old Martha." This forlorn and desolate spot, a sort of Tadmor in the wilderness, marks the scene of a former hive of industry—for here, in old times, stood and flourished an iron furnace, drawing its supplies of ore from the bogs close by, while the abundant pine forests on every side furnished a wealth of charcoal for fuel. Now nothing remains but a heap of ruins where the furnace stood, and an occasional chimney stack where the houses of the operators had been. A grove of catalpa trees and a wilderness of white poplar suckers helped to give an uncanny look to the place, and we were glad to be off again under the familiar shadows of the pitch pines and scrub oaks.

The road to Batsto is through a very barren stretch, and we found the botanizing poor. From Batsto, where we passed the night, we took a northerly route through sandy pine barrens between the Atsion and Batsto rivers to Quaker Bridge, a spot classic in botanical annals as the first-discovered station of *Schizaea pusilla.* Here we built our last camp-fire, and made a farewell tea of *Solidago odora* leaves, which turned out to be a rather palatable brew—if taken hot. The beautiful greenbrier, *Smilax laurifolia,* another southerner which attains its Ultima Thule in the New Jersey pines, was noted here, while deep in the cedar swamp we found *Abama Americana* in bloom, though not nearly so abundant as we had seen it in the savanna near the Plains. The stream at Quaker Bridge was quite a wild water-garden, with the white water lilies, the blue spires of *Pontederia,* the yellow helmets of the flowers of the bladderwort (*Utricularia fibrosa*), and the showy red blossoms of *Rhexia Virginica,* while here and there in the midst of the green grasses along the river, *Sabbatia lanceolata* would display its ample cymes of white bloom, like showers of stars half fallen. From here to Atsion is four miles, and there we arrived in time for the evening train citywards.

Among the grasses gathered on this trip, and which were submitted to a close examination later on, were found specimens of *Panicum* which Mr. Nash describes as *Panicum Clutei,*[1] in honor of W. N. Clute, my companion on this excursion.

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[1] *Bul. Torrey Bot. Club,* Nov., 1899.

LOWER CALIFORNIAN SPECIES OF CŒLOCENTRUM AND BERENDTIA.

BY HENRY A. PILSBRY.

The Lower Californian species now known of these genera are confined to the plateaux of the middle portion of the peninsula.[1] Thus far none have been found in the mountainous region extending from La Paz southward.

Cœlocentrum[2] is rather widely distributed in Mexico, though none are known in the States immediately bordering upon the Gulf of California.

W. M. Gabb described *Cœlocentrum irregulare*[3] from the high table-lands of the interior, especially about "Moleje" (Muleje), where it lives hidden under loose volcanic rocks. This is on the east coast of the peninsula, a little below the twenty-seventh parallel.

Mons. J. Mabille has more recently described two species belonging to this group, under the generic name *Berendtia*. His *B. Digueti*[4] is costulate with sculptured interstices, or, in his words, "*costellis lamellosis, obtusis, pulcherrime ornata; interstitiis costellarum striis minutissimus, costellisque arcuatis, sat regulariter dispositis, solum oculo armato perspicuis, munita.*" For the rest, it has 19–20 convex whorls, the embryonal 4 or 5 cancellated and beautifully granulose; the last whorl is solute, keeled at the insertion, and with an obtuse, short keel about the umbilical tract; aperture oval, angulate above; the columella is "*contorto-arcuata,*

[1] J. G. Cooper, in the *American Journal of Conchology*, IV, 1868, p. 212, footnote, states that "Mr. R. H. Stretch has recently brought from near Carson Valley, Nevada, lat. 39°, fossils, or rather casts, closely resembling the *Holospira Newcombiana* and *H. irregularis* Gabb, of Lower California. They occur, he says, in the same formation that contains *Carinifex*," etc. Nothing further is known on this topic.

[2] There is a genus *Cœlocentrus* in Mollusca (*Enomphalidæ*), based upon the Devonian *Enomphalus Goldfussi* d'Arch. and the Triassic *Cirrus Polyphemus* Laube Its date is unknown to me, but I have not seen it mentioned earlier than about 1882.

[3] *Cylindrella* (*Urocoptis*) *irregularis* Gabb, *American Journal of Conchology*, III, p. 238, pl. 16, f. 4, 1867.

[4] *Bulletin de la Société Philomathique de Paris* (8), VII, 1895.

ad basin obscure denticulata" from the slight basal channel. Length 30½–33, breadth 5 mm. It is from the "Plateau de San Zavier, N. lat. 25°." Probably this should be lat. 26°, as a Mission similarly named lies near this parallel.

B. minorina Mabille is presumably smaller, though no dimensions are given. It is also costellate, with 4 embryonal whorls minutely sculptured with spirally descending lines, handsomely granulose. The intercostal spaces of the rest of the shell are smooth. Whorls 17, with deep sutures. The last whorl is angulate toward the suture, very obtusely keeled on the back, solute and a little descending. The aperture is angulate above, ovate. Other features are alluded to under the description of *C. Gabbi*, below. It is from "Plateaux above the Arroya de la Purissima." This is doubtless the Mission de la Purissima, above the twenty-sixth parallel of latitude, in W. longitude 112°.

Upon examining Gabb's type lot of *C. irregulare* it became obvious at once that two species were included therein: one (*irregulare*) with the general features of the mainland Cœlocentrums, the other, represented by three specimens, with the last whorl free anteriorly and the aperture shaped like that of *Berendtia*. The latter may be described as follows:

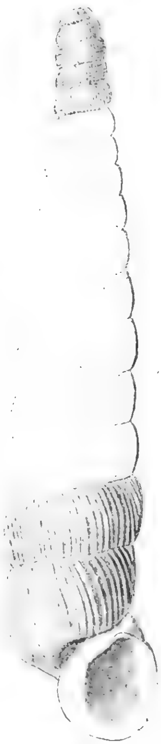

Fig. 1.

Cœlocentrum minorinum var. **Gabbi** n. v. Fig. 1.

Shell very slender and lengthened, cylindrical below, tapering and attenuated above, retaining the apex perfect; thin, rather fragile, covered with a light brown cuticle; composed of 16½–18½ whorls, of which the initial one is globose, the earlier 4½ form a cylindric or apically swollen portion; increase in the diameter of the shell beginning with the fifth whorl and continuing for about 6 whorls, the remaining whorls of about equal diameter; all whorls decidedly convex, separated by well-impressed sutures, the last somewhat more lengthened, a little flattened peripherally, its latter portion becoming free (*Cylindrella*-like), the solute portion variable in length, somewhat descending, decidedly carinated above, obtusely angular at base, with a slight spiral groove within the margin of the umbilical tract, the umbilicus pervious but small. Sculpture: earliest $2\frac{1}{3}$ whorls with close, fine, straight vertical riblets only, the next 2 whorls with the riblets cut into beads by spiral striæ; following whorls with strong arcuate riblets separated by intervals of their own width, and about 62 in number on the next-to-the-last whorl. Aperture irregularly ovate, decidedly oblique, its length contained about five and one-half times in that of the shell; peristome thin, moderately expanded throughout, the inner margin dilated and obtusely angular in the middle; columella slightly concave, a little excavated below. Internal column rather slender, smooth, oblique and slightly gibbous below, less swollen within each whorl than in *C. irregulare.*

Alt. 24.5, diam. of last whorl above aperture 4.5, longest axis of aperture 4.5 mm.; diam. of second whorl 1.7 mm.

Compared with *C. irregulare* Gabb, this form is somewhat more attenuated, with the latter part of the last whorl projecting free, the aperture more oblique and of a wholly different form, strongly resembling that of *Berendtia Taylori.* The riblets are more slender and threadlike; finally the retention of the early whorls may be another difference, but too few specimens of either species are known to warrant insistence upon this character at present.

This form differs from *C. Digueti* in being smaller, with fewer whorls, without sculpture between the riblets, and with scarcely any observable twist to the columella. It is evidently more nearly allied to *C. minorina;* but the riblets are arcuate rather than "*fere rectilineis;*" only the third and fourth whorls have spiral granulose striæ; the last whorl can hardly be said to be "*versus suturam angulato, dorso obtusissime carinato;*" the aperture is not "*paululum obliqua,*" but decidedly oblique; and the columella is simply concave above, channeled at base, not "*torta, leviter incrassata.*" Whether these differences indicate specific distinction cannot well be decided in the absence of a figure or dimensions of Mabille's species, or of specimens for comparison.

In the figure the sculpture is omitted, except on the earlier and later whorls.

Cœlocentrum Eisenianum n. sp. Fig. 2.

Shell excessively slender and lengthened, the upper half much attenuated, retaining the apex in adult individuals; thin, rather fragile, light brown. Whorls 21–22, the first globose, the second slightly wider, then decreasing slightly in calibre to the fifth; the earlier $4\frac{1}{2}$ whorls thus forming a pupoid or slightly club-shaped nepionic portion, below which the diameter slowly increases; last 4 or 5 whorls of nearly equal diameter. All whorls strongly convex; the last whorl a trifle flattened peripherally, its latter third becoming free and deviating tangentially somewhat, the free portion carinated above, having a cordlike keel about the umbilical region below. Umbilicus small. Sculpture: first $2\frac{1}{2}$ whorls bearing very close, fine, delicate vertical riblets; next 2 whorls with these riblets cut into granules by spiral decussating lines; following whorls with close, fine, slightly arcuate riblets, about 47 in number on the next-to-last whorl. Aperture decidedly oblique, rhombic, its length contained nearly eight times in that of the shell; peristome thin, continuous, slightly expanded throughout.

Fig. 2.

Alt. 23.5, diam. of last whorl above aperture 2.7, length of aperture 3 mm.; diam. of second whorl 1.3 mm.

Lower California (Fred L. Button).

This species differs from *C. minorinum Gabbi* in the following respects: With the same length it has a much more slender form, more numerous and narrower whorls, coarser costulation and a smaller aperture. The apical whorls are, moreover, rather more club-shaped. It is not closely related to any other species known.

Cœlocentrum irregulare (Gabb). Figs. 3, 4.

After eliminating the specimens of *C. minorinum Gabbi*, there remain four imperfect examples of this species in the collection presented by Gabb to the Academy. Two of these are young or broken shells, showing only the tapering early growth, without the embryonic whorls. They are about 11 mm. long. Another (fig.

3) is Gabb's figured type, which likewise lacks the attenuated early portion; and the fourth example is an adult shell of which only the lower $3\frac{1}{2}$ whorls remain (fig. 4). The apical characters are therefore still to be ascertained, as well as the total number of whorls, although the species will probably prove to be constantly truncated when adult.

Fig. 3.

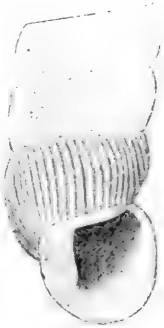

Fig. 4.

The type (fig. 3, sculpture omitted) retains 12 whorls, which are convex and sculptured like those of *B. minorinum Gabbi*, except that the riblets are stronger. The whorls are shorter, so that a greater number is contained in the same length of shell than in the other species mentioned. There are 58 riblets on the next-to-the-last whorl. *The last whorl does not in the least become free but remains adnate*, as in the Mexican species. The aperture is rounded, squarely truncate above, and but very slightly oblique, the peristome is moderately expanded, the outer and basal margins arcuate, columellar margin broadly dilated; parietal margin adnate to the preceding whorl, nearly straight and nearly horizontal. The figured type (fig. 3), which is decollate, measures: Alt. 19, diam. above aperture 4.2 mm.; alt. of aperture 3.5 mm. Another specimen (fig. 4), broken, but with the aperture perfectly adult, measures: Diam. above aperture 4.8 mm.; aperture, alt. 4, diam. 4 mm.

C. irregulare is much like the species of the Mexican mainland except in being smaller and especially more slender. All the specimens known are bleached to a faint brown tint or white.

BERENDTIA.

Berendtia was based by Crosse and Fischer upon the single species *Taylori* of Pfeiffer, with which Gabb's *Cylindrella Newcombiana* is identical. The species is from the same region inhabited by *Cœlocentram irregulare.* The apex of *Berendtia* is retained in the adult state, as in *Cœlocentrum minorinum Gabbi* and *C. Eisenianum*, but unlike most other species of that genus. Beginning with a bulbous tip as in *C. Eisenianum,* there are two finely costulate whorls; then spiral striæ appear and continue for a half whorl, when the termination of the nepionic stage is reached and the oblique costulation of the adult stage begins. The apical characters are therefore essentially as in *Cœlocentrum.* The aperture is ovate with free and entire peristome, very similar to that of *Cœlocentrum minorinum Gabbi.*

The only feature remaining to differentiate *Berendtia* from *Cœlocentrum* is the extremely slender axis, imperforate throughout.

It is evident that *Berendtia* is a tangent from *Cœlocentrum,* and distinguished from certain Lower Californian species of that genus solely by the reduction of the columella from a tube to a solid style, as in the genus *Eucalodium.*

SONORELLA, A NEW GENUS OF HELICES.

BY HENRY A. PILSBRY.

In a former volume of these *Proceedings*,[1] the writer in collaboration with Prof. Cockerell established a new genus for certain externally Polygyra-like Helices from Arizona and New Mexico, under the name *Ashmunella*. It was there stated, with some reserve (p. 191), that "*Ashmunella* is a member of the *Belogona euadenia* or Asiatic-American group of dart-bearers, which has lost the dart apparatus and developed apertural characters of the shell similar to those of *Polygyra*." So far as exterior and shell are concerned, *Ashmunella* converges so completely to the *Polygyra* type that the most experienced malacologists in America were deceived, although, if my view be correct, their phylogenetic history has been widely different.

It was therefore with unusual interest that I found that alcoholic specimens of "*Epiphragmophora*" *hachitana* Dall, recently forwarded by the Rev. E. H. Ashmun, confirm the position in classification proposed for *Ashmunella*, or at least they supply a new genus allied to *Ashmunella* in the degeneration of the appendages of the sexual organs, while some other viscera and the shell have the characters of the Belogonous genus *Epiphragmophora*.[2]

SONORELLA n. g.

Gen. Char.—Shell umbilicate, depressed heliciform, similar to *Epiphragmophora*, but neither malleate nor spirally striate; uniform or having a dark shoulder-band usually pale-bordered; the lip more or less expanded. Genitalia without accessory organs on the ♀ side, the spermatheca globose on a very long duct; vagina long; penis small, continued in a much longer epiphallus, the lower portion of which is embraced by the penis retractor; flagel-

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[1] *Proc. A. N. S. Phila.* 1899, p. 188. See also 1900, p. 107.

[2] *Conf.* note on a young specimen of *E. hachitana* received from Prof. Cockerell, this volume, p. 109, last paragraph.

lum extremely small. Jaw high, arcuate, with few (five or six) strong ribs grouped in the median part. Teeth with side cusps obsolete on centrals and laterals, otherwise as in *Ashmunella* and many other ground Helices. Salivary glands connected merely by some narrow bands above. Lung with simple pulmonary vein or "rachis," the venation chiefly transverse and on the intestinal side; double the length of kidney. Kidney band-like, three times the length of the pericardium (in the type species).

Type.—*Sonorella hachitana* (Dall).

Distribution.—New Mexico, Arizona (and probably southern California and adjacent portions of Lower California and Mexico).

Affinities.—*Sonorella* is like *Ashmunella* in genitalia except that the spermatheca is normally developed and the epiphallus is more embraced by the penis retractor muscle. It also agrees in the pallial organs except that the lung is shorter. The shell differs widely from that of *Ashmunella*, being like the dart-bearing Californian Helices, from which *Sonorella* differs greatly in genitalia, and to a less degree in the shorter lung, with but slightly developed venation on the cardiac side of the rachis. The new genus therefore stands decidedly nearest to *Ashmunella*, but in some important characters (spermatheca, jaw and shell) it is like *Epiphragmophora*, and thus is a connecting link between the two groups.

Sonorella hachitana.

The specimens examined were collected by Rev. E. H. Ashmun, at Oak Creek, Purtyman's, Arizona.

Genitalia (Pl. XXI, fig 5).—Atrium extremely short. Penis slender and small, continued beyond its apex in an epiphallus of about the same diameter, its lower portion somewhat sinuous and completely enveloped in the lower portion of the penis retractor muscle, which has the usual insertion on the lung floor. Latter portion of the epiphallus free, ending in an extremely short flagellum (fig. 5, *fl.*). The vagina is much longer than the penis; spermatheca ovate and very large, with the duct enlarged for some distance near it; lodged near the heart, and caught in the cephalic loop of the aorta. Duct of the spermatheca very long and slender. Other ♀ organs as in *Helicidæ* generally.

Measurements: length of penis 6 mm.; of epiphallus, portion imbedded in penis 5, free portion 6 mm.; of flagellum .7 mm.

Length of vagina 8 mm.; of spermatheca and its duct 35 mm.; diam. of spermatheca 3.5 mm.

Pallial tract (Pl. XXI, fig. 2).—Lung reticulation almost wholly confined to the intestinal side, where the venation is transverse and branching. Cardiac side almost plain, with only a few faint branches, except toward the anterior extremity. Pulmonary vein simple and direct, with no large branches.

Kidney half the length of the lung, three times that of the pericardium, narrow and band-like. Ureter reflexed, as usual.

Digestive tract.—Jaw (Pl. XXI, fig. 4) similar to that of many *Epiphragmophora* species, short and stout, with five or six strong ribs a little wider than their intervals, and grouped in the median portion, denticulating both margins; the ends of the jaw smooth.

Teeth (Pl. XXI, fig. 3), 37, 1, 37; 13 laterals. Rachidian with the cusp shorter than the basal plate, laterals with it longer, the side cusps obsolete. Marginals with the cusps split, as in *Ashmunella* and *Polygyra*.

Salivary glands (Pl. XXI, fig. 2, *s.g.*) long and irregular, concrescent above the crop by several bands and filaments; separate below. Crop long and tapering. Stomach thick. Folds of the intestine mostly exposed on the lower (inner) face of the left lobe of the liver, part of *G* only immersed.

Free muscles (Pl. XXI, fig. 1).—Left ocular band uniting with the pharyngeal retractor (on its ventral face) at about the posterior third of the length of the latter; all the other main muscles fiee except at the columellar insertion where they unite. Buccal retractor (*ph.r.*) split into three bands anteriorly, the two lateral branches once forked. Ocular bands giving off a group of pedal retractors, and the tentacular retractors (*r.t.r.*). Tail retractor (*t.r.*) rather long (pulled to the left in the figure). The right ocular retractor passes between the ♂ and ♀ branches of the genitalia.

Comparison with other Genera.

The genitalia of *Sonorella* agree with *Ashmunella* in wanting any trace of dart-sack or mucous glands. The duct of the spermatheca is very long, as in that genus, but it expands into a large ovate spermatheca, as in *Epiphragmophora*, while in *Ashmunella* there is no distal enlargement. The structure of the male organs is like *Ashmunella*, even in the minute vestigial flagellum; but while

Ashmunella has a double insertion of the penis retractor, which is attached to both penis and epiphallus, in *Sonorella* the retractor muscle envelopes the lower portion of the epiphallus, down to the penis. This is a further development of the other structure. In one species of the subgenus *Micrarionta* examined by Mr. Vanatta and myself,[3] the dart-sack is much reduced in size, but the mucous glands remain, the flagellum is long, and the right ocular retractor does not pass between ♂ and ♀ branches of the genitalia. These features are all unlike *hachitana*.

The pallial organs are much alike in *Sonorella*, *Ashmunella*[4] and *Epiphragmophora* (*exarata* and *fidelis* the only species examined); but the venation of the cardiac side is decidedly sparser in the former two, and the kidney is comparatively longer (or perhaps it should be said the lung is shorter) in *Sonorella*, being only about twice the length of the kidney. The proportionate length of pericardium is nearly the same in *Ashmunella* and *Sonorella*. *Polygyra* has a somewhat longer kidney than any of the other genera mentioned.

The teeth are like *Ashmunella* except in the obsolescence of side cusps on the central and lateral teeth. The jaw is decidedly like that of *Epiphragmophora* in both shape and ribbing.

In the free muscles, *Sonorella* agrees with *Ashmunella*, *Epiphragmophora fidelis* and *infumata*, and even with *Helix aspersa*, in having the left ocular and pedal band united with the pharyngeal retractor, *the right ocular and pedal band separate to its insertion*. This arrangement may prove to prevail in the whole of the *Belogona*, though my observations so far cover too few species to generalize upon. In *Polygyra* a widely different arrangement obtains: the right ocular and pedal band being *united with the left to a point anterior to the origin of the pharyngeal retractor*. This arrangement recalls *Limax*, and is widely different from *Sonorella* or *Epiphragmophora*.

[3] *Epiphragmophora* (*Micrarionta*) *guadalupiana* Dall. These *Proceedings* for 1898, p. 68, Pl. I, fig. 11.

[4] The lung of *Ashmunella thomsoniana porteræ* is shown in fig. 6 of Pl. XXI. Except for the pulmonary vein it appears plain unless viewed by transmitted light, when a sparse venation similar to that of *Sonorella* appears, chiefly on the intestinal side. The kidney is about $3\frac{1}{2}$ times the length of the pericardium, the lung decidedly over double the length of kidney. Measurements are as follows: total length of lung 26, of kidney 12 mm.; and another specimen, lung 24, kidney 11 mm.; the last was measured from the outside through the transparent mantle. The specimens were from the type locality, Beulah, N. M., sent by Prof. T. D. A. Cockerell.

Species of Sonorella.

The anatomy is known only in *hachitana;* but from conchological indications, the following species, originally described as "*Helix*" or "*Epiphragmophora,*" probably belong to *Sonorella:* *magdalenensis* Stearns, *coloradoensis* Stearns,[5] *arizonensis* Dall, *rowelli* Newc., *indioensis* Yates and *lohrii* Gabb, possibly also the true *carpenteri* Newc., though if Binney's description of the genitalia of this species was from a correctly determined specimen, it will belong to *Epiphragmophora.* In the Classified Catalogue published in the *Nautilus,* p. 5 of separate copies, the new genus will probably include numbers 29 or 30 to 35.

Sonorella is probably not much nearer *Epiphragmophora* in shell characters than *Ashmunella* is to *Polygyra;* but in this case the distribution is less restricted and compact, and the prediction of generic position by shell characters may perhaps not have the brilliant fufillment that further material has demonstrated in the case of *Ashmunella.* Still I feel some confidence in the list as given.

This is the third American genus of *Belogona* established since the publication of my *Guide to the Study of Helices,* in 1895, the others being *Ashmunella* Pils. and Ckll. and *Metostracon* Pils. In internal structure the American *Belogona euadenia* are vastly more varied than any known in the Old World.

EXPLANATION OF PLATE XXI.

Fig. 1. *Sonorella hachitana* (Dall). Free muscles, dorsal aspect, the tail retractor brought to the left side. *l.r.*, left labial retractor; *pn.r.*, pharyngeal retractor; *pp.r.*, pedal retractors; *r.o.t.r.*, right ocular tentacle retractor; *r.t.r.*, right tentacular retractor; *t.r.*, tail retractor.

Fig. 2. Pallial region and digestive tract, × 2. G^2, G^4, second and fourth folds of the intestine; *k.*, kidney; *m.*, mantle; *p.*, pneumostome; *s.g.*, salivary glands; *u.*, ureter.

Fig. 3. Teeth.

Fig. 4. Jaw.

Fig. 5. Genitalia. *epi.*, epiphallus; *fl.*, flagellum; *p.*, penis; *p.r.*, retractor muscle of the penis; *sp.*, spermatheca; *sp.d.*, duct of the spermatheca.

Fig. 6. *Ashmunella thomsoniana porteræ* P. and C. Pallial organs.

[5] I have not seen authentic specimens of *coloradoensis* and *arizonensis* and insert them with some reserve.

ON THE ZOÖLOGICAL POSITION OF PARTULA AND ACHATINELLA.

BY HENRY A. PILSBRY, SC.D.

The classification of the land snails has an attraction for the systematic or morphological malacologist disproportionate to the rank of the group; and once entered upon, the phylogenetic problems presented for solution are surpassed in interest by those of no other group, unless it be the Chitons. The great amount of work along sound lines that has been done since the days of Beck and Held has merely opened the mine, as it were; and the wealth in sight is more abundant than our generation can develop.

In dealing with *Partula* and *Achatinella*[1] it appears that nothing yet written upon their structure and its meaning goes to the root of the matter. Fischer, in his admirable *Manuel*, subordinates *Partula* to *Bulimulus* as a subgenus, and places the family *Achatinellidæ* between the *Stenogyridæ* and the *Succineidæ*. Kobelt[2] considers *Partula* to be closely allied to *Placostylus*, a genus of the *Bulimulidæ;* and others have held a like opinion. Semper grouped *Partula* with *Placostylus*, but in his posthumous appendix on the pulmonate kidney, he recognizes that it has the basommatophorous arrangement of kidney and ureter (p. 70).

It is generally agreed that the primary division of the Stylommatophores into *Monotremata* and *Ditremata*[3] is a just one, though the fact expressed in the names has a significance quite secondary to that of the diverse modification of the pallial organs in the two groups.

From the *Monotremata* arose a lateral line, profoundly modified in the structure of the lung, etc., the *Athoracophoridæ* or *Janel-*

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[1] I have been assisted in the examination of these snails by Mr. E. G. Vanatta.

[2] *Syst. Conchyl. Cabinet*, edit. 2, *Placostylus*, p. 5, 1891.

[3] I used the more expressive term *Teletremata* in my *Catalogue of American Land Shells,* but as stability is better than meaning in nomenclature, the innovation was probably unwise.

lidæ. Our knowedge of the morphology of this branch is largely due to Dr. Ludwig Plate, who proposes the term *Tracheopulmonata* for the *Janellidæ*, the remainder of the monotremate group taking that of *Vasopulmonata.*

The two groups *Ditremata* and *Tracheopulmonata* are strongly specialized, and far from the main line of descent of the mass of the Stylommatophores.

The group of *Vasopulmonata*, comprising a vast majority of the air-breathing snails, has been divided into families by characters of the jaw, teeth, shell, caudal pore, scarcely any two authors agreeing in the number or limits of the families so established. No one can review the classifications given by various authors during the past decade without being impressed by the chaotic condition of the subject. This is largely due to the use of external or peripheral organs in taxonomy; the jaw, teeth, caudal pore and form of the shell being directly acted upon by external conditions or food, consequently changing rapidly, and subject to deceptive convergent development.

The truly primary divisions of the *Vasopulmonata* rest upon the modifications of the pallial region. In one series of forms, of which *Buliminus, Partula* and *Achatinella* are prominent members, the ureter passes directly forward from the kidney, toward the anterior margin of the lung. This is also, as is well known, the condition of these organs in the *Basommatophora*, or fresh-water *Pulmonata*, which have been generally, and I believe rightly, considered ancestral to the *Stylommatophora.*[4] Compare *Partula* (Pl. XVII, fig. 8) and *Limnæa* (Pl. XVII, fig. 2). This direct form of kidney and ureter, together with various other characters, indicates, in my opinion, that *Partula* and its fellows with a direct ureter are members of an ancient and ancestral group lying at the very base of the vasopulmonate phylum. This group I propose to call *Orthurethra.*

In all the other groups of *Vasopulmonata* the position of the ureter relative to other pallial organs has been changed, though least in the *Succineidæ* and certain macroögonous genera. From the apex of the kidney the ureter is abruptly reflexed, passing to the posterior end of the lung-cavity. Thence an open groove or

[4] Compare Semper, *Reisen im Archip. Phil.*, III, zweites Ergänzungsheft, p. 70.

a closed tube continues across to the last fold of the gut, which it follows forward to the mantle-edge. This continuation of the ureter is morphologically merely a narrow strip of the ærating surface of the lung set apart by a slight ridge to form a canal, or, in more advanced forms, a tube. It has been aptly called the "secondary ureter," or the gut ureter—*Darmharnleiter* of German anatomists. The snails having this sigmoid form of ureter (Pl. XVII, fig. 6) I propose to segregate as a group, *Sigmurethra*, taxonomically standing equal in rank to its parent group, the *Orthurethra*. The open or closed condition of the secondary ureter is a matter of very little importance. The backward flexure of the primary or true ureter is the significant character, indicating as it does a total change in the route by which the "urine" is conducted from the system.

The group *Orthurethra* consists, so far as I know, of some four or five families, not separated by characters of great importance. The *Sigmurethra*, on the other hand, contains numerous family groups of very unequal relationships *inter se*. The further division of the group is based upon characters of the foot, lung, central nervous system, radula, etc.,[5] the main outlines or skeleton of the system being about as follows:

I. Margin of the foot defined by grooves, etc., . AULACOPODA.

II. No pedal grooves.

A. None of the teeth of the aculeate or thorn-like type; jaw present, distinct, ... HOLOPODA.

B. All of the teeth aculeate, thorn-shaped; jaw often obsolete. Carnivorous.

α. Cerebral ganglia concentrated, in close contact, AGNATHOMORPHA.

β. Cerebral ganglia separated, a rather long commissure connecting them, ... AGNATHA.

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[5] Full discussion of the divisions of *Sigmurethra* is not practicable in this place as it will require extensive illustration. Moreover, material in some families is still eluding me. I have therefore not attempted a partial treatment, but merely give a synopsis of results.

The system of *Vasopulmonata* may then be roughly tabulated thus :

Vasopulmonata.	Orthurethra.	Subdivisions, if any, to be determined.	Partulidæ.
			Pupidæ.
			? Valloniidæ.
			? Cochlicopidæ.
			Achatinellidæ.
	Heterurethra.	Elasmognatha.	Succineidæ.
	Sigmurethra.	Holopoda.	Acavidæ.
			Helicidæ.
			Bulimulidæ.
			Urocoptidæ.
			Clausiliidæ.
			Achatinidæ.
		Agnathomorpha.	Glandinidæ.
			Rhytididæ.
			Streptaxidæ.
			Circinariidæ.
		Agnatha.	Testacellidæ.
		Aulacopoda.	Zonitidæ.
			Limacidæ.
			Endodontidæ.
			Arionidæ.
			Philomycidæ.

Probably there are some other groups of family value, though, of course, no anatomist could multiply families with the liberal hand of some recent writers.

The family *Acavidæ* is here understood to be equivalent to the *Acavinæ* of my arrangement of Helices, with the addition of *Strophocheilus*, which forms a remarkable and archaic subfamily. The *Helicidæ* is not the group so called by Fischer, but stands as defined in *Man. Conch.* (2), ix, *minus* the Macroögona. *Circinariidæ* is a new name for *Selenitidæ*, *Selenites* being preoccupied. I have elsewhere discussed the families of *Aulacopoda*. The *Urocoptidæ* (*Cylindrellidæ*) and *Pupidæ* have been sadly mixed by Fischer; the former family has been the subject of a paper by Mr. Vanatta and myself.[6] Other families need no special remark.

The foregoing is sufficient to show the general position in the system of *Achatinella* and *Partula*, which may now be considered in more detail. What follows is the joint work of Mr. E. G. Vanatta and myself.

Partula rosea Brod.

The specimens dissected were collected by Andrew Garrett.

Pallial organs (Pl. XVII, fig. 8).—The pulmonary vein is the

[6] *Proc. Acad. Nat. Sci. Phila.*, 1898, p. 264.

only blood-vessel visible on the lung wall, the general surface being smooth, densely peppered with white specks in parallel lines; the heart is placed obliquely against the kidney (fig. 8, *k.*), which is short and triangular. From the apex of the kidney arises the ureter (fig. 8, *u.*), which runs directly forward, opening by a lateral pore at its end, which is remote from the mantle edge.

Digestive system.—The jaw and teeth have been described by Binney and others. There is a fusiform crop and moderately dilated stomach (fig. 8).

Genitalia (Pl. XVII, fig. 1).—The penis is quite stout with terminal retractor, and divided internally into a lower, coarsely wrinkled portion and an upper densely granulose and coarsely plicate portion. The vas deferens opens above a papilla at about the lower third of the granulose part. The vas deferens is bound to the penis, to the vagina and basal portion of the spermatheca (the adnate portion being shown by dotted lines in fig. 1); it is then free as far as the upper portion of the oviduct, where it is again shortly adnate. The ovisperm duct is strongly knotted as usual.

The basal portion or duct of the spermatheca is much swollen, the upper part being conspicuously smaller and tapering. There is an egg in the oviduct in the preparation figured.

Free muscles (Pl. XVII, fig. 4).—The buccal retractor is free to its proximal insertion. At about the middle of its length the left ocular and tentacular retractor joins it, and a little further out the anterior foot retractors branch off. The broad posterior pedal or tail retractor is united far forward with the right ocular and tentacular retractor, which gives off a group of anterior pedal retractors (fig. 4). The right ocular retractor passes between ♂ and ♀ branches of the genitalia.

This muscle system differs from that of *Achatinella* chiefly in the union of the right ocular retractor with the tail retractor. In the latter genus both ocular retractors are free.

Achatinella dolei Baldwin.

The specimens dissected were received from Mr. D. D. Baldwin.

Pallial organs (Pl. XVII, fig. 3).—The broad pulmonary vein is the only conspicuous blood-vessel. The surface of the lung is heavily pigmented and intensely black, except anteriorly near the rectum, where it is paler. It is traversed by very fine veins transverse to the pulmonary vein. The heart lies parallel with the kidney. The anterior end of the pericardium and the adjacent surface of the kidney are blotched and dotted with black pigment. The kidney is bulbous or ovate, passing into a wide, pale-colored ureter, which runs directly forward nearly to the anterior edge of the mantle. From its apex a narrow ridge or thread runs backward a short distance on the side toward the rectum; the space between this thread and the ureter having the pigment arranged in oblique striæ.

Digestive system (Pl. XVII, fig. 3).—The jaw and teeth of *Achatinella* have frequently been figured, and need not be described here. The salivary glands (*s.g.* and fig. 3*a*) are united above and below the œsophagus, forming a complete ring. The œsophagus is long and unusually slender, not dilated into a crop. The stomach is much lengthened, curved at the end. Intestine unusually long, especially the fourth fold (fig. 3, on the right side).

Genitalia (Pl. XVII, fig. 7).—The external orifice is on the left side, as usual in sinistral species. The penis is moderate in length, cylindrical, with terminal retractor muscle and vas deferens. From the middle of its length arises a very long, vermiform appendix (*ap.*), which is irregularly coiled, and between the lower third and fourth of its length is conspicuously constricted for a short distance. Near the base of the appendix a branch of the retractor muscle is inserted, passing to the apex of the penis. The lumen of the penis is narrowed above by two large pilasters, at the apical end of which the vas deferens enters. The orifice communicating with the cavity of the appendix is situated at the lower end of one of the pilasters.

The vas deferens is completely free from the other organs, from its lower insertion to the base of the albumen gland, where it becomes adnate.

The vagina is quite short. The spermatheca is small and ovate, upon a very long, slender duct, and is imbedded in the albumen gland (but shown removed therefrom in the figure). There is a long free oviduct, and a sacculated uterus, much distended by the young contained in the individual figured. The albumen gland is divided into slender cæca (fig. 7*a*), clustered in a dense mass.

Free muscles (Pl. XVII, fig. 5).—The retractor muscles of the tentacles are free from the tail retractor, and both divide into three branches, ocular, tentacular and anterior pedal, at about the middle of their length. The left ocular band passes between ♂ and ♀ branches of the genitalia. The buccal retractor (*ph.r.*) unites with the left tentacular band at about the posterior fourth of the latter; it is deeply bifurcate anteriorly. The retractor of the tail (*t.r.*) is normal except in its freedom from both tentacular bands.

While *Achatinella* is obviously allied to *Partula* by the direct ureter and plain ærating surface of the lung, it differs so conspicuously in other characters that no very close relationship can be admitted. The ureter in *Achatinella* approaches nearer to the anterior edge of the mantle, and has a terminal ridge, apparently homologous with that of *Limnæa*. The digestive system is lengthened, though of the ordinary four-folded type. The genital system approaches that of *Buliminus* in the appendix of the penis, but is peculiar in the freedom of the vas deferens from the oviduct. In this peculiarity, however, *Partula* shares to a great extent, the adhesions being superficial. The unique structure of the albumen gland and its envelopment of the spermatheca are more aberrant characters. Usually a long-stalked spermatheca is caught with the gut by the cephalic branch of the aorta, and lies near the heart, separated from the albumen gland.

The family *Achatinellidæ* is apparently a group of great antiquity, the archaic pallial organs and male genitalia being associated with peculiarly specialized female reproductive organs.

EXPLANATION OF PLATE XVII.

Fig. 1. *Partula rosea.* Genitalia.
Fig. 2. *Limnæa stagnalis.* Pallial region and digestive tract.
Fig. 3. *Achatinella dolei.* Pallial region and digestive tract.
Fig. 3*a*. *Achatinella dolei.* Lateral view of salivary gland.
Fig. 4. *Partula rosea.* Free retractor muscles, dorsal aspect.
Fig. 5. *Achatinella dolei.* Free retractor muscles, dorsal aspect.
Fig. 6. *Rumina decollata.* Pallial region and digestive tract.
Fig. 7. *Achatinella dolei.* Genitalia.
Fig. 7*a*. *Achatinella dolei.* More enlarged tubules of the albumen gland.
Fig. 8. *Partula rosea.* Pallial region

ap., appendix; *k.*, kidney; *l.o.r.*, left ocular retractor; *l.t.r.*, left tentacular retractor; *ph.*, pharynx; *s.g.*, salivary gland; *sp.*, spermatheca; *s.u.*, secondary ureter; *t r.*, tail retractor; *u.*, ureter.

THE GENESIS OF MID-PACIFIC FAUNAS.

BY HENRY A. PILSBRY.

The new system and implied phylogeny of the Vasopulmonata outlined in my paper on *Partula* and *Achatinella* throw a new light upon the constitution of the island faunas of the Pacific, and reopen the whole discussion of their origin and distribution.

Within the last decade a South Pacific continent, stretching its great arc from New Zealand to Chili, has been postulated by Dr. von Ihering[1] and Professor Hutton,[2] while Dr. G. Baur[3] has also adduced evidences toward a similar conclusion. This hypothesis will be alluded to below. The views of Wallace regarding these faunas, based upon the absence of amphibia and terrestrial mammals, and upon certain geological considerations, have been accepted by the great majority of zoogeographers, who hold that the Polynesian faunas have been forever insular, and have derived their constituents from circum-Pacific continents by over-sea drift, and by wind or birds carrying animals or their eggs.

To the student of vertebrates such conclusions seem justified by the facts; but a little reflection shows one that opinions based upon the distribution of vertebrates may require radical revision when

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[1] *Trans. New Zealand Institute*, XXIV, 1892, "On the Ancient Relations between New Zealand and South America."

[2] *Proc. Linn. Soc. of New South Wales*, 1896, p. 36, "Theoretical Explanations of the Distribution of Southern Faunas." Professor Hutton has given so full a summary of the principal literature bearing upon the subject, that I feel it unnecessary to lengthen the present communication by a bibliography. Two strong papers upon similar topics have appeared in the same periodical since Hutton's paper—Deane's "President's Address," *P. L. S. N. S. W.* for 1896, p. 821, and Hedley's "A Zoogeographic Scheme for the Mid-Pacific," 1899, p. 391.

[3] *American Naturalist*, XXXI, 1897.

invertebrate groups are taken into consideration. This is especially true in zoogeographic matters because the higher groups have changed rapidly, the lower slowly. Many genera of land snails reach back to the oligocene unchanged save in specific characters, and there can be no reasonable doubt that the modern family groups of these snails diverged far back in mesozoic time; yet how complete a revolution the brief pliocene wrought in mammalian life! A land mass isolated in, say, mid-tertiary or oligocene times, would necessarily be lacking in many important mammalian genera and families developed subsequently, yet it might be quite identical in molluscan genera with the tract from which it was insulated. The existing families and genera of even the reptiles and batrachians do not have the antiquity of groups of the same nominal rank among non-marine mollusks. But no especial argument need be made here in support of the thesis that *the rate of structural differentiation has been constantly accelerated as animals rose higher* in the scale; and therefore it follows that zoogeographic "provinces" based upon the distribution of land snails or earthworms, for instance, recall older arrangements of sea and land than those based upon the distribution of terrestrial vertebrates—mammals and birds.

Now upon glancing at the table of mid-Pacific faunas on p. 576, the student of continental molluscan faunas will first notice the great rarity of *Holopoda*, and the total absence of *Agnathomorpha* and *Agnatha*, and of the more specialized and presumably late Aulacopod families *Limacidæ, Arionidæ, Philomycidæ,* as well as the highly organized forms of *Zonitidæ* with complicated genitalia, such as the *Ariophantinæ.* This leaves a fauna composed almost exclusively of *Orthurethra, Elasmognatha,* and the less specialized families of Aulacopoda. The land operculates are chiefly *Realiidæ* and *Helicinidæ;* and in the fresh-water faunas, *Limnæa, Planorbis* and *Physa* of the continents give place to "*Bulinus,*" a stock probably ancestral to *Planorbis;* and "*Melania*" alone represents the prosobranchs.

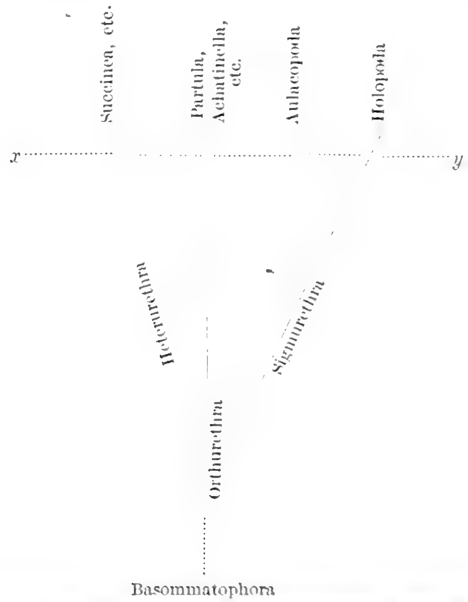
The significance of a fauna so constituted becomes startling when we consider that the *Orthurethra* are a little-changed remnant of the parent stock of all Vasopulmonata; the *Elasmognatha* are an early branch of this stock, while the *Aulacopoda* are unquestionably, on anatomical grounds, the lowest branch of the *Sigmurethra* or ordinary land snails.[4] Is not the whole fauna what we would expect in a region populated near the time of divergence of the earlier groups of Vasopulmonates, and isolated since? Or, to state the question in its bald entirety:

Are the mid-Pacific snail faunas witnesses to the existence of a palæozoic or early mesozoic land mass, probably continental in proportions, and peopled by representatives of nearly all land-snail groups then existing?

A negative answer implies the alternate hypothesis that these faunas are assemblages of waifs, the survivors of many a precarious voyage. An affirmative answer should give reasons for the supposition of more extended land area than now exists, and for the geologic date assigned.

The primitive or antique character of the Polynesian faunas, commented on above, may be graphically represented by a table, in which the families and genera of land Pulmonates of continents

[4] See these *Proceedings*, p. 564, for a sketch of the classification of Pulmonates. The earlier phylogeny of the main groups may be roughly represented by the following diagram:



The line x–y may represent the degree of differentiation reached when the Pacific land-faunas were established. Subsequent differentiation is not represented on the diagram.

or continental islands are contrasted with those of the mid-Pacific. I select continental North America, Great Britain and the Philippine Islands for this purpose, merely because good recent lists lie on my desk;[5] but practically the same results would be seen were I to contrast South America, the Antilles, Africa, Europe or Australia with the Pacific archipelagos.

	Polynesia.	Philippines.	Great Britain.	United States.
DITREMATA:[6]				
Veronicellidæ, Rathouisiidæ		2		1
ORTHURETHRA:				
Achatinellidæ	4	1		
Partulidæ	1			
Pupidæ	2	5	3	5
HETERURETHRA:				
Succineidæ	2	1	1	1
SIGMURETHRA: (*Aulacopoda*):				
Zonitidæ[7]	5	18	3	9
Limacidæ			3	2
Endodontidæ	2	3	2	4
Arionidæ			2	7
Philomycidæ				1
(*Agnatha* and *Agnathomorpha*):				
Testacellidæ			1	
Glandinidæ				1
Streptaxidæ		2		
Circinariidæ				1
(*Holopoda*):				
Helicidæ		11	7	11
Bulimulidæ		1		4
Urocoptidæ				4
Achatinidæ[8]	1	5	3	3
Clausiliidæ		1	2	

[5] In tabulating the genera I have taken a few liberties with the Conchological Society's British list, in subdividing their "Helix" group, and with Dr. von Moellendorff's Philippine list in lumping some of his families of *Holopoda*. These changes are made merely that the values of the groups used may be more uniform. To count families and genera in the three lists as they stand would give a false idea.

[6] Existing Ditremata may be looked upon as excessively modified from a very old branch of Pulmonates. I cannot accept Dr. von Ihering's theory of the primitive structure of *Vaginulus*, or the homology of the Stylommatophore lung with a renal duct.

[7] The Polynesian *Zonitidæ* are all unspecialized genera, the Philippine mainly of more complex structure, and the British and American partly so.

[8] This family is used here in the conventional sense, synonymous with Fischer's *Stenogyridæ*. We know little of the structure of many small members, but probably they will group in two rather widely separated families.

Note that the *Sigmurethra* in North America number 11 family groups and 47 genera (with a vast preponderance of species), to 3 families and 7 genera of all other (lower) Stylommatophores. In Polynesia there are only about as many genera of *Sigmurethra* as of *Orthurethra*, and nearly the whole of the former belong to low and primitive types of *Aulacopoda*.

But, it may be objected, oceanic faunas are thus unsymmetrical from the very nature of the accidental means by which oceanic islands have been populated. Granted; but is there any reason why the occasional and unusual vehicles by which such population is effected should act with exclusive discrimination against whole series of higher groups, in favor of the lower? It is very easy to show that snails may have been carried from place to place by a hurricane, a floating tree or "floating island," or their eggs may find room in the pellet of earth clinging to a bird's feather; but it is incumbent upon the theorist who peoples the mid-Pacific islands by such means to show why such dominant groups as the *Helicidæ*, *Bulimulidæ*, *Rhytididæ*, *Streptaxidæ*—in fact, the whole Holopoda and Agnathomorpha, with higher members of Aulacopod families, as well as the higher operculates—should have utterly failed to take advantage of these means of transport.

To the possible objection that low forms survive an ocean voyage better than high, may be urged the fact that such has not been the case in Madeira, the Azores, Cape Verdes, St. Helena or Bermuda, in all of which Holopod groups occur, and in many cases were established long enough ago to become generically or specifically differentiated. To the further objection that the primitive groups may adapt themselves more readily to new environments, the same argument applies. Moreover, it is well known that the most successful emigrants of all snails are species of the highly organized or specialized *Helicidæ*, *Achatinidæ*, *Limacidæ* and *Arionidæ*, which have followed modern agriculture and commerce all over the world. Although a number of snails have been introduced by commerce into Polynesia from the East Indies, Europe or America, I know of no single case of a Polynesian snail becoming acclimated in any other part of the world.

The advocate of a Polynesian waif fauna is then compelled to adopt the view either that accessions to the mid-Pacific snail faunas practically stopped a long time ago, from causes unknown or hypothetical, or that an unparalleled series of accidents intervened to prevent the, in recent times, ubiquitous and prominent continental groups of snails from effecting a landing in these islands.

Wallace derives the Polynesian faunas from his Australian region, mainly on the evidence of the birds. But no such idea can be entertained regarding the snails. In a rich development of *Endodontidæ*, the two areas agree; but that family is of world-wide distribution and known great antiquity, and therefore proves nothing. Nowhere in Australia, New Zealand or adjacent islands do we find a parent stock for the most characteristic of Polynesian groups, the *Orthurethra*. Australia itself has of this group only modern continental types of *Pupidæ*—*Pupa*, *Pupoides* and *Bifidaria*,[9] which probably reached that continent with the epiphallogonous Helices, from an East Asiatic center. If there were earlier Australian *Orthurethra*, they became wholly extinct before the higher snail groups which have long occupied Australian soil. Most of the *Pupidæ* (except *Bifidaria*) and the few other *Orthurethra*, such as *Tornatellina* and *Partula*, which extend into Melanesia, etc., are Polynesian in their affinities, and evidently to be regarded as outlying colonies from that centre, derived from the western edge of the Pacific land. Far from being a faunal dependency of the Australian or Oriental regions, Polynesia has every appearance of being a region which started with a fauna long antedating the present Australian and Oriental faunas, developing along its own lines, retaining old types because they did not come into competition with the higher groups developed on the greater and less isolated continents.[10] It is significant that the typical Polynesian groups attain their acme of structural as well as specific differentiation in the mid-Pacific Society and Hawaiian groups. Were these faunas derived from waifs drifted, blown or otherwise carried from the Australian or Oriental regions, we might reasonably expect a diminution from the West outward, such as the Azores show compared with Madeira, or Bermuda compared with the Bahamas.

On the supposition that Polynesia has always had the constitu-

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[9] These *Proceedings*, p. 426.

[10] It seems characteristic of islands that while specific differentiation usually proceeds apace, more fundamental changes are retarded, or perhaps, more properly, are not induced; and the faunæ lag behind those of the continents, old types lingering on.

tion the name implies, it is difficult to see why agencies which introduced representatives of some eight families of snails into the Hawaiian group should totally fail to act during the late mesozoic and tertiary. Even Wallace felt that some explanation was called for, and speaks vaguely of the "extensive shoals to the south and southwest" and "two deep submarine banks in the north Pacific between the Sandwich Islands and San Francisco."[11]

Dr. G. Baur, in discussing the Galapagos fauna, applied the terms "harmonic" and "disharmonic" to island faunas and floras. The fauna or flora of a continental island will be *harmonic*, because it will share the several groups of the parent continent in due proportion. An island elevated from the sea bottom and not connected with other land will have a *disharmonic* fauna and flora —"that is to say, it will be composed of a mixture of forms which have been introduced accidentally from other places."

It is almost inconceivable that a number of widely separated islands of oceanic origin should agree or be harmonic among each other in their faunal constituents; but taking the Polynesian groups included in or adjacent to a triangle with the Hawaiian Islands, Marquesas and Samoan groups at the angles, we find a remarkable agreement between their faunas. Comparing any one with the nearest continental faunas of to-day, they seem disharmonic; but *among themselves* there exists a remarkable homogeneity; and if we compare them with what the continental faunas must have been shortly after the divergence of the Holopod from the Aulacopod *Sigmurethra*, it will be seen that Polynesia now possesses representatives of what must have then been all the main groups of Vasopulmonata; and the preponderance of *Orthurethra* is precisely what would be expected.

The harmonic characters of these faunas is the more striking when we compare them with the Atlantic islands admitted to be "oceanic"—Madeira, the Azores and the Cape Verdes. In these islands the genera are all clearly derived from Eur-African sources, being all either genera still existing on the mainland, or more nearly allied to existing or tertiary European groups than to those

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[11] In writing that "none of these oceanic archipelagos present us with a single type which we may suppose to have been preserved from mesozoic times" (*l. c.*, p. 305), Wallace makes a statement totally at variance with the nature of their land mollusks.

of any other part of the world. Only two genera are common to the three island groups and the mainland, and but one other genus is common to the three archipelagos. Madeira and the Azores have 7 genera in common, and Madeira and the Cape Verdes 7; only 4 of these being identical in both cases, and this in a total fauna of 21 genera, 16 of which are common to Europe and one or another of the island groups. We eliminate from the account all known or presumed introductions during the period of commerce. The sporadic or disharmonic character of the faunas is strikingly illustrated by the almost omnipresent Palæarctic genera *Clausilia*, found only in Madeira; *Helicella*, wanting in the Azores, and, further, by the distribution of *Cochlicopa*, *Helix*, *Punctum*, and especially *Succinea* and *Buliminus*, both groups of great antiquity, the former found on almost all islands, but wanting in the Azores and Madeira. The presence of slugs (*Plutonia*) on the outlying Azores, and their absence in Madeira (until *Limax* was introduced by commerce) is also notable.

The distances are much less than those sundering many of the Pacific archipelagos, and yet their faunas are less harmonic than those of Polynesia. And still in all probability the older elements of these Atlantic waif faunas do not much precede the tertiary, if at all, and additions by natural causes have continued to, I suppose, the present time. Indeed, part of the common element in the three island groups may fairly be traced to a common ancestry in the European tertiary, rather than to actual communication between the archipelagos themselves.

Contrast, now, a table of seven widely separated Polynesian faunas:

	Hawaiian Is.	Marquesas.	Cook's Archip.	Tahiti.	Tonga.	Samoan Is.	Caroline Is.[12]
Orthurethra:							
Tornatellina	*	*	*	*	*	*	*
Achatinella, etc.	*						
Partula		*	*	*	*	*	*
Pupa	*	*	*	*	*	*	*
Elasmognatha:							
Succinea	*	*	*	*	*	*	*
Aulacopoda:							
"Microcystis"	*	*	*	*	*	*	*
Trochomorpha		*		*	*	*	*
Other larger Zonitidæ		*		*	*	*	*
Flammulina							*
Charopa	*		*	*	*	*	*
Endodonta	*	*	*	*	*	*	*
Holopoda:							
Opeas	*		*		*	*	*
Aquatic snails:							
"Bulinus"	*				*		
Melania	*			*	*	*	
Rhipidoglossa:							
Helicina	*	*	*	*	*	*	*
Hydrocenidæ					*	*	*
Tænioglossa:							
Realiidæ		*	*	*	*	*	*
Diplommatina						*	*
Ostodes						*	

The remarkable homogeneity of faunas scattered over so wide an area as Polynesia, indicates either a former great extension and therefore approximation of the archipelagos, or that they actually formed parts of a single land mass. Although the distances between them are generally far greater than separate the Atlantic island groups, the faunas show a much greater common element; and had they been derived from similar sources it is difficult to see why the Atlantic faunas should be so much less harmonic than the Pacific.

The former moderate extension of the Hawaiian and other islands considered probable by Wallace, while a step in the right direction, is insufficient to account for the facts. The faunas are, in

[12] *Pupina* and *Eulota* also occur in the Carolines. *Flammulina* will doubtless be recognized in other island groups.

fact, what might be expected were they remnants of a sunken continent; and the waif theory signally fails to account for their composition, although no such difficulty attends its application to the Atlantic islands.

It may fairly be asked, Why have Polynesian snail faunas failed to be enriched by the action of those means of dispersal which peopled the Atlantic islands? (1) Because in mid-Polynesia the distances between islands are great, and few snails are likely to survive the voyage, whatever the means of transport. Similarly, in the Atlantic we find no American snails in the Azores in spite of favoring currents. (2) There has no doubt been a certain amount of exchange between the island groups. It is only thus that we can explain the presence on several archipelagos of identical species. But this diffusion has been almost entirely restricted to small or minute species, such as *Pupidæ*, *Realiidæ*, etc. "With the exception of the *Auriculidæ* it [*Partula hyalina*] is the *only* species of Polynesian land shell of its size common to two or three distant groups of islands. As the above statement does not harmonize with the distribution of the various species of Polynesian shells as recorded by different authors, I will add that in Dr. Pfeiffer's last volume of his *Mon. Heliceorum*, where he enumerates 77 species of Polynesian (I exclude the Melanesian and Pelew) *Partula*, there exist 26 errors in localities. . . . . All the species which are diffused over one or more groups are *invariably* minute shells."[13]

These observations by the most experienced of Polynesian naturalists agree with my results in studying the Bermuda fauna,[14] and confirms the opinion that the whole Polynesian fauna cannot be due to drift or chance immigrants.

In the case of *Bifidaria* (*Pupa pediculus*), *Opeas juneea*, and probably some other widespread species, I think it extremely likely that they have been carried in vessels from island to island during the period of human occupancy; in some cases probably before the historic period. But there doubtless are a few cases where minute land snails have been carried from one archipelago to another by natural means, and over vast distances. We can hardly explain otherwise the scanty faunas of most of the "low" islands, to say

[13] A. J. Garrett, in *Journ. Acad. Nat. Sci. Phila.*, VIII, 396.
[14] *Trans. Conn. Acad. Sci.*, X, 1900.

nothing of the unquestionable occurrence of *Tornatellina* in the Galapagos,[15] this genus being a stranger and alien in America.

In the southwestern Pacific, in and near the area where Forbes maps his "Antipodea" and Hedley his "Melanesian Plateau," comparatively recent groups have invaded a portion of what probably was part of the earlier Pacific land-mass. Some of the early fauna remains, such as *Partula* and *Tornatellina*, but merely as stragglers in a more powerful, more recent fauna, which seems to justify the hypothesis of an early or mid-tertiary land extending oceanward to the Fijis,[16] such as Hedley and others advocate. Obviously later land connections have obscured the far earlier record in this area.

That the hypothetical Pacific continent was finally separated from any other land as early as the middle mesozoic would seem to be indicated by the absence of numerous families of land snails which had become fully differentiated by the end of the mesozoic; and it is evident that the portion north of the equator must have been isolated before the final separation of the remainder from the mainland, not only from the high differentiation of the *Achatinellidæ*, but because certain operculates and some groups of *Zonitidæ*, such as *Trochomorpha*, did not reach the Hawaiian area.

To the southward, it is likely that land extended from the Marquesas (whence granite and gneiss have been reported) and the Austral group to the Fijis or further, and northwestward possibly to the Caroline and Marianne groups, although it is obvious that these have been influenced by their proximity to the Oriental region, by drift or other causes, chiefly shown in the presence of *Eulota*, *Diplommatina* and *Pupina*, as well as certain lizards, etc.[17] Where the Pacific continent may have touched Australo-Asiatic land is of course quite idle to inquire at present.[18]

[15] See Dall, these *Proceedings* for 1900, p. 95. *Tornatellina chathamensis* is the sole species of Polynesian affinities known in the Galapagos. The supposed *Endodonta* I would refer to *Strobilops*, and the *Trochomorpha* to *Guppya*, both American groups.

[16] *Cf.* Baur, *Amer. Nat.*, 1897, p. 676, where the Batrachians and Reptiles of the Fijis are discussed, with a summary of Wichmann's conclusions on their geology.

[17] See v. Moellendorff, Land Shells of the Caroline Islands, *Journal of Malacology*, VII, pt. 5, 1900. Baur, *Amer. Naturalist*, 1897, p. 879, *et seq.*

[18] The following extract from a letter received from Mr. Charles Hedley contains suggestions of value in this connection:

"In a recent paper on the Caroline Island land shells by Moellendorff I have been struck by the similarity to the Tahitian fauna. Can you make

It may be noted here that the distribution of ants and lizards, from which Baur argues, affords no support to the position I have taken, because the former, by having a winged stage, could be much more widely spread by wind than snails, and the distribution of recent Pacific lacertilia cannot possibly date to nearly so early an epoch as that of Polynesian land snails, but is rather traceable to later elevations, after the main mass of the ancient Pacific continent had been isolated or largely submerged.

Returning to the hypothesis of Hutton and Von Ihering, it remains to examine the evidence for a connection between the supposed mid or South Pacific continent and southern South America or "Archiplata." Prof. Hutton, in his temperate and judicious paper of 1896, says:

"The theory of a mesozoic South Pacific continent not only explains the origin of the Australian and South American marsupials, but also the almost simultaneous appearance of different Eutherian mammals in North and South America. We must suppose that this continent threw off first New Zealand, then Australia, then Chili, and finally disappeared under the waves. . . . .

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out any sequence between the *Partula* from North and South Pacific? It would be interesting to learn that those of the Carolines were a derivative of the Tahitian or the reverse.

"Now if you accept my theory that the Marshall-Austral chain is not a phantom but a reality, an earth-fold or line of weakness in the terrestrial crust, then we may suppose a former more or less continous land connection between Tahiti and the Carolines. It would have served for the transmission of *Garretia*, *Partula* and your other primitive snails. On its connection by drift with the Placostylus land we are agreed. In the Gilbert and the Ellice Islands, as I have previously said, the land sank, drowning the primitive fauna, rose again and was repopulated by drift. I am inclined to think that the same fate overtook Samoa. That, however, on rising pressed an earth-fold against the Fijian *massif* and swelled into lofty mountains. That archipelago derived *Ostodes*, etc., by drift from Fiji. Hence it lacked many characteristic forms which survived in Tahiti.

"A grave objection to your hypothesis, and one which deterred me from valuing Tahiti as continental instead of oceanic, is that it proves too much. Although a palæozoic continent is so far back as to be almost out of sight, still some other forms ought to be found to support your snail fauna. I do not press the fact that the insect fauna is extremely poor, since insects are held to be of comparatively recent date. But I do press for collateral evidence from the vegetation. I should like to see an old proteaceous genus, for example, produced. Most of all I emphasize the absence of any peculiar marine mollusca. I think that *Clavella* is peculiar, but I have found none other. The argument that *Nautilus*, *Onchidium* and the Polyplacophora are incapable of drift and though ancient forms are conspicuously absent from Polynesia is worth careful attention. I do not lean on the absence of fossiliferous beds, since circumstances may be imagined under which they might have existed and disappeared."

At a later date, as I pointed out in my former papers, New Zealand must have formed part of a large island joined to New Caledonia, but not to Australia. This has lately been called Antipodea by Dr. Forbes, and the Melanesian Plateau by Mr. C. Hedley. Still later again, New Zealand must have stretched south and obtained its Antarctic fauna and flora from Patagonia through a number of islands."[19]

Notwithstanding the able arguments of Hutton and Von Ihering for a connection between Chili and a Pacific continent, it seems to me to involve grave, in fact insurmountable, difficulties. To have supported a marsupial fauna, to say nothing of Eutherian mammals, this continent must have persisted *at least* to near the end of the cretaceous. But if so, it is inconceivable that there should be no trace in Polynesia of characteristic land mollusks of South America, and none in South America of typical Polynesian groups. It is equally inconceivable that the Pacific continent completely disappeared under the waves about the end of the mesozoic, and that the present islands are of later appearance; for their faunas bear the stamp of a vastly greater antiquity, and (always excepting the "low" islands) have not the characteristics of "drift" faunas. The common elements of Australo-Zealandic and Archiplatan life, such as marsupials, *Bulimulidæ*, crawfishes, etc., are conspicuously absent from Polynesia, and may better, it seems to me, be accounted for by the much-discussed Antarctic route.[20] I cannot trace any connection between the mid-Pacific continent and either of the Americas, nor with any continental mass whatever since the time of the advent of mammals.

One of the chief difficulties in the theory herein advanced is that many of the island groups, notably the Hawaiian, seem to be composed of only comparatively recent volcanic and coral rocks. In this connection Wichmann (as quoted by Baur) remarks: "No older massive rocks or sedimentary strata are known from the other "volcanic" groups of islands of the Pacific Ocean, and on some of these, for example, the Galapagos or the Sandwich Islands—it seems really to be made out that they have been built up by

[19] *Proc. Linn. Soc. N. S. Wales*, 1896, p. 46.

[20] The only Polynesian type in America known to me is *Tornatellina*, in the Galapagos, as already noted. A minute straggler or two may reasonably be expected. The present fauna of "Archiplata" is as remote as any on earth from that of Polynesia.

younger and recent volcanic masses. There is every possibility, and even probability, however, that older formations served as a fundament, the examination of which is prevented by the extensive covering."

Hedley urges the weighty objection that mesozoic plant forms should have survived on so ancient a land. Possibly the great facility with which seeds may be transported over sea allowed a new flora to displace the old one.

Summary.

The hypothesis of a late palæozoic or early mesozoic mid-Pacific continent (upon the sunken heights of which the present island-masses, volcanic or coral, have been superposed) is advanced to account for the constitution of Polynesian land-snail faunas, which are shown to be (1) nearly homogeneous over vast areas, (2) composed of ancient types, with no admixture of the great series of modern families, and (3) not derivable from any tertiary or modern continental fauna or faunas in the sense Atlantic island faunas have been derived. The mollusca, land and marine, supply no evidence that this Pacific continent was ever connected with or faunally affected by the Americas, but emphatically deny such connection.

A PARTIAL REVISION OF THE PUPÆ OF THE UNITED STATES.

BY HENRY A. PILSBRY AND EDWARD G. VANATTA.

In the present communication we have endeavored to express the morphology of the "teeth" or protective armature guarding the apertures of these minute land snails, in a terminology of the structures involved based upon their homologies, and applicable to Pupæ the world over. The remainder of the paper deals with such particular genera and species of the United States as require elucidation, and concludes with a list of the species of our fauna, with a brief statement of their distribution.

Our Pupæ were first systematically studied by Dr. Augustus A. Gould, who published his results in a well-considered monograph, in 1840–43.[1] In 1867,[2] Prof. E. S. Morse did some excellent work on the group, particularly on the species of New England. Mr. W. G. Binney, in his successive works of 1869, 1878, 1885 and 1892, included the species of our fauna then known. Finally, in 1888, Dr. Victor Sterki published the first of a long series of studies upon American Pupidæ,[3] which have marked a great advance in our knowledge of the group, not alone in an increased number of species, but in the more just appreciation of their interrelationships.

TERMINOLOGY OF THE "TEETH" OF PUPÆ.

As is well known, most of the folds or teeth in the apertures of *Pupa* have definite positions, and the principal ones are homologous throughout the group. Pfeiffer[4] adopted a system of terms for them

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[1] *Boston Journal of Natural History*, July, 1840, Vol. III, p. 395; April, 1843, IV, p. 350.

[2] *Annals of the Lyceum of Natural History of New York*, Vol III (1867), p. 207.

[3] *Proc. U. S. Nat. Mus.*, 1888; *Proc. Acad. Nat. Sci. Phila.*, 1890; *Nautilus*, 1890 to 1899.

[4] *Monographia Heliceorum Viventium*, II, p. 300.

in 1848 which was excellent, but not sufficiently detailed. Most later authors have followed this terminology more or less closely. In 1888 Dr. V. Sterki,[5] in an excellent paper on *Vertigo*, proposed to designate the principal folds by letters and the accessory ones by numerals. This system, while justly discriminating between the constant and variable folds, is not sufficiently self-explanatory to be generally useful in descriptive work, and would require modifications as well as additional symbols to adapt it to the description of the numerous exotic Pupidæ with a great number of folds or teeth.

We therefore offer below a revised terminology of the aperture armature, applicable to all Pupidæ, and requiring no especial reference to a key, as the terms are to a large extent self-explanatory.

The folds in *Pupa* are probably not truly homologous with those of *Clausilia*, though some occupy the same positions. It is therefore not practicable to use the same set of terms; but we consider it essential to adhere to the principles used in the terminology of the aperture armature of *Clausilia* as set forth by Messrs. E. A. Smith and B. B. Woodward.[6] The plan is to call all projections upon the parietal wall and columella "lamellæ," those within the basal and outer walls of the aperture "plicæ" or folds. The nomenclature of particular folds is then as follows:

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[5] *Proc. U. S. Nat. Mus.*, XI, 1888, p. 369, Pl. XLII, fig. 5.

[6] *Annals and Magazine of Natural History* (6 Ser.), V, 1890, p. 209. One must actually use the perfected *Clausilia* scheme as set forth in this paper to appreciate its great utility. Fifty years of development have resulted in a plan of consummate simplicity for such a complex subject. Messrs. Smith and Woodward deserve the gratitude of conchologists for their admirable exposé. Compared to this, *Pupa* is simplicity itself. It is much to be regretted that recent French authors do not adopt the Schmidt-Bœttger nomenclature in describing Clausilias.

	Terminology Adopted.	Dr. V. Sterki. 1888.	Dr. V. Sterki. 1889–1898.	Dr. L. Pfeiffer. Monogr. II, 1848.	Corresponding Folds in *Clausilia*.
Upon the parietal wall	Angle lamella	1	Angulo-parietal	lamella angularis	
	Parietal lamella	A	Apertural	lamellæ parietales	Lamella superior
	Infraparietal lamella	2	Infraparietal		Lamellæ interlamellares
Upon the columella	Supracolumellar lamella				
	Columellar lamella	B	Columellar	lamellæ columellares	Lamella inferior
	Subcolumellar lamella				L. subcolumellaris
Within the basal and outer lips.	Basal fold	C	Basal		
	Infrapalatal folds	3, 4			Plicæ palatales
	Lower palatal fold	D	Lower palatal	Plicæ palatales	
	Interpalatal folds				
	Upper palatal fold	E	Upper palatal		Plica principalis
	Suprapalatal folds	5, 6			Plicæ suturales

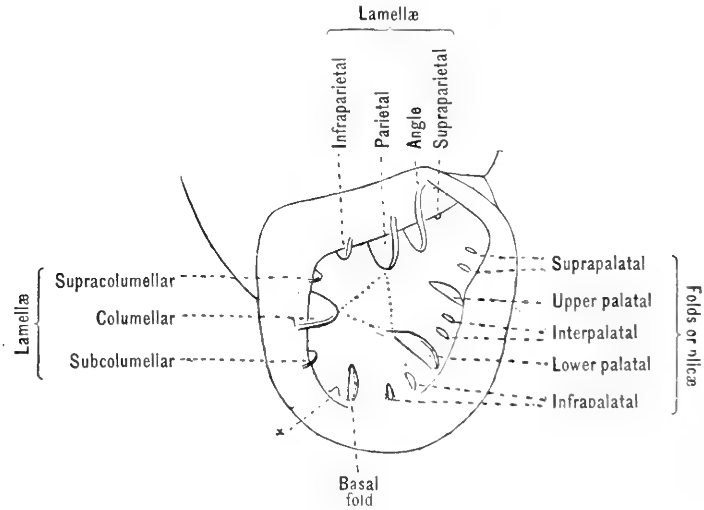

Fig. 1. Terminology of lamellæ and folds.

It will be seen that this is merely an amplification of Pfeiffer's terminology of 1848.

But few Pupidæ have all of the folds named, and some of them are rarely present in American species. Their positions are shown in the annexed diagram, fig. 1, which is a composite, not representing any special species. The infraparietal, supra- and subcolumellar lamellæ and the infra-, inter- and suprapalatal folds are "secondary" in nearly all groups, and often vary in the species. The others are more constant, and vary but little *in position* when developed. *The parietal and columellar lamellæ and the lower palatal fold are at the angles of a nearly equilateral triangle,* when the said palatal is not deeply immersed. This is useful as fixing the identity of the lower palatal, not always clear in multidentate forms, or in those where there has been extensive reduction of teeth; these three being usually retained when all others have disappeared. Thus in *Pupa blandi* or *triplicata* only the lower of the palatal folds is developed, and in *P. armifera* the lower and upper palatals and a suprapalatal, but no basal fold.

With these preliminaries out of the way, we may proceed to discuss certain American species requiring revision.

PUPOIDES.

Pupoides Pfr., Malak. Blätter I, p. 192, 1854, for *B. nitidulus* Pfr. and *B. marginatus* Say.
Leucochila Martens in Albers, Die Hel. 1860, p. 296, type *Pupa fallax* = *marginata* Say.
Leucochiloides Pfr., Nomencl. Hel. Viv. p. 292, 1878, for *B. cœnopictus*, etc.
Pupa sp., *Bulimus* sp. and *Cyclostoma* sp. of Say and authors generally.

A widely distributed genus of toothless Pupæ occurring in equatorial Africa, southern Asia, Australia and both Americas, most of the species closely resembling the one commonly known as "*Pupa fallax*"—the real "*Cyclostoma*" *marginata* of Thomas Say.

Species of the *marginatus* type occur in the United States and West Indies, but in the Andean region of South America, northern Mexico and the adjacent States, Arizona and New Mexico, a group of somewhat dissimilar forms are found, represented by *P. paredesii* Orb., *limensis* Phil., *chordatus* Pfr. and *hordaceus* Gabb.

The names of the leading United States species of *Pupoides* have been involved in errors almost from the time of their description to the present day; it is thus essential that we go to the original descriptions for our nomenclature.

Pupoides marginatus (Say).

> *Cyclostoma marginata* Say, Jour. Acad. Nat. Sci. Phila., II (1821), p. 172.
> *Leucochila marginata* Say, Tryon, Amer. Jour. of Conch., III (1868), p. 305.
> *Pupa fallax* Say of Gould, Binney and nearly all authors and collectors.
> *Pupa arizonensis* Gabb, Amer. Journ. Conch., II, p. 331 (1866).

The name *Pupa marginata* was used by Draparnaud in 1805, and hence when Say's successors transferred his species from *Cyclostoma* to *Pupa* they sought another and unprejudiced name, in an unlucky day selecting that of "*fallax* Say," which has been perpetuated and passed into general use everywhere. Say himself used "*P. marginata*" in all his references to his species, carefully distinguishing *Pupa fallax* from his *marginata*.

Pupa fallax was described in 1825 from a specimen sent to Say by Dr. T. W. Harris, of Milton, Mass. In 1829, after Say had cast his fortunes with the communist society at New Harmony, Ind., he happened upon the shell again, and forgetting his former description, wrote another *of the same specimen* under the name "*Pupa placida.*"

Say was a masterly diagnostician, and it is interesting to see both how similarly he expresses the characters in the two diagnoses and how excellently he pictures the shell, which was really nothing else than the common European *Buliminus obscurus* Müll.!

The two descriptions are as follows:

Journ. A. N. S., Vol. V, p. 121, 1825.

"PUPA.

"P. *fallax.* *Shell* turreted, pale horn colour; wrinkles rather obtuse, hardly prominent: *suture* rather deeply impressed: *volutions* nearly seven, a little convex: *apex* somewhat obtuse: *aperture* unarmed, suboval, truncated above by the penultimate whorl, less than ⅓ the whole length of the shell: *labium*[7] nearly transverse, colour of the exterior part of the shell: *columella* reflected, rectilinear, longitudinal, forming an obvious though a rounded angle with the labrum and labium: *labrum* hardly reflected: *umbilicus* narrow.

"Length more than three-tenths of an inch.

"For this species I am indebted to Dr. T. W. Harris, of Milton, Massachusetts.

"It closely resembles P. *marginata* Nob., but is much larger, and the labrum is not widely reflected; when viewed in front it has a reflected appearance, but the opposite view presents only a very limited excurvature."

The Disseminator of Useful Knowledge, II, No. 15, p. 230, July 29, 1829.

"PUPA.

"P. *placida.* *Shell* dextral, cylindric conic, pale yellowish horn colour; *apex* whitish, obtuse: *whorls* six & an half, somewhat wrinkled: *suture* moderately impressed: *aperture* unarmed longitudinally oval, truncate a little obliquely above by the penultimate volution: *columella* so recurred[8] as almost to conceal the umbilicus: *labrum,* with exception of the superior portion, appearing a little recurved when viewed in front, but when viewed in profile this recurvature is hardly perceptible: *umbilicus* very narrow.

"Length over three tenths of an inch.

"Inhabits Massachusetts.

"For this shell I am indebted to Dr. T. W. Harris, of Milton, from whom I have received many interesting species of our more northern regions.

"At first view it might be mistaken for the P. *marginata* Nob., but it is quadruple the size, and the labrum is not reflected and thickened."

It follows from the foregoing that *Pupa fallax* and *Pupa placida* Say become synonyms of *Buliminus obscurus* (Müll.). *Cyclostoma marginata* Say survives as *Pupoides marginatus* (Say) for our well-known species.

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[7] Error for *labrum.*

[8] Error for recurved.

Pupoides hordaceus (Gabb). Pl. XXII, fig. 11.

Pupa hordacea Gabb, Amer. Jour. Conch., II, p. 331, Pl. 21, fig. 7 (1866).
Pupa arizonensis Gabb, W. G. Binney, Land and Fresh-Water Shells of North America, 1869, Part I, p. 240, fig. 416; and in subsequent works. Not *P. arizonensis* Gabb.
Pupa arizonensis W. G. Binney, Sterki, Nautilus, III, pp. 118, 119.
Pupa gabbi Dall, Proc. U. S. Nat. Mus., Vol. XIX, 1896, p. 367.
Bifidaria hebes Ancey, Pilsbry, Classified Cat., p. 19; Nautilus, XI, p. 117 (1898). Not of Ancey.
?*Pupa arizonensis* var. *saxicola* Ckll., Zoe, Vol. II, 1891, p. 18. (Round Mt., Custer Co., Colorado.) Not *P. saxicola* Lowe nor Moquin-Tandon.
Pupa gabbi mexicanorum Ckll., Nautilus, X, p. 143.
Not *Pupa hordeacea* W. G. Binney; not *Bifidaria hordeacea* Sterki or Pilsbry.

The original description of this species is as follows:

"*Pupa hordacea* Gabb.

"Description.—Shell very small, cylindrical; apex obtuse; whorls 6, convex; suture well impressed, smooth, thin, horn-color; aperture small, rounded below, unarmed, lip narrowly reflected and white; base umbilicate, the umbilicus bounded by an angle.

"Dimensions.—Length .11, width .04 inch.

"Locality.—With the preceding" [Fort Grant, at the junction of the Arivapa and San Pedro rivers, Ariz. Collected by Dr. G. H. Horn].

Gabb's figure is very small and leaves much to be desired, but it has the merit of agreeing with the diagnosis in being toothless. His type lot was a mixture of several species. He did not even take the trouble to separate out *P. procera;* and consequently the specimens he sent out misled conchologists who did not verify them by the description. Mr. Binney figured and described the true *hordacea* as "*arizonensis,*" and the associated *procera* as "*hordeacea.*" Sterki detected the incongruity between *arizonensis* of Gabb and *arizonensis* Binney, but did not recognize the identity of the latter with *hordacea* Gabb. Dall renamed Binney's *P. arizonensis,* calling it *P. gabbi.* In the *Catalogue* published by Messrs. Johnson and Pilsbry, the latter accepted Binney's identification of *P. hebes* Ancey with *arizonensis* W. G. B.,[9] and used that name for the unfortunate species.

So far we have only wandered deeper into the labyrinth, and the several gentlemen who have handled the matter certainly cannot by any hyperbole be called Ariadnes. We find the guiding thread

[9] *Man. Amer. Land Shells,* p. 173, footnote; 2d Suppl. to *Terr. Moll.,* V, p. 40.

in *Gabb's original description* and one of his original specimens (Pl. XXII, fig. 11). *The true Pupa hordacea of Gabb is arizonensis of Binney not Gabb, hebes of Pilsbry not Ancey, gabbi of Dall and mexicanorum of Cockerell.*

The systematic position of this species has not been correctly defined hitherto. It has real affinity to *P. chordatus* Pfr., of Lower California and Mazatlan, and *P. paredesii* Orb., of Ecuador. It has been considered by some to be a toothless *Bifidaria*, allied to *corticaria*, but the characters of the shell seem clearly against this view.

The degree of surface wrinkling or ribbing is somewhat variable, but we have not seen a smooth example, and do not doubt that it is always irregularly ribbed. The specimen figured has 5½ whorls, and measures, length 3.5, diam. 1.6, diam. of penult. whorl 1.36 mm. It is the same shell figured by Binney as *P. arizonensis* and now deposited in the Binney and Bland collection in the American Museum Natural History, New York city. Some of the New Mexican specimens collected by Prof. Cockerell are slightly larger and a little rougher.

We know nothing of the Colorado shells called *P. arizonensis* var. *saxicola* by Mr. Cockerell.

PUPA.

This genus is well developed in Europe, Asia, Africa and Australia, but is represented in America by only six species, so far as we now know. Five of these belong to the holarctic group of *P. muscorum*, while one, *P. sterkiana* Pils., is strongly differentiated, and is the only member of the genus ranging south of the United States. It belongs to the Lower Californian fauna.

Pupa hebes Ancey. Pl. XXII, figs. 9, 10.

P. hebes Anc., Le Naturaliste, 1881, p. 389. Not *P. hebes* Pilsbry, Nautilus, XI, p. 117.

P. arizonensis W. G. Binney, 2d Supplement to Terr. Moll., V, p. 40, Pl. III, fig. 12.

Shell rimate, cylindrical, bluntly rounded at the ends, thin, light chestnut colored, not glossy, very slightly striate. Whorls 6½, the earlier 3 rapidly increasing, the rest of about equal width, quite convex, the last whorl ascending in front, its latter third somewhat compressed, the base showing a blunt projection when viewed in profile; a decided contraction behind the outer lip, but scarcely any crest. Aperture truncate-oval, slightly oblique, without lamellæ or folds, though there is a slight projection on the columella, far within. Peristome thin, narrowly expanded, not in the least thickened within Length 3.5, diam. 1.8 mm.

Near Jerome, Ariz.; Page's ranch, Walnut Gulch and top of Mt. Mingus (about 8,500 feet alt.); collected by Rev. E. H. Ashmun. White Pine, Nev., Ancey's type locality.

Well distinguished from *P. muscorum* and *P. blandi* by the absence of a callus within the lip, as Mr. Ancey pointed out in his original description. The original types are lost,[10] but we have no hesitation in identifying the shells found by Mr. Ashmun near Jerome, Ariz., with Mr. Ancey's species, as they completely fill the requirements of his diagnosis. The senior author of this paper formerly identified *hebes* with *P. arizonensis* of W. G. Binney, following a statement by the latter authority that the two were identical.[11] Attention to Mr. Ancey's diagnosis should have prevented such a *rapprochement*.

BIFIDARIA.[12]

This group was founded by Dr. V. Sterki to contain certain Pupæ in which the parietal and supraparietal lamellæ converge to form a single bifid, or twisted lamella, or lie adjacent; there is a single columellar lamella and, as a general rule, two palatal folds and one basal. He included a large number of American species and a few forms from Asia, *hunana* Gredl., *strophostoma* Mlldff., *armigerella* Reinh., *recondita* T.-C., etc.

The most cursory acquaintance with *Pupidæ* develops the fact that there is a widespread and general similarity in the lamellæ and folds, and in species of many groups, in Europe, South Africa, Australia and America the development of the principal plaits is not conspicuously dissimilar. However, taking the entire structure into consideration, there is no *Pupa* in Europe or South

[10] "Unfortunately I cannot forward to you a specimen of the typical lot of my *Pupa hebes*. The two typical examples have been destroyed. The glass tube containing them was broken when I removed from Boghari, my former residence, and I could find no trace of the shells." *Ancey in litt.* July 16, 1900.

[11] Second Supplement to *Terr. Moll.*, V, p. 40, Pl. III, fig. 12. It is only fair to say that Mr. Binney did not have his *arizonensis* by him for actual comparison, else the union would probably not have been made.

[12] *Bifidaria* Sterki, in Pilsbry, *Proc. A. N. S.*, 1891, p. 315 (for *P. contracta* and *P. servilis*); Sterki, *Nautilus*, VI, pp. 4 (May, 1892) and 99 (Jan., 1893).

Africa which could be referred to the *P. hunana* group of eastern Asia or the *P. armifera* group of America.

The distribution of *Bifidaria* outside of America is extensive. In Japan (*B. armigerella* Reinh.) and China (*B. monas* and *atoma* Heude) the species are minute, and while referable to the typical section of the genus, have affinities with *Albinula*. In India we have the type of a new section in *B. plicidens* Bens.,[13] with a typical *Bifidaria* exceedingly similar to *B. hordeacella* Pils., in *B. mimula* Bens. This type extends to the islands of the Indian Ocean near Madagascar, where we find in *B. seignaciana* C. and F., of Nossi-Be, and *tripunctum* Morel., of Mayotte, forms very close to *mimula* and *hordeacella*, while *B. lienardiana* Cr. (Rodriguez Island), and *exigua* H. Ad.[14] (Mauritius), are so near the Antillean *B. servilis* Gld. that one can hardly believe them different. It is not impossible that these Indian and insular species, which so wonderfully mimic widespread West Indian forms, have really been imported on plants or otherwise from the Antilles, as some Stenogyroid species, *Ennea bicolor*, *Vallonia*, etc., have been carried over the globe. No South African species referable to *Bifidaria* have been found.

In the East Indies *Bifidaria* is represented almost everywhere, though not numerously so far as known. Von Möllendorff records four species from the Philippines—*artensis* Montr., *pediculus* Shuttl., *capillacea* Dohrn and *euryomphala* Mlldff.

Melanesia has the widely distributed *B. pediculus* (Shuttl.) and in Australia there are numerous species of the type of *B. pediculus*.

In Europe there are apparently no recent species, but *P. flexidens*, *obstructa* and *didymodus* Al. Br., of the Main Basin (Lower Miocene), and *heterodus* Bttg. (Middle Miocene) may perhaps be referred here. The recent *P. theeli* Westerlund, of Siberia, from the description seems to be a *Bifidaria*.

It is worthy of note that it is only in America and eastern and

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[13] Section *Bensonella* nov. Peristome continuous, calloused within except near the posterior angle of the aperture; parietal lamellæ long, separate, the angle lamella deeply entering, an infraparietal developed. Palatal folds standing in a row within the labial callus, their number increased by accessory folds. Texture and whitish color of *Bifidaria*. Type *Pupa plicidens* Bens.

[14] This is not *Pupa exigua* Say, and if a valid species, which is doubtful, the name must be changed.

southern Asia that any great diversity of type occurs. The East Indian, Polynesian and Australian species are all of a single rather generalized type characterized by the imperfect union of the parietal and angle lamellæ.

Hypselostoma is an allied genus, with dark-brown, opaque shell and more produced "neck," though some *Bifidariæ*, such as *B. perversa*, parallel it in the latter respect. Genera are rather cheap in *Pupidæ*, but on the whole *Hypselostoma* seems rather nearer to *Nesopupa* and even *Torquilla* than to *Bifidaria*. As a subgenus of *Hypselostoma* we would rank *Boysidia*,[15] in which the conic spire, brown color of the shell-substance and continuous peristome, as well as the dentition, agree. Both of these groups may have the parietal and angle lamellæ either independent or united. We think it will be obvious to any one who will compare several species of *Boysidia*, such as *hunana* Gredl., *strophostoma* Mlldff., *moellendorffi* Bttg., with a number of the less modified forms of *Hypselostoma*, that the relationship is very close. *Hyp. tubiferum*, the type of the genus, is one of the most extreme modifications, and not a fair criterion.

Other Oriental *Pupidæ*, such as *Boysia* Pfr., which may perhaps be a modification of *Pupisoma* Stol., and *Aulacospira* Mlldff., while finding their place in this family, in all probability are not at all closely allied to the forms under consideration.

Regarding the status of the name *Bifidaria*, it should be mentioned that in 1881, Dr. O. Bœttger proposed to transfer *P. fallax* Say from *Leucochila* to *Buliminus*, and retained the name *Leucochilus* for the species allied to *P. armifera* Say,[16] which would thus replace *Bifidaria*. But as the type of *Leucochila* had been expressly stated by Prof. von Martens to be *Pupa fallax* Say (by which *marginatus* Say was intended), such a restriction was unlawful; and as Bœttger considered his group only a modification or restriction of *Leucochila* Martens, I do not see that by changing the gender of the name he rendered it any more acceptable.

In America the *Bifidaria* group has been modified into several subordinate groups, some of wide range and numerous species. These groups may be tabulated thus:

[15] *Boysidia* Ancey, *Le Naturaliste*, May, 1881, p. 407 (for *P. hunana* and *P. dorsata*). *Gredleriella* Mlldff., *Jahrb. d. d. Malak. Ges.*, XI, 1884, p. 179 (for *Pupa hunana*), is a synonym.

[16] Von Martens' *Conchologische Mittheilungen*, II, p. 64.

Key to American Sections of Bifidaria.

a.—Parietal and angle lamellæ independent, long; a columellar lamella and palatal folds present.

b.—Palatal folds deeply immersed, hardly or not visible from the aperture, the lower *behind,* rather than below, the upper, the basal transverse; last whorl straightened and free, the peristome continuous, . *Immersidens* P. and V.

b[1].—Palatal folds normal in positon, not deeply immersed, visible from in front; last whorl normal in shape, not built forward nor free, ... *Sterkia* Pils.

a[1].—Parietal and angle lamellæ very short, small and tuberculiform; no palatal folds; shell cylindrical, . . *Privatula* Sterki.

a[2].—Parietal and angle lamellæ elongate, more or less united, either by a callous ridge or so extensively as to appear like a single sinuous or emarginate lamella.

b.—Aperture not much contracted by the teeth. Shell cylindric or cylindro-conic, rather narrow; parietal and columellar lamellæ moderate or small, the latter a simple entering lamella; palatal folds 3 (sometimes fewer), not situated upon a callous ridge, . . . *Bifidaria* s. str.

b[1].—Throat nearly closed by the teeth. Shell oblong or conic, rather wide; parietal and columellar lamellæ long and tortuous, the latter more or less vertical; palatal folds several, situated on a ridge, . . . *Albinula* Sterki.

a[3].—Parietal lamella simple; no angle lamella; palatals normal or increased by accessory denticles, often standing upon a callous ridge, ... *Vertigopsis* Ckll.

Bifidaria dalliana Sterki. Pl. XXII, fig. 8.

B. dalliana Sterki, Nautilus, XII, p. 91, Dec., 1898.

Nogales (type locality), Santa Rita Mts., and Tempe, Ariz., also Mexican side of line near Nogales, Ariz.

A very small species, length 1.6 to 1.8 mm., differing from *B. hordeacella* chiefly in the much less united angle and parietal lamellæ, the transverse position of the basal fold, and the more deeply immersed lower palatal.

B. pilsbryana is an equally small species, with a simple parietal amella and three subparallel palatal folds, the lower palatal not immersed. It stands between the typical *Bifidarias* and *Verti-*

gopsis, but on account of the absence of an angle lamella we are disposed to rank it with *B. pentodon*, in *Vertigopsis*.

Bifidaria hordeacella (Pilsbry). Pl. XXII, fig. 3.

Pupa hordeacella Pils., Proc. A. N. S. Phila., 1890, p. 44, Pl. 1, fig. *g* to *k*.
Pupa hordeacella Binney, Fourth Suppl. to Terr. Moll., V, p. 193, Pl. 2, fig. 2.
Pupa hordeacella Dall, Proc. U. S. Nat. Mus., XIX, 1896, p. 367.
Pupa hordeacella Sterki, Nautilus. IV, p. 141 ; VI, p. 4.
Pupa hordeacella Ckll., Nautilus, X, pp. 42, 43.
Bifidaria hordeacella Pils., Nautilus, XI, p. 117 ; Classified Cat., p. 19.

Ranges from Cape May, N. J., and St. Simon's Island, Ga., to the St. John's river valley and Sarasota Bay, Fla., west to Indian Territory (Fort Gibson) and southern Texas, and New Mexico. We have not seen it from the Antilles.

The small size (length 2.1, diam. .8 mm.) and slender contour, nearly simple or slightly emarginate parietal lamella and thin outer lip distinguish it from *B. rupicola* and *procera*. In Texas and the West it is light brown, but in Florida is often thinner and corneous. Almost always associated with *B. rupicola* in the eastern Gulf States, and with *B. procera* in the West, but readily separated from either by size alone.

Bifidaria hordeacella parvidens (Sterki). Pl. XXII, fig. 2.

P. hordeacella parvidens Sterki, Nautilus, XII, p. 128 ; XIII, p. 16.

Mescal Gulch, near Jerome, and Jerome, Ariz.

Easily distinguished by the very small size or obsolescence of the upper palatal and basal folds.

Bifidaria procera (Gould). Pl. XXII, figs. 6, 7.

Pupa procera Gld., Bost. Journ. N. H., III, 401, Pl. 3, fig. 12 (1840); IV, p. 359, Pl. 16, fig.12.
Pupa procera Gld. Sterki, Nautilus, IV, p. 140 ; VI, p. 4.
Pupa procera Gld., Ckll., Nautilus, X, p. 43.
Bifidaria procera Gld., Pilsbry, Nautilus, XI, p. 117 ; Class. Cat., p. 19.
Pupa carinata Gld., *olim*, an abnormal shell.
Pupa gibbosa Say, Küster, and *P. minuta* Say, Pfr. Not of Say.
Pupa rupicola Say, W. G. Binney, Land and Fresh-Water Shells of N. A., I, p. 243, figs. 423, 424 ; Man. Amer. Land Sh., p. 328, fig. 354. Not of Say.
Pupa pellucida Pfr., Strebel, Beitr. Mex., Theil IV, p. 91, Pl. 4, fig. 12 ; Pl. 15, fig. 10.
Pupa hordeacea Gabb, W. G. Binney, L. and F.-W. Sh., I, p. 241, fig. 417 ; Man. Amer. L. Sh., p. 173, fig. 165 (bad). Not *P. hordacea* Gabb!

The large size, subcylindrical form, distinctly bifid parietal lamella and deeply situated lower palatal fold separate this species from *rupicola* and *hordeacella*. It ranges from Baltimore, Md., to South Carolina, west to Kansas, and southwest to Arizona and Mexico. We have seen no specimens from Florida.

Binney's description and figure of "*P. hordeacea*" are surprisingly inaccurate, and contradict each other. There is no species known in America which agrees even approximately with either. They were doubtless made from a specimen sent by Gabb, who had *procera* mixed with his *hordacea;* but it is safe to say that they inaccurately represent the shell.

Bifidaria procera cristata P. and V., n. var. Pl. XXII. figs. 4, 5.

Pupa and *Bifidaria hordeacea* Gabb, Sterki, Nautilus, IV, p. 141; VI, p. 4, 102; X, p. 42, 43. Pilsbry, Nautilus, XI, p. 117. Not *P. hordacea* Gabb.

Angle and parietal lamellæ more completely united than in *B. procera,* hardly bifid; crest behind the outer lip very strong. Average size slightly greater.

Length 2.8, diam. 1.2 mm.

Types No. 78,694, coll. Acad. Nat. Sci. Phila., from Camp Verde, Ariz., collected by Rev. E. H. Ashmun.

This Southwestern form is readily distinguishable from *B. procera* by the above characters. It ranges eastward to central Texas.

Bifidaria rupicola (Say). Pl. XXII, fig. 1.

Originally described from Fort Picolato on the St. John's river, not far from St. Augustine, Fla., this species is before us from South Carolina and St. Simon's Island, Ga., southward to Miami, Fla., and west to New Orleans, La. It is abundant along the St. John's river, has not yet turned up in the Texas litoral, but occurs in Cuba and Bermuda.

Compared with *B. procera,* this species tapers much more, a point Say laid stress upon. The outer and basal margins of the lip are broad, flatly spreading and thickened within, but at the posterior or upper curve of the outer lip it abruptly becomes narrower. The parietal lamella is moderately emarginate, and the lower palatal fold is less immersed than in *procera.* There is a very narrow but distinct crest close behind the peristome. The color is subtransparent whitish-corneous or brownish-corneous. Length about 2.4, diam. 1.1 mm. It is larger and more tapering than *B. hordeacella,* which has not the spreading, calloused lip of *B. rupicola.*

Cf. also Sterki, *Nautilus*, IV, 139, where the characters are well indicated.

In addition to the preceding species, another form, insufficiently defined, calls for notice, *B. riograndensis* Sterki. In the *Nautilus*, IV, p. 142, Dr. Sterki gives descriptive notes on a form from Hidalgo, Tex., under the head "*Pupa* ——" It is stated to resemble *P. servilis* Gld., except in having *an infraparietal lamella* and a very long lower palatal fold. In *Nautilus*, VI, p. 4, he lists a "*P. riograndensis* Sterki MSS." from the same locality, without description or reference to his previous note. Of course there is no necessary connection between the nameless *Pupa* with a description and the later nude name; but we have little doubt that the two are identical, though Dr. Sterki in introducing a new name into the list has left others to guess at what it may be.

We have not seen specimens, and in the eight years since the name *riograndensis* was published it has not been made good by a description. If our theory regarding its identity be correct, it may be known by the infraparietal lamella, which is present in no other known *Bifidaria* of the United States fauna.

VERTIGO.

This genus was established in 1774 for the single species *V. pusilla*, of central Europe. Some authors have proposed to unite *Vertigo* and *Pupa* in one genus, bearing the latter name;[17] but the fact that *Vertigo* is the prior name seems to have escaped these gentlemen. *Pupa* was not established until 1802.

Vertigo seems to be neither more nor less distinct than *Bifidaria*, *Torquilla*, *Fauxulus*, *Hypselostoma* and other Pupoid groups now ranked as genera; and while we freely admit that the differences between these groups are not great, it is obvious that if all be united into one genus, that must be called *Vertigo*. The recognition of several genera among the Pupæ seems to us to be a wiser course, as otherwise the relationships of the forms would be lost sight of in so vast and composite a genus.

Vertigo has a wide range in the three northern continents, but apparently does not occur below the equator. The American forms have been studied by Dr. V. Sterki, who has cleared up a

[17] Even by Prof. von Martens, in the *Biol. Amer. Centrali*, 1898, this course has been taken.

number of doubtful points and defined numerous species hitherto unknown in the fauna. There yet remain some wholly undefined names in the literature, which have been awaiting characterization for many years; others, while known by brief diagnoses, call for fuller exposition, while a species defined by Thomas Say seventy-six years ago is now for the first time recognized as valid, and restored to its usurped place.

In America there are several outlying species for which sectional divisions of *Vertigo* have been established—*Nearctula*, *Haplopupa*, *Bothriopupa* and *Angustula*. The last group was established for *V. milium* and V. *venetzii*, the latter a European species, and (under the synonymous name, *V. plicata*) one of the two types of *Vertilla* Moquin-Tandon. *V. pusilla* Müll. was the other species of *Vertilla*, and as it had been made the sole type of *Vertigo* by Müller, it must be removed from Moquin-Tandon's group, leaving *V. plicata* (= *venetzii* = *angustior*) the type of *Vertilla*. Or, to tabulate the matter:

Types of *Vertilla* Moq., 1855	pusilla = Type of *Vertigo* Müller, 1774.	
	venetzii	Types of *Angustula* Sterki, 1889.
	milium	

It would seem from this that *Vertilla* must replace *Angustula* as a subgeneric name for *V. milium* and *venetzii*, the latter species being the type. Several well-known experts in nomenclature to whom we have submitted the case agree in this opinion. It is rather a pity, because Moquin-Tandon had no idea of the really peculiar characters of *V. venetzii*, which were first exposed by Dr. Sterki.

The Group of Vertigo modesta.—The Vertigos of the *californica* and *modesta* groups agree in *lacking a basal fold*, or tooth near the base of the columella. The parietal and columellar lamellæ and lower and upper palatal folds are developed and nearly equidistant, giving a somewhat cruciform outline to the aperture. Sometimes the angle lamella appears, but never any others ; and in a few forms several of the teeth become reduced or lost. The outer lip is not very noticeably caught in at its upper third to form a "sinulus," as it is in most species of *Vertigo*. These features give a particular aspect to the group which Dr. V. Sterki has recognized in taxonomy by the name "*Nearctula*." This distinction, however, is more apparent than real, the species of the *modesta* group really being exceedingly close to such forms as *V. gouldii*, and in fact *V. columbiana* is hardly separable specifically. For this reason, we think *Nearctula* must be restricted to the single species *V. californica*, characterized by its ribbed, opaque shell, and the other species associated therewith by Dr. Sterki will group better among the true *Vertigos*.

The group of *Vertigo modesta* includes species with *a crest varying from very low to strong, behind the lip;* in this respect differing from the group of *V. californica*, the species of which have no crest, and are rather less glossy.

The American species are Canadian or boreal, extending southward in the Rocky Mountain region. Their number has been estimated at as many as eight species and three varieties (Sterki, 1892); but this seems to us to be too generous. We are able to distinguish four species, and several varieties may conveniently be recognized, though their determination is at times difficult from the intergradation with parent stocks. We omit from the account *P. hoppii* Möller, a Greenland species not shown to occur on the mainland of North America (conf. *Nautilus*, XII, 104), and *P. borealis* Morelet, described from Kamchatka, and not known to us from America, the Alaskan Pupæ of this type being referable to *V. modesta* Say, so far as we have seen.[18]

The forms of the *V. modesta* type make a beautiful variation-chain, or "*Formen-kette*," as recent German authors term these series of species connected by intermediate variations in the living fauna. The relationships of the forms may be expressed diagrammatically, dashes representing breaks in the chain; figures referring to Plate XXIII :

castanea, fig. 5.
castanea, fig. 4.
modesta, fig. 3—*modesta*, fig. 6. *corpulenta*, fig. 7.
modesta parietalis, fig. 2.
parietalis, fig. 1.
|
concinnula, fig. 8.
|
arizonensis, fig. 9—*utahensis*, fig. 10—*columbiana*, [fig. 11.

The group not separated by dashes is shown by our series to be

[18] We have not seen Kamchatkan *P. borealis*, but it is evidently very near *V. modesta*, perhaps only a form of that species.

completely connected by intermediate specimens. This is not sufficiently shown in the plate because, in order to emphasize the characteristics of geographic races, we have selected the most strongly differentiated individuals for figuring. In view of the fact that the Rocky Mountain region is most imperfectly explored for small snails, we hold the opinion that still more connecting links will be found, and probably *V. concinnula* will become a subspecies of *modesta.* It is not impossible that *V. dalliana* will fall into line as a terminal member of the series, beyond *castanea,* in which all teeth have been lost.

Variation among individuals from one place, as well as geographic racial differentiation, is ubiquitous among these pygmy snails, though less striking to the eye than in larger forms, or those in which color or sculpture is more modified. The development of the teeth is greatest in the mountain forms, *concinnula* (Pl. XXIII, fig. 8) and *arizonensis* (Pl. XXIII, fig. 9), occurring at high altitudes; while *modesta* (fig. 3) and *castanea* (figs. 4, 5) are at least mainly from much lower levels. The form of *modesta* from the Iowa loess is also more or less deficient in teeth. But we do not think to correlate this character of the shells with mere elevation, for it is more likely to be a reaction due to some unknown element of the faunal environment, such as minute snail-eating insects.

Vertigo concinnula Cockerell. Plate XXIII, fig. 8.

Vertigo californica Ingersoll, Bull. U. S. Geol. Surv. Terr., I, p. 128 (1875). No description. Not of Rowell.
Vertigo ingersolli Ancey MSS. in Cockerell, J. of Conch., Leeds, VI, 1889, p. 64 (name only, substituted for *P. californica* Ing. non Row.); British Naturalist, 1891, p. 100 (not seen); Sterki, Nautilus, VI, 1892, p. 5, with varieties *haydeni* Anc. and *accedens* Anc. (names only); Cockerell, Nautilus, X, 1897, p. 135 (identity with *concinnula* affirmed from part of original lot).
Vertigo concinnula Cockerell, Nautilus, X, 1897, p. 135.
Pupa concinnula Ckll., Pilsbry, Nautilus, XI, 1898, p. 119; Class. Cat. L. Sh. Amer., p. 21; Nautilus, XII, 1899, p. 103.

Shell ovoid-cylindrical in outline, slightly tapering toward the blunt apex; solid and somewhat opaque, so that the folds of the outer lip are usually only dimly seen through from the outside. Surface shining, irregularly, obliquely striate. Whorls 5, apical 2 whitish, the rest chestnut-brown, often with numerous irregularly scattered spots and flecks of very light buff. Whorls quite convex, the last slightly ascending toward the aperture, its latter half very decidedly flattened on the outer-inferior portion, this part bearing a low broad wavelike "crest" or ridge behind the lip, and then slightly constricted. Umbilical rimation short, imperforate. Aperture rounded, truncate above; peristome a little expanded; parietal wall bearing a rather strong entering lamella in the middle, and usually a smaller angle lamella to the right of its outer end; columella with a strong deep-seated entering lamella; outer lip with two rather low long palatal folds, the lower one longest. Alt. .2, diam. 1.1 mm.

The dull, rather opaque shell, cylindrical and small, with long palatal folds and parietal lamella, separate this from *V. modesta* and its varieties, but it certainly approaches *V. modesta parietalis*, which, however, is larger and smoother. The form of *modesta* from Labrador agrees with *concinnula* in having the penultimate whorl distinctly striate. The larger size, more cylindrical shape and presence of an angle lamella distinguish it from typical *coloradensis*. According to Cockerell, it occurs at higher elevations than *V. coloradensis*, between 6,000 and 10,000 feet.

Custer and Summit counties, Colo. (Ckll.); Jemez Mts., N. M. (Ashmun). Numerous other localities in Colorado are given by Ingersoll.

The specimens from the Jemez Mts. have a much stronger crest behind the lip than those from Colorado, and are less opaque.

Vertigo modesta (Say). Plate XXIII, figs. 2, 3, 6.

> *Pupa modesta* Say, Long's Second Expedition, II, appendix, p. 259, Pl. 15, fig. 5 (1824).
> *Pupa decora* Gld., Proc. Bost. Soc. N. H., II, p. 263 (1848). Fig. in text.

More cylindrical than *V. corpulenta*, with one whorl more; crest moderate or low; teeth typically four, parietal, columellar, upper and lower palatal; but sometimes a fifth, the angle lamella, is added.

Fig. 3 is drawn from a specimen from Laggan, Alberta, collected by Rev. George W Taylor. Length 2.5, diam. 1.3 mm.; whorls $5\frac{1}{2}$.

Fig. 2, Dyea Valley, Alaska, collected by Mr. P. B. Randolph. Length 2.4, diam. 1.3 mm. The form is a little stouter than typical, and the crest perceptibly stronger. In some specimens the teeth are slightly better developed than in typical *modesta*, and some have a second parietal lamella. This lot is perfectly intermediate between *modesta* and *parietalis*.

A Labrador specimen (Pl. XXIII, fig. 6) is smaller, length 1.9, diam. 1.2 mm., about the size of *concinnula* Ckll., typical in teeth, but closely and deeply striate on the penultimate whorl. The crest is slighter than in typical *modesta*.

The type locality of *V. modesta*, Northwest Territory, was somewhere in northern Minnesota, southern Manitoba, or near the western end of Lake Superior, on the route of Major Long's second expedition (see map in volume cited above). *P. decora* was also described from Lake Superior. From this region the species ranges to Labrador, to the Rocky Mountains and northward to Alaska It also occurs in the loess deposit at Iowa City, Ia. ; many of these specimens having the upper palatal fold subobsolete or wanting, as in the variety *castanea*.

P. modesta has been erroneously placed in the synonomy of *Vertigo ovata* hitherto, but reference to the original description shows it to be identical with *decora*. Say's description is as follows:

"*P. modesta. Shell* dextral, suboval, minutely wrinkled; *apex* obtuse; *whorls* six; *umbilicus* distinct; *aperture* obliquely subovate; *labium* with a prominent compressed semioval tooth equidistant from the extremities of the labrum, and a somewhat conic one rather below the middle of the columella; *labrum* not reflected, joining the preceding whorl at its upper extremity with a curve; bidentate, lower tooth placed opposite to that of the middle of the labium, the other smaller and placed a little above. Length less than one-tenth of an inch. Inhabits the Northwest Territory."

V. modesta parietalis (Ancey), n. v. Plate XXIII, fig. 1.

Shape somewhat more obese than *V. modesta ;* whorls about 5; teeth 5, the angle lamella being developed. This form is intermediate between *modesta* and *corpulenta* in contour and size. It may be a case of dimorphism rather than a true variety, as it occurs in some places with 4-toothed shells, and with the fifth lamella in various stages of development in apparent adults, as in the Dyea Valley. The figured specimen is from Ogden Cañon, Utah, collected by Hemphill, with *corpulenta*.

V. modesta corpulenta (Morse). Plate XXIII, fig. 7.

Isthmia corpulenta Morse, Ann. Lyc. Nat. Hist. of N. Y., VIII, p. 210, fig. 7 (1865).

Typically much shorter than *modesta*, more obese, with only about 4½ whorls. Teeth 4, short. Type locality, Little Valley, Washoe county, Nev. It occurs also in Utah, the figured specimen being from Ogden Cañon. The lower palatal fold is decidedly tubercular, at least in typical *corpulenta*, and the surface is smooth. Length 2.1, diam. 1.3 mm.

Vertigo modesta castanea (Sterki), n. v. Plate XXIII, figs. 4, 5.

V. castanea Sterki, Nautilus, VI, 1892, p. 5.
P. castanea Sterki, Pilsbry, Nautilus, XI, 1898, p. 119; Class. Cat. Land Shells Amer., p. 21.

Shell oblong or cylindric-oval, glossy, somewhat translucent; chestnut, sometimes with some whitish stripes. Whorls $4\frac{3}{4}$–5, the last with a moderate crest behind the lip. Teeth very small, placed as in *corpulenta*, the lower palatal largest, columellar usually developed, parietal very small or obsolete, upper palatal wanting or minute. Alt. 2.3, diam. 1.4 mm.

Fish Camp, Fresno county. Cal. (Hemphill). Lake county, Cal. (Sterki).

This stands toward *V. modesta* as var. *diegoensis* toward *V. californica*. Both are subterminal members of series running from toothed forms toward a toothless condition. The specimens described and figured are from the locality first mentioned above. In the series before us, this intergrades directly with *modesta*. The specimens vary greatly in development of the teeth.

Vertigo columbiana Sterki MSS., n. sp. Pl. XXIII, fig. 11.

V. columbiana Sterki, Nautilus, VI, 1892, p. 5 (name only).
Pupa columbiana Sterki, Pilsbry, Nautilus, XI, 1898, p. 119; Class. Cat., p. 21, No. 212; Nautilus, XII, p. 103.
V. columbiana var. *utahensis* Sterki, Nautilus, VI, 5 (name only).

Shell very minute, cylindric-oval, perforate, thin, pale corneous-brown, somewhat transparent, glossy and weakly striatulate. Whorls nearly 5, convex, the last expanded in a low crest very close to the lip, not noticeably constricted in front of the crest. Aperture truncate-oval, 4-toothed, the peristome thin, hardly expanded; parietal lamella short and high, columellar a little smaller, lower palatal a short conic fold continued inward; upper palatal smaller, shorter, almost tuberculiform; all the teeth white and the palatals showing through the outside wall. Alt. 1.9, diam. 1.1 mm.

Vancouver Island (George W. Taylor); Olympia, Tacoma and Seattle, Wash. (Henry Hemphill); Douglas county, Ore. (F. H. Andrus).

Types of above description and figure are Nos. 60,468 and 68,881, coll. A. N. S., from Vancouver Island.

An exceedingly small species with four well-developed teeth. The palatal folds are rather shorter than in *V. coloradensis* or *V. concinnula*, both of which are, moreover, more striate and less transparent. The specimens from Vancouver Island, Washington and Oregon are quite uniform in all respects. The above references to literature refer to the name in lists, as there has been no definition of the species.

V. columbiana stands perilously near forms of *V. gouldii* without the basal fold. It may be merely an occidental subspecies of *gouldii;* but in a considerable series examined, there never seems to be a trace of the basal fold. It is this which induces us to give the form specific standing.

Vertigo columbiana utahensis Sterki MS., n. var. Plate XXIII, fig. 10.

Smaller, length 1.8, diam. 1 mm., and *quite distinctly striate.* Aperture about as in *columbiana*, but a little shorter.

Box Elder Cañon, Utah, elevation 4500 feet (Henry Hemphill).

Vertigo coloradensis (Cockerell).

Pupa coloradensis Ckll., Journ. of Conch., Leeds, VI, 1889, p. 63 (name only); British Naturalist, 1891, p. 100;[19] and in Binney, Fourth Supplement to Terr. Moll., V, Bull. M. C. T., XXII, No. 4, p. 191 (January), 1892.

Vertigo coloradensis Ckll., Sterki, Nautilus, VI, 1892, p. 5. Cockerell, Nautilus, X, 1897, p. 134.

Pupa coloradensis Ckll., Pilsbry, Nautilus, XI, 1898, p. 119; Classified Cat. L. Sh. Amer., p. 21.

"Shell brown, shiny, thinnish, translucent enough to show teeth through (body whorl) from outside, striate, especially on penultimate whorl. Outline oblong-oval, barrel-shaped, apex blunt. Whorls four. Aperture pyriform. Peristome brown, thick, continuous by a well-marked callus on parietal wall. Outer lip not constricted; a crest is indicated behind peristome, but not well developed. The teeth within the aperture are brown, one long one on parietal wall, one on columellar, and two, the lower one largest, on outer wall. Length $1\frac{1}{2}$, diam. 1 mm.

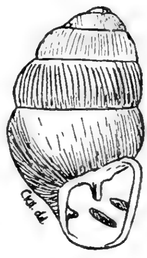

Fig. 2.

"Near Swift creek, Custer Co., Colo. (T. D. A. Cockerell).

[19] We have not seen Prof. Cockerell's paper in this journal, and do not know whether the species was described or merely mentioned there.

"This shell is nearest allied to *corpulenta*, but is decidedly smaller, more striate, and slightly narrower. I have never observed a second parietal tooth in *coloradensis*."

The above description, somewhat amplified from that published in Binney's Fourth Supplement, was received from Prof. Cockerell, and the figure was drawn by him. It seems to us more nearly related to *concinnula* than to *corpulenta*, on account of the long palatal folds; but the very small size distinguishes it, if constant. Only two or three specimens were taken, the type being in the British Museum.

V. coloradensis basidens n. var.

Similar to *V. c. arizonensis* P. & V., but the parietal lamella stands alone upon the parietal wall, and a small basal tubercle is developed. The last character separates *basidens* from typical *coloradensis*.

Bland, New Mexico (Rev. E. H. Ashman), with *V. c. arizonensis* and *V. concinnula*.

Vertigo coloradensis arizonensis n. var. Plate XXIII, fig. 9.

Shell cylindric-oval, rimate, very small; very densely and sharply but most minutely striate; light brown. Whorls $4\frac{3}{4}$, convex, the last tapering below, the later half whorl narrow as though pinched at base, flattened over the position of the palatal folds, then rising in a low, hardly noticeable crest, obsolete except near the base. Aperture irregularly truncate-oval, the peristome well expanded, brown. Denticles 5 or 6, the parietal high and strong, a minute angle lamella usually standing near its outer end. Columellar lamella obliquely entering. Upper and lower *palatal folds very long, rising conically in the middle,* distinctly showing through from the outside, the lower fold being a little stronger and more immersed, its position marked by a depression outside.

Length 1.8, diam. .9 mm.

Top of Mt. Mingus, near Jerome, Ariz., about 8,500 feet elevation (E. H. Ashmun).

This pygmy form differs from *V. columbiana* in being smaller, duller, more slender and with much longer palatal folds, which show their length well from the outside where they show through the outer wall. It is more slender and rather less coarsely striate than *V. columbiana utahensis*, besides differing in its long palatals.

V. concinnula differs chiefly in being very much larger, and *V. coloradensis* has only a single lamella on the parietal wall, and seems less cylindric.

Catalogue of Species and Subspecies of the United States.

Genus **PUPOIDES** Pfeiffer, 1855.

(*Leucocheila* Martens, 1860, of former lists.)

Group of P. marginatus.

Pupoides marginatus (Say).

Canada to Florida, west to Arizona.

This is *Pupa fallax* of authors, not of Say. See notes.

Pupoides modicus (Gld.).

Georgia sea islands and Florida, west to Alabama.

Group of P. chordatus.

Pupoides hordaceus (Gabb).

Arizona and New Mexico.

Genus **PUPA** Drap., 1801.

Group of P. muscorum.

Pupa hebes Ancey.

White Pine, Nev. (Newcomb); around Jerome, Ariz. (Ashmun).

Pupa muscorum (L.).

Canada and Northern States, southward in the Rocky Mountain region. Typical *muscorum* is toothless. Form *unidentata* C. Pfr., parietal tooth developed. Occurs with preceding. *P. badia* C. B. Ad. is a synonym. Form *bigranata* Rossm., a small, low lower palatal nodule also present. Occurs with preceding. Fig. of *muscorum* in Binney's works belongs to this last variety.

Pupa blandi Morse.

Rocky Mountain region. Form *obtusa* Ckll., Colorado.

Pupa blandi sublubrica Ancey.

Nevada.

Pupa sonorana Sterki.

New Mexico.

Pupa sonorana tenella Sterki.

Capitan Mountains, New Mexico.

Pupa syngenes Pilsbry.

New Mexico, Arizona, Montana.

Form *dextroversa* P. and V. (n. f.) is dextral, with 8½–9 whorls. San Rafael, N. M., collected by Rev. E. H. Ashmun.

Eighty-seven per cent. of the specimens taken at this locality were of the dextral form.

Group of P. sterkiana.

Pupa sterkiana Pilsbry.

San Diego county, Cal.; San Ramon, Lower Cal.

Genus **BIFIDARIA** Sterki, 1891.

Section IMMERSIDENS Pils. and Van., 1900.

Bifidaria ashmuni Sterki.

Arizona, Jerome; Santa Rita Mountains.

A form *minor* Sterki (*Nautilus*, XII, 92), Nogales, Ariz., is smaller, thinner, with narrower lip and 1 to ½ whorl less.

Bifidaria perversa Sterki.

Nogales, Ariz.

Section STERKIA Pilsbry, 1898.

Bifidaria rhoadsi Pilsbry.

Miami, Fla.

Bifidaria calamitosa (Pilsbry).

San Diego, Cal., to San Tomas river, Lower Cal.

Bifidaria hemphilli (Sterki).

Same range.

Bifidaria clementina (Sterki).

San Clemente Island.

Section PRIVATULA Sterki, 1893.

Bifidaria corticaria (Say).

Canada and Minnesota south to South Carolina and Mississippi.

Section BIFIDARIA s. str.

(*Eubifidaria* Sterki, 1893.)

Bifidaria dalliana Sterki.

Arizona.

Bifidaria hordeacella (Pilsbry)

Cape May, N. J., Georgia sea islands and Florida, west to Indian Territory and Arizona.

Bifidaria hordeacella parvidens Sterki.

Arizona.

Bifidaria rupicola (Say).

South Carolina and Florida, west to New Orleans, La., also Cuba, Bermuda.

Bifidaria procera (Gld.).

Maryland and South Carolina, west to Arizona and Mexico.

Bifidaria procera cristata Pils. and Van.

Arizona, New Mexico, Indian Territory and Texas.

Bifidaria quadridens Sterki.

Capitan Mountains, New Mexico.

Section ALBINULA Sterki, 1892.

Bifidaria contracta (Say).

Canada, United States and Mexico, east of Rocky Mountains.

Bifidaria armifera (Say).

Quebec and Maine to Minnesota, south to New Mexico and Florida. A var. *ruidosensis* Ckll. has been described from New Mexico.

Bifidaria holzingeri (Sterki).

Minnesota to Kansas and Illinois. A var. *fordiana* Sterki has been described from Wichita, Kan.

Subgenus **Vertigopsis** 'Ckll.' Sterki.

Nautilus, VI, p. 4, 101. Type *Pupa curvidens* Gld.

* Palatal folds two or three, in the typical positions; no palatal callous rib.

Bifidaria cincinnatiensis (Judge).

Cincinnati, O.

Bifidaria pilsbryana (Sterki).

Arizona and New Mexico.

** Palatal folds tuberculiform, their number increased by some accessory denticles, and standing upon a callous rib.

Bifidaria pentodon (Say).

Quebec to Alberta, south to Nevada, Texas and Florida; Sterki mentions a form *curta* from Ohio. *P. montanella* Ckll., undescribed, is a synonym.

Bifidaria curvidens (Gld.).

Quebec to Minnesota and southward.

Sterki distinguishes a form *gracilis* from Rhode Island, Ohio, Tennessee.

Bifidaria curvidens floridana (Dall).

Archer, Alachua county, Fla.

Genus **VERTIGO** Müller.

Section VERTIGO.

Vertigo rugosula Sterki.

South Carolina, Gulf coast to Texas.

Vertigo rugosula ovalis Sterki (**ovulum** Sterki, preoc.).

Volusia county, Fla.

Vertigo ovata Say.

Canada, United States and Mexico.

Pupa ovata antiquorum Ckll. is a synonym.

Vertigo morsei Sterki.

Kent county, Mich.; Sandusky, O.

Vertigo binneyana Sterki.

Manitoba to Seattle, Wash., south to New Mexico.

Vertigo pygmæa Drap.

Lake Superior and New England, south to Pennsylvania and west to Ohio. Synonyms: *V. callosa* Sterki, not Reuss; *P. superioris* Pilsbry.

Vertigo andrusiana Pilsbry.

Douglas county, Ore.

Vertigo arctica Wallenb.

Identified by Westerlund from Port Clarence, Alaska. We have not seen it.

Vertigo tridentata Wolf.

New York and eastern Pennsylvania to Illinois.

Vertigo parvula Sterki.

Northern Ohio; Mitchell county, N. C.

Vertigo ventricosa (Morse).

Quebec and Maine to Illinois. Synonym: *V. approximans* Sterki.

Vertigo ventricosa elatior Sterki.

Western Alberta to Ohio. Synonym: *V. gouldii lagganensis* Pilsbry.

Vertigo gould i Binn.

Ontario and Maine to Montana, south to Tennessee, Maryland and New Jersey. *V. gouldii paradoxa* Sterki is an undescribed variety from Woodland, Aroostook county, Me.

Vertigo gouldii bollesiana (Morse).

Middle and New England States.

Vertigo bollesiana arthuri Martens.

Little Missouri, Dakota. (Unknown to us.)

Vertigo columbiana Sterki.

Vancouver Island to Oregon.

Vertigo columbiana utahensis Sterki.

Box Elder Cañon, Utah.

Vertigo modesta (Say).

Synonym: *Pupa decora* Gld.

Lake Superior region to Alberta and northward; also loess of Iowa.

Vertigo modesta corpulenta (Morse).

Utah, Nevada.

Vertigo modesta parietalis (Anc.).

Utah and Colorado.

Vertigo modesta castanea (Sterki).

Fish Camp, Fresno county, and Lake County, Cal.

Vertigo coloradensis (Ckll.).

Custer county, Col.

Vertigo coloradensis basidens P. & V.

Bland, New Mexico.

Vertigo coloradensis arizonensis P. and V.

Jerome, Ariz.

Vertigo concinnula (Ckll.).

Colorado and New Mexico.

Vertigo rowelli (Newc.).

Oregon to middle portion of California.

Section NEARCTULA Sterki.

Vertigo californica (Rowell).

San Francisco, Cal.

Vertigo californica elongata Sterki.

San Clemente Island.

Vertigo californica catalinaria Sterki.

San Clemente Island and S. Catalina Island.

Vertigo californica diegoensis Sterki.

San Diego, Cal., to San Ramon, L. Cal.

Vertigo californica trinotata Sterki.

Monterey, Cal.

Vertigo californica cyclops Sterki.

Placer county, Cal.

Section HAPLOPUPA Pils.

Vertigo dalliana Sterki.

Lake county, Cal.

Section ———

Vertigo oscariana Sterki.

Florida to Texas; Tennessee.

Section BOTHRIOPUPA Pils.

Vertigo variolosa Gld.

Near mouth of Miami river, Fla.

Subgenus **Vertilla** Moq.-Tand.

Vertigo milium Gld.

Ontario and Maine, west to Minnesota, south to Florida and Texas.

EXPLANATION OF PLATES.

Plate XXII.

Figures 9, 10, 11 × 13 ; 1–8 × 20.

Fig. 1. *Bifidaria rupicola* (Say). Tick Island, Volusia county, Fla. No. 69,500, coll. A. N. S.
Fig. 2. *B. hordeacella parvidens* Sterki. Mescal Gulch, Jerome, Ariz. No. 78,717.
Fig. 3. *B. hordeacella* (Pils.). New Braunfels, Tex. No. 60,460.
Figs. 4, 5. *B. procera cristata* Pils. and Van. Camp Verde, Ariz. No. 68,694.
Figs. 6, 7. *B. procera* (Gld.). Washington, D. C.
Fig. 8. *B. dalliana* Sterki. Nogales, Ariz. No. 78,689.
Figs. 9, 10. *Pupa hebes* Ancey. Summit of Mt. Mingus, near Jerome, Ariz. No. 78,709.
Fig. 11. *Pupoides hordaceus* (Gabb). Fort Grant, Ariz. One of the original lot, probably the type specimen.

Plate XXIII.

All figures × 25.

Fig. 1. *Vertigo modesta parietalis* (Ancey). Ogden Cañon, Utah.
Fig. 2. *Vertigo modesta parietalis* (Anc.). Dyea Valley, Alaska. No. 73,661.
Fig. 3. *Vertigo modesta* (Say). Laggan, Alberta. No. 76,375.
Figs. 4, 5. *Vertigo modesta castanea* Sterki. Fish Camp, Fresno county, Cal.
Fig. 6. *Vertigo modesta* (Say). Labrador. No. 4,352.
Fig. 7. *Vertigo modesta corpulenta* (Morse). Ogden Cañon, Utah.
Fig. 8. *Vertigo concinnula* (Ckll.). Jemez Mountains, Ariz. No. 73,587.
Fig. 9. *Vertigo coloradensis arizonensis* Pils. and Van. Summit of Mt. Mingus, near Jerome, Ariz.
Fig. 10. *Vertigo columbiana utahensis* Sterki. Box Elder Cañon, Utah.
Fig. 11. *Vertigo columbiana* Sterki. Vancouver Island. No. 68,881.

October 2.

Mr. Charles Roberts in the Chair.

Fifteen persons present.

October 9.

Mr. Charles Morris in the Chair.

Eleven persons present.

October 16.

Mr. Charles Morris in the Chair.

Seventeen persons present.

"A Biographical Notice of Charles Eastwick Smith," by Thomas Meehan, was presented for publication.

October 23.

Mr. Charles Morris in the Chair.

Eighteen persons present.

A paper entitled "Additions to the Japanese Land Snail Fauna, III," by Henry A. Pilsbry, was presented for publication.

October 30.

Mr. Charles Roberts in the Chair.

Forty-one persons present.

Dr. Adolph W. Miller made a communication on his recent visit to the zoölogical and botanical gardens of Paris and Germany. (No abstract.)

Thomas S. Stewart, M.D., was elected a member.

The following were ordered to be printed:

POST-LARVAL CHANGES IN THE VERTEBRAL ARTICULATIONS OF SPELERPES AND OTHER SALAMANDERS.

BY J. PERCY MOORE.

In defining the minor subdivisions of the Urodela, Cope and Boulenger have given fundamental importance to the form of the vertebral central articulations. Cope ('89, p. 33, and earlier papers) arranges the families of Pseudosauria in two series, the one characterized by amphicœlous, the other by opisthocœlus vertebræ, and on p. 190 he states that the peculiarity of the vertebræ chiefly distinguishes the Desmognathidæ from the Plethodontidæ. Boulenger ('82, p. 2), whose subfamilies of salamanders have nearly the same content as Cope's families, mentions the form of the central articulations as the sole distinguishing feature between his Plethodontinæ and Desmognathinæ.

Apparently the only serious criticism of the value of this character has been made by Vaillant, who in a short note ('84) describes the vertebræ of *Autodax* (*Anaides*) *lugubris* as opisthocœlous. Boulenger, after an examination of the dissection made by the French zoölogist, characterizes ('85) this statement as erroneous. In a second note ('86) Vaillant explains the reason for this difference of opinion and reiterates his former statement. The vertebræ in question he describes as osteologically amphicœlous but physiologically opisthocœlous, meaning by this that if the actual bone tissue alone be considered the centra are biconcave ; but that the anterior cup is filled by a cartilaginous nodule, which projects freely in the form of a hemipshere whose free surface fits into the posterior socket of the preceding vertebra.

If a full-grown larva of *Spelerpes ruber* be examined, the vertebral centra will be found to be very deeply concave. The apices of the two cone-shaped cavities almost meet at the middle of the vertebra, where they communicate through a small foramen through which the here constricted notochord passes. The cavities are largely occupied by the notochord, which suffers a second (intervertebral) constriction due to an annular thickening of the cartilaginous notochordal sheath by which contiguous vertebræ are bound together.

After the metamorphosis, when the young salamander has a length of 90–100 mm., this cartilaginous ring increases in thickness and extent so that it largely replaces and constricts the notochord. The cartilage becomes firmer and may be removed in its entirety as a fusiform nodule bearing fragments of the notochord at its ends. If the vertebral column, either in its fresh state or after preservation in alcohol, be bent sharply so that it parts intervertebrally, this nodule will remain attached indifferently either to the anterior or posterior contiguous vertebra.

Gradually the cartilage extends, encroaching more and more on the notochord, and at the same time its posterior peripheral parts begin to calcify, first in a post-equatorial zone which lies just within the rim of the anterior cup of the succeeding vertebra. In individuals having a length of 120 mm.[1] this calcified ring is already quite conspicuously developed and has united with the anterior vertebral rim. Dried skeletons of this stage show the anterior vertebral cup with a thick, rather rough rim and a correspondingly constricted opening, while the posterior cup remains almost exactly of its previous form and proportions. Its opening is large, unconstricted and has a smooth, thin margin which embraces the next succeeding centrum; its inner surface is bounded everywhere by hard, true bone lined by a thin layer of cartilage. Moreover, if the column be forcibly broken as described above, the cartilaginous nodule almost invariably parts from the preceding and remains attached to the succeeding vertebra, showing its more intimate organic union with the latter. A smooth articulation between this cartilage and the posterior face of the preceding vertebra begins to be evident and the contiguous centra are united by an annular intervertebral ligament. A condition closely approximating that just described is figured by Wiedersheim ('93, p. 61, fig. 41,C.).

With increasing age and size the calcified area continues to encroach on the cartilaginous matrix. The ring becomes thicker and its posterior margin extends toward the middle region of the centrum. As a result the anterior cavity of the bony vertebra grows

[1] As there appears to be some individual variation in the rate of change, the conditions described must be understood as belonging to individuals of only approximately the lengths stated.

smaller as it is filled up from the bottom and sides by the gradual replacement of true cartilage by calcified cartilage. To a corresponding degree the cartilaginous nodule becomes incorporated with the succeeding vertebra and structurally separated from the preceding one. In ordinary breeding individuals, having a length of 130–150 mm., is reached the condition which Vaillant has happily described as physiologically opisthocœlous, in which the actual intervertebral centre of movement is between a cartilaginous ball structurally united with the anterior end of one vertebra and a deep cup borne on the posterior face of the other. There is no synovial articulation formed at this stage but only a curved surface of fracture which divides the intervertebral cartilage.

In still larger individuals, up to a length of 170 mm., which are not rare, the process of calcification has extended all through the cartilage within the anterior vertebral cup, at first leaving here and there little lakes of unaltered cartilage, which are finally also affected by the change. The transformation of tissue then overflows the boundaries of the cup, first at the rim, but gradually extends into the centre and anterior superfices of the cartilaginous head. At this period of development the unchanged cartilage has been reduced to a cap which fits over a rounded calcified head of its transformed substance and becomes constantly reduced in thickness as the process of calcification extends. If the cartilage be scraped away or shrunken by complete drying a larger or smaller central depression appears in the anterior face of the vertebra at the point where the notochord and its cartilaginous envelope longest persist.

Finally, in the very largest individual which I have seen, which, if the tail were complete, would measure upward of 180 mm., the vertebræ are quite as opisthocœlous as even in the largest individuals of *Desmognathus.* The anterior ball has become, with the exception of a thin articular surface such as persists in all opisthocœlous salamanders, completely calcified and as hard and dense as the body of the vertebra. So far as microscopical examination has extended, this calcified tissue does not become true bone. In sections after removal of the lime salts the original cartilage, except for the rearrangement of the cells, remains in a nearly unaltered state. In many of the larger specimens the annular intervertebral ligament ossifies, beginning at its anterior attachment and extending caudad. By this means the rim of the posterior cup is built up higher and the socket deepened. Between the overlapping vertebral rims an annular synovial sac is developed.

Whether the vertebræ of *Spelerpes ruber* are properly designated as amphicœlous or opisthocœlous depends, therefore, on the age of the individual under consideration, and whether attention is directed to the bony parts only or to the cartilage as well. During late larval life and for a time after the metamorphosis, the vertebræ are both osteologically[2] and physiologically amphicœlous. During the prime of life they are still amphicœlous so far as the strictly bony portions of the centra are concerned; but if, as seems more logical, the cartilaginous structures also are considered they cannot be characterized otherwise than as opisthocœlous. In old age they are opisthocœlous in every sense in which that term can be applied to the vertebræ of *Desmognathus*. Developmental progress in the structure of the vertebræ from a primitive to a more specialized type is continuous throughout life.

It is well known that the amphicœlous condition of the vertebræ of the higher salamanders is attained by a course of development essentially similar to what has just been described for *Spelerpes*. The examination of a large series of *Desmognathus fusca* and *D. nigra* shows that this is true of these species. The species of *Desmognathus* transform when of much smaller size relatively to the limit of growth than those of *Spelerpes*. The just transformed *D. fusca* is about one-half the length of *S. ruber* at a corresponding period, although the breeding adults are only about twenty per cent. inferior. Calcification of the intervertebral cartilage proceeds quite rapidly, so that individuals of 50–60 mm. are in the same stage as *Spelerpes ruber* of 135–140 mm. Even before attaining a length of 100 mm. the vertebræ are as strictly opisthocœlous as in the largest *S. ruber*, and have attained that condition by a similar series of steps. It is noticeable that the calcified material of the ball is softer than the fully ossified portions of the vertebræ, and that small enclosures of unchanged cartilage may persist, as well as a remnant in the centre of its free surface, where a depression appears in the dry skeleton. The later development consists simply in the completion of calcification.

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[2] Used in the sense of Vaillant in the papers cited, and of some systematists to denote the condition of actual bone and calcification.

The vertebræ of the two forms now under consideration do not properly belong to two types, but differ only in the period of life at which the steps in development are passed through and at which the higher structural type is attained. The completely osseous opisthocœlous condition is reached in *Desmognathus fusca* prior to the period of maturity and reproduction, in *Spelerpes ruber* only after that period.

It seemed desirable to ascertain whether these conditions are general among the genera of the more primitive families of the Pseudosauria.[3] As it was important to mutilate most of the material as little as possible, but a single articulation was generally exposed and studied on each specimen, and for the sake of uniformity this was always the same one, the fifth anterior to the sacral vertebra being selected for various reasons. The following notes show the character of typical genera:

AMBLYSTOMIDÆ.

The largest available specimens of *Amblystoma opacum*, *A. tigrinum*, *A. punctatum* and *A. jeffersonianum* were examined without the detection of any changes of the nature sought. Throughout life the vertebræ appear to remain deeply and equally amphicœlous and the intervertebral cartilage to undergo no calcification.

Chondrotus tenebrosus.

It was fully expected that this species, because of its large size and robust build, might present calcified intervertebral cartilages, but even an unusually large individual (282 mm.) remains in the simplest amphicœlous condition. The two faces of the centrum are equally and very deeply cupped. The notochord is largely persistent. The intervertebral thickening of the cartilaginous sheath is slight and extends into the concavities of the contiguous vertebræ, from which it may be easily removed without injury.

PLETHODONTIDÆ.

The very small species of this family will require to be studied by means of sections, but the following will illustrate the conditions met with :—

[3] This I have been enabled to partially do chiefly through the courtesy of the Curators of the Academy of Natural Sciences of Philadelphia, and especially of the Conservator of Vertebrata, Mr. Witmer Stone, who placed at my disposal the extensive collections of that institution.

Hemidactylium scutatum.

The largest specimens examined measure 80–85 mm. and are strictly amphicœlous.

Plethodon cinereus.

Always strictly amphicœlous. This species and the next are among those which show that neither a terrestrial habit nor a long period of growth between metamorphosis and maturity is the determining factor in the complete calcification of the articular head.

Plethodon glutinosus.

Many specimens of this species were examined, including two large ones of 167 mm. and 177 mm., belonging to the collection at the Academy. All have deeply biconcave vertebræ without any visible sign of calcification of the intervertebral cartilage, though in the larger individuals it is evidently more firmly attached to the succeeding than the preceding vertebra. Although there is no fully formed articulation, a definite curved surface of fracture corresponding to one is developed.

Plethodon æneus. Plethodon oregonensis.

Both amphicœlous. Of the former the largest specimen examined measured 164 mm.; in this the whole body of the vertebra appears to be somewhat imperfectly ossified.

Autodax lugubris.

In two examples of 90 mm. and 105 mm. length the vertebræ are biconcave, with the intervertebral cartilage unmodified and most strongly attached by the articular ligaments to the anterior vertebra. The intervertebral articulation is developed. Two others of about 145 mm. have the posterior face deeply cupped, the anterior, after removal of the cartilage, much more shallow and rough from the development of calcified tissue. The uncalcified cartilage has a smooth surface which fits into the next anterior socket.

Geotriton fuscus.

Only one small specimen of 86 mm. was available for dissection, and this was nearly equally amphicœlous, with the intervertebral cartilage remaining attached to the posterior face on being fractured. Murray ('97) has figured a section of a vertebra of this species which exhibits no modification of the cartilaginous intervertebral ring. Probably older specimens would show changes similar to *Spelerpes ruber*.

Œdipus variegatus.

One with the tail missing and the body measuring 45 mm. in length has the anterior face slightly less cupped than the posterior, and retaining the intervertebral cartilage. In two specimens of 145 mm. and 147 mm. the anterior cup is about one-third filled with calcified cartilage.

Gyrinophilus porphyriticus.

A larva of 78 mm. has the bony centra deeply biconcave, the notochord largely persistent but constricted by a narrow but rather thick intervertebral cartilaginous ring.

A specimen of 106 mm., probably recently metamorphosed, exhibits a much more extensively developed intervertebral cartilage, but appears to be unchanged otherwise.

In one of 133 mm. the notochord is still largely persistent, the intervertebral articulation has formed in the cartilage as a curved plate of flattened cells and the widely flaring posterior rim of the bony centrum begins to overlap and embrace the more constricted anterior rim. This is nearly the stage figured by Wiedersheim.

One of 172 mm. shows a slight annular calcification of the intervertebral cartilage within the anterior cup.

In individuals of larger size the process of calcification is rapid. One measuring 185 mm. has the anterior cup filled flush to the brim with calcified tissue which presents a rough, nearly flat surface when the cartilaginous head is scraped away. The largest specimen examined measured 200 mm., and in this the calcification extends slightly beyond the cup's rim.

Spelerpes bellii.

This large species probably undergoes intervertebral calcification, if at all, relatively later than *S. ruber*. In specimens of 180 mm. and 240 mm. no trace of calcareous infiltration could be detected. In both cases the intervertebral cartilage is more firmly attached by the articular ligaments to the anterior vertebra than by direct union to the posterior one.

Spelerpes longicudus.

Of all the species of Plethodontidæ examined this appears to be the most precocious in respect to the feature under consideration.

In an example measuring only 90 mm. calcification has already progressed so far as to fill about one-half of the anterior cup, and in one of 135 mm. the cup is filled to the brim, leaving only a very slight central depression.

Spelerpes bilineatus. Spelerpes guttolineatus.

Exhibit changes similar in character but somewhat more tardy in the time of their appearance.

DESMOGNATHIDÆ.

Typhlotriton spelæus.

The vertebræ of a 90 mm. example of this interesting blind salamander, of which only slightly larger specimens have been taken, are in about the same condition as those of a 60 mm. *D. fusca*, and consequently opisthocœlous only in the sense in which a mature *Spelerpes ruber* is opisthocœlous.

Desmognathus nigra.

Similar to *D. fusca*, but somewhat more retarded in development.

Leurognathus marmorata.

Of this species only a single skeleton of a length of 117 mm. has been examined. It differs from *Desmognathus* only in the greater prominence of the articular head.

Of the Salamandridæ and Pleurodelidæ no specimens were examined in this connection, as the vertebræ are well known through the researches of Wiedersheim ('75) and others to be strongly opisthocœlous and to ossify early.

When recourse is had to sections of a sufficient series of stages, other interesting changes and generic differences will no doubt appear ; but from the study of gross features alone it becomes evident that as regards the form of the vertebral articulations the genera of the families of salamanders present an unbroken developmental series.

The Amblystomidæ are probably always amphicœlous throughout life.

Within the Plethodontidæ the genera arrange themselves in two groups, the one including *Plethodon* and *Hemidactylium*, the other *Spelerpes*, *Gyrinophilus*, *Autodax* and *Œdipus*. The *Plethodon* group remains in the primitive state with little or no post-larval calcification of the intervertebral cartilages. The members of the *Spelerpes* group all (*S. bellii ?*) tend toward the opisthocœlous condition, and earlier or later in life the intervertebral cartilages are affected by a process of calcification which is progressive and may finally involve the entire substance of the articular heads. It may be observed that the grouping of the genera as suggested, with the exception of *Autodax,* is confirmatory of Cope's view of their affinities.

Desmognathus and its allies arrive at the final opisthocœlous stage much earlier but by a series of post-larval stages quite similar.

Many peculiar structural features segregate the amphicœlous Amblystomidæ, on the one hand, and the opisthocœlous Salamandridæ and Pleurodelidæ, on the other, into distinct family groups. The failure of the only important character which has seemed to make the family distinction of the Plethodontidæ and Desmognathidæ desirable renders their separate continuance no longer necessary. Although *Leurognathus* resembles *Desmognathus* in the absence of a prefrontal bone in the adult, this is a very doubtful character, and in any case would probably have, with the peculiarities of the tongue, no more than subfamily value. The family should retain the prior name of Plethodontidæ. It seems to represent a phyletic line connected directly with the lower amphicœlous salamanders ; and distinct from the Amphiumidæ, on the one hand, and the Pleurodelidæ and Salamandridæ on the other.

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AN ECOLOGICAL STUDY OF THE NEW JERSEY STRAND FLORA.

BY JOHN W. HARSHBERGER, PH.D.

The development of the Atlantic sea coast from Maine to Virginia, and especially of the coastal lands of New Jersey, as places of summer resort has rendered a botanical survey of the shore line an imperative necessity. With the rise of towns and cities and the building of railroads, the primitive condition of the sea beaches has been remarkably changed. Dunes have been leveled, marshes have been filled in, old drainage areas have been removed, new soil has been brought to cover the sand formations to prevent their drifting, and these alterations have not failed to produce corresponding changes in the vegetation. New plants, weeds and the like, able, as well as the native plants, to withstand the saline conditions of air and soil, have been introduced with the coming of man as a permanent habitant; the old vegetation has been gradually removed, or, no longer able to grow under the altered conditions, has given place to the emigrants distributed by the aid of human beings.

Recognizing these facts, the present study of the sea-beach flora of New Jersey was undertaken by the writer, so as to preserve in some permanent form a record of the plant life, the distribution of the peculiar vegetation and the ecological relationships of the plants before the rapid change of the old conditions rendered impossible such an ecological survey. The material for this paper has been collecting for a number of years. As far back as 1894 the writer began his observations on the sea-beach flora, but during the present season (1900) the major part of the facts recorded here were gathered to form this permanent record.

During the summer's field work a number of places were visited along the Jersey coast, so as to make the account of the coastal flora as comprehensive as possible. The most exact reconnoissance was made at Seaside Park, Ocean County, where the writer has summered for a number of seasons, so that Barnegat Beach is taken as typical, and the beaches of other situations visited (South Atlantic City, Ocean City and Wildwood) are chosen as modifying or strengthening the conclusions reached by a close study during several seasons of the salt-strand formations at Seaside Park, N. J. The choice of Barnegat Beach as a typical sea strand is not an arbitrary one. Of all the beaches visited, it conforms most closely to the ideal beach formation, and presents in its southern extension the coastal vegetation undisturbed by the hand of man, and in a condition as nature has left it.

While the collection of material was under way, a very important and instructive paper[1] appeared from the pen of Thomas H. Kearney, Jr., dealing with the plant covering of Ocracoke Island, N. C.

In order to make the results recorded in this paper conform with those obtained by Mr. Kearney, the nomenclature used is made identical with his. The nomenclature is mainly that followed in Britton and Brown's *Illustrated Flora of the Northern United States and Canada*, but, in order that those who are interested in ecological work and are not familiar with this nomenclature may find no difficulty in recognizing the species described, the names used in the later works of Gray and of Chapman are quoted in parentheses. It is hoped that by doing this—*i.e.*, adopting the same plan as used in the above-cited paper—an unbroken survey of the coast vegetation from Sandy Hook to North Carolina will be presented to the botanist ecologically inclined. In Mr. Herbert J. Webber's paper, "Dunes of Florida," printed in *Science*,[2] we have presented the conditions of plant growth as found along the seashore of Florida. What is needed to complete an account of the ecology of the Atlantic coast of temperate North America is a study of the strand vegetation of Long Island, which I believe to be much like that of New Jersey; a study of the New England coast, from Rhode Island to Maine, and a survey of the conditions to be found in Nova Scotia and Newfoundland, which work may well be committed to some enterprising Canadian botanist.

The appended list is derived from three sources of information:

[1] 1900, Kearney, "The Plant Covering of Ocracoke Island: A Study in the Ecology of the N. C. Strand Vegetation," *Contrib. U. S. Nat'l Herbarium*, Vol. V, No. 5, pp. 261–319.

[2] 1898, Webber, "Dunes of Florida," *Science*, N. S. Vol. VIII, pp. 651–660, 690–700.

(1) The collections of plants made by the writer at Seaside Park, South Atlantic City, Ocean City and Wildwood. (2) The specimens in the herbarium of the Philadelphia Botanical Club. (3) The "Catalogue of Plants Found in New Jersey," by Dr. N. L. Britton.[3] Synonyms are also given in the list, so as to render it more intelligible.

The several divisions under which the subject of the ecology of the New Jersey strand flora is presented are the following: (1) Physiography; (2) geology and soils; (3) climate; (4) the plant formations, their composition and physiognomy; (5) ecological forms—adaptations to environment; (6) phytogeography; (7) list.

Physiography.[4]

From Bay Head, lat. 40° 4′ N., to Cape May City, lat. 38° 58′ N., stretches in front of the mainland of New Jersey a protective barrier of sand, in width from a few rods to a half a mile, separated from the mainland by bays or shallow inlets of the ocean, or where these have been gradually filled in by the deposition of sand and the action of plants, by wide stretches of salt or tidal marshes, consisting of tide-swept sand, or covered by a luxuriant growth of salt-marsh plants. These narrow sand beaches which fringe the coast have been cast up by the action of the waves on the shallow continental ocean front. The sand thus deposited is caught up by the wind, which exerts a shovel-like action on the sand, greatest when an east wind blows, and is piled up in dunes, which on the New Jersey coast rise usually from

[3] *Final Report State Geologist of N. J.*, Vol. II, pp. 27–642.

[4] The student of the New Jersey coast flora is referred to the following excellent maps of the State and of the coast line:

"The Atlas of New Jersey," comprising maps showing Geodetic and Topographic Surveys of New Jersey, issued in 1889.

No. 9. Monmouth Shore, Sandy Hook to Manasquan.
No. 13. Vicinity of Barnegat Bay.
No. 16. Egg Harbor and Vicinity, including Atlantic shore from Barnegat to Great Egg Harbor.
No. 17. Cape May Shore Line.
No. 18. New Jersey State Map. Geographic.
No. 19. New Jersey Relief Map. Hypsometric.
No. 20. New Jersey Geological Map.
Coast Charts U. S. Hydrographic Office.
Chart 8. Montauk Point to Cape Henlopen.
Chart 121. Sandy Hook to Barnegat.
Chart 122. Barnegat to Absecon.
Chart 123. Absecon to Cape May.

15 to 25 feet, but on Seven-mile Beach to a height of 43 feet. In front of the dune formation extends the tidal beach proper of varying extent. It may be divided into the lower, the middle and the upper beaches, using the terms of Cowles.[5] At high tide the water never completely reaches to the base of the dunes, but with exceptionally high water or during a storm the base and even the top of the dune may be water-swept. Back of the primary dune formation are usually found other dunes more or less broken up into rounded eminences by wind action, and presenting deep gullies subject at all times to the scooping power of the breezes which are active in the formation of the dune complex.[6]

The upper beach exists at the places visited, according to the observations of the writer, only at Wildwood. Its limits elsewhere are vague and uncertain. The lower beach is the zone of land limited by the wash of summer storms, and is in New Jersey entirely barren of plant life. The middle beach is determined by the presence of driftwood and extends to the foot of the dunes. The hollows of the secondary dunes in depth usually correspond to the level of the ground water, for digging a few inches into the wet sand reveals the presence of fresh water, which has filtered through the sand from the ocean on the one side, and from the salt marshes or bays on the other. The force with which this sand is blown against obstacles in its path may be realized if one stoops down and faces it. The carving of dead and living trees exposed to these sand blasts is another evidence of their power.

Back of the dune complex, which is constantly shifting its position on the broader beaches, is found the belt or zone which has been captured by vegetation. Such belts are found at Seaside Park (a mile below the town at Read's Hotel), at South Atlantic City, where it exists in the middle of the salt marsh, at Ocean City and at Wildwood. I have denominated such areas thicket formations, in contradistinction to beach and dune formations. At Seaside Park proper, where the thicket formation does not exist,

[5] 1899, Cowles, "Dune Floras of Lake Michigan," *Botanical Gazette*, XXVII, p. 114.

[6] The dune complex consists of active or wandering dunes and of primary and secondary embryonic dunes, or those just starting to form by the piling up of the blowing sand around some obstacle. The most striking topographical effect of the dune complex is that of a vast, billowy sea of sand. It illustrates almost all conditions of a dune's life history.

the dune complex gradually slopes to meet the salt marsh which fringes Barnegat Bay, and is in turn followed by the sandy bay beach, which is backed by low dunes or sand hills a foot or two high. Where the thicket formation exists it may reach the bay dunes proper, when the salt marsh is practically absent, or exists as swampy depressions surrounded by shrubby or arborescent vegetation in the centre or edges of the thicket formation proper, as exemplified at Island Beach Life Saving Station, Seaside Park. Allusion will be made to these later, when the plants of the several formations are referred to. The position of these swampy areas, in which grow many salt-marsh plants, seems to indicate that at some time the sand has blown out upon the salt marsh, covering it up with dunes, afterward captured by woody plants which prevent them from wandering farther. At Wildwood and Ocean City the thicket formation is succeeded toward the westward by the low-lying, typical salt marshes.

The slope and position of these New Jersey beaches are constantly changing. At New Inlet, Long Beach extended three miles farther southward in 1885 than it did in 1841, while the beach south of Little Egg Harbor Inlet had grown one mile northward in the same time. Five-mile Beach had its south end three-quarters of a mile farther south and half a mile more to seaward than its position in 1772.[7] From Bay Head to Cape May, the beaches are cut through by ten inlets, through which the tide ebbs and flows to the bays inside. The interval between these inlets is over 20 miles at the north, but decreases to 2 miles near Cape May. There has been a tendency to decrease in the number of inlets and at least six have been permanently closed during this century. Inside of this line of beaches is a series of bays and sounds connected by a network of narrow crooked channels, called thoroughfares, in such a way that boats of light draft can pass from the head of Barnegat Bay over 90 miles down to Cape May, keeping entirely inside the beaches. Barnegat Bay is the largest of these, being nearly 30 miles long, with an area of 72 square miles. Its depth northward from Barnegat Inlet scarcely exceeds 10 feet, but southward it reaches a depth of 20 feet. It varies from two to four miles in width, leaving the beaches well cut off

[7] 1888, Vermeule, *Final Report Geological Survey of New Jersey*, I, p. 179.

from the mainland. Barnegat Beach, as the series of beaches to the eastward of Barnegat Bay are called collectively, may be taken, therefore, as the most typical beach of the New Jersey coast, and the one most exhaustively described from an ecological standpoint in this paper.

The salt marshes northward from Barnegat Inlet nowhere exceed a mile in width and are usually much less, as at Seaside Park. Southward they widen, encroaching more on the bays, but there is back of Long Beach a width of from two to four miles of water. Between Tuckerton and Beach Haven, Little Egg Harbor Bay is four miles wide. It has a depth of from 5 to 10 feet at mean tide, but there is a channel running down from Cedar Bonnets to the Inlet in which the minimum depth is 10 feet and the maximum 32 feet. Through this bay are scattered many islands of marsh, and at its foot a long tongue of marsh puts out from the mainland toward the south end of Long Beach, 4½ miles. It is from 1 to 2 miles wide, and is cut up into numerous islands by thoroughfares. Going from Great Bay southward to Great Egg Harbor Bay, the tidal plain diminishes in width from 6½ miles to less than three. It is fronted by Island, Brigantine and Absecon Beaches, back of which the marshes are cut up by a series of small bays and broad channels into countless islands, the areas of marsh and water being nearly equal. Southward in Cape May County the plain varies from 2 to 4 miles, and the marshes exceed in area the water.[8]

Geology and Soils.

From a geological standpoint, the sea beaches of New Jersey are of recent origin. They lie upon the older rock formations which crop out in parallel series along the Delaware river side of the State. These earlier rocky strata slant downward and southeastward, and presumably the whole of the overlying strata in southern New Jersey are built upon gneiss, which is followed in

[8] Under the caption "Plant Formations, their Composition and Physiognomy," more detailed reference will be made to the physiographical features of the places visited. The above account must suffice at this point. The student of the dynamics of dunes who desires to study the detailed effects of the wind action on the formation of dunes and the modification of vegetable organisms is referred to the papers of Dr. Cowles, where in an elegant style his studies on the dunes of Michigan are set forth at some length.

order upward by deposits of Cretaceous, Eocene, Miocene and Recent Periods. Numerous borings for artesian wells along the Atlantic seaboard have revealed the extent of the deposits of the several periods. These investigations have been pursued indefatigably by Woolman, who has given in several papers the results of his study.[9] The superficial deposits concern the ecologist, but the following data are given by way of comparing the superficial, recent soil deposits and the older, deeper-lying ones.

Artesian Well at Longport (803 feet deep).

Recent, ...	75 feet.	
Pleistocene, ...	93 "	
Age ?	92 "	
Miocene, ...	543 "	Diatomaceous.
	803	

Diatomaceous bed extends from 292 to 664 feet = 372 feet thick.

Artesian Well at Wildwood (655 feet deep).

Recent { Soil and black muck full of roots of cedar and holly = 3 feet.
Beach sands, lower ten feet slightly darker in shade = 3 to 30 feet. }

30–61 feet. Age ?
61–152 feet. Marine and fresh-water diatoms.
61–290 feet. Age ? Made up of mixed marine and fresh-water deposits, say 61 to 185 feet.
290–665 feet = Miocene.[10]

The details given as to the most superficial deposits, which form the soil in which plants grow, are instructive. At Seaside Park the vegetable mold is of but slight depth and barely covers the sand in the thicket formation. On the salt marsh it is about a foot deep. The dunes are practically without any vegetable detritus.[11] At Wildwood, which, as will be shown later, possesses

[9] Woolman, *Annual Reports New Jersey Geologist.*

[10] 1894, Woolman, "Vertical Sections of Wells at Atlantic City and Wildwood," *Annual Report New Jersey Geologist*, p. 188.

[11] The oxidation or removal of decaying vegetation is almost complete on the newer dunes, so that the accumulation of humus is not important. On the old, established dunes the mold becomes deeper and deeper, and after the lapse of centuries the sandy soil beneath may become buried so deeply that a mesophytic flora is able to establish itself, as beautifully exemplified on Five-mile Beach.

a remarkable forest growth, the depth of the vegetable mold is about three feet, indicating that the surface of Five-mile Beach was one of the first to have been captured from the drifting action of the winds. The soil of the dunes is chiefly quartz sand, consisting of grains remarkably uniform in size, since the wind has made a selection, being unable to pick up gravel or large sand particles. The sand, as a whole, appears whitish, but in the hollows of the dune complex it is generally streaked with grains of black sand, largely hornblende and magnetite. Such a sandy soil has a marked effect upon vegetation, being extremely porous and almost devoid of cohesion between the grains. Plants growing upon such porous sand deposits show always a xerophytic character. This is the character of the soil of most of the beaches of the New Jersey coast with the exception of Five-mile, Two-mile and Poverty, or Cape May Beaches, where the sand, being finer, is more compact and not easily blown into dunes. Wildwood, Holly Beach and Cape May have long been known for the silky or velvety character of their beach sands.

Another fact of very considerable interest must be mentioned here. Many beaches of to-day rest on the tide marsh and a very heavy storm will sometimes cut away the sand and expose the marsh on the ocean front. This was shown at Sea Isle City in 1892, but never to the knowledge of the writer at Barnegat Beach. The sand of the beach here, and in other places, has been carried over and deposited on the marsh, which was west of where the beaches formerly lay. This is shown at Island Beach Life Saving Station, where the old marsh has been entirely covered up with the exception of a few spots which exist as isolated marshy places in the midst of the dunes long since captured by trees and other plants. The drifting in of the beach and the wearing away of the sand in front has caused the kind of soil deposits described above.

Climatology.

The introductory remarks concerning the climate of the Atlantic coast of New Jersey are derived from the *Final Report of the Geological Survey of New Jersey*, Vol. I, "Topography, Magnetism, Climate," p. 347.

That part of the State which borders the ocean and is near enough to be more directly exposed to the ameliorating influence of its waters is here designated as the Atlantic Coast Belt. The influence of the ocean's waters is felt very decidedly to a distance of four to eight miles from the line of beach, or outer coast line, from Sandy Hook to Cape May. The distribution of the open bays, tides, marshes, rivers and clearings alter this distance very considerably. In severe storms the salt spray is felt several miles back from the shore. "According to Eli Collins,[12] of Barnegat, a dry storm, September 3, 1821, carried spray of salt water three miles inland, upsetting stacks, etc. It lasted from 9 A.M. to 3 P.M. For two hours it was cloudy and dark as a hurricane. It killed the leaves of the trees, and after they fell new buds and flowers were developed the same year." Col. B. Aycrigg, of Passaic, says of the same storm: "Its violence may be estimated from the fact that where I was staying, two miles from the bay and six miles from the sea, the salt water was blown against the windows and left a crust of salt, which had the effect of ground glass, and the leaves on the southeast sides of the trees were killed, turned brown and dropped off." The effect of the prevailing sea winds is not, however, noticeable far from the shore in the pine districts. But the isolated and scattered trees of fields and the woods on the beaches all show it in their unsymmetrical growths.

Water equalizes the temperature and renders it more even. The winds from the sea are warmer in winter and cooler in summer. The sea breezes of the hot season spring up generally about noon, so that the maximum temperature of the day is in the forenoon, just before the inblowing of the cool sea air. The influence of these sea winds is to temper the extreme heat, to reduce both the range and the mean temperature in the warmer months, and to give a more humid character to the air.

The sea beaches situated, as they are in New Jersey, with the ocean on one side and the tidal waters on the other, have a climate partaking slightly of the insular type. Barnegat Station is separated from the mainland by four miles of water. There is a noteworthy difference in the winter season between Cape May and other coast stations. It is seen in the difference in the average daily minimum, which at Barnegat and Atlantic City is four to five degrees lower than it is at Cape May. The position of Cape May is more

[12] P. 348, *l.c.*

insular than that of Atlantic City or Barnegat. It is warmer in winter than Washington, and its mean daily range of temperature is four degrees less than Norfolk, Va. The range is nearly as low as Cape Lookout in North Carolina, and Key West, New Orleans and Galveston in the Gulf States. Figures show that in the daily range of temperature Cape May compares favorably with our most southern localities. The effect of so high a mean temperature in the spring is to produce crops of vegetables and small fruits quite as early as Portsmouth and Norfolk, Va., and the season is generally a month in advance of the same season in the northern part of the State.

The mild climate of Cape May appears in the character of its flora. Britton[13] says:

"(1) All the southern counties of New Jersey have a somewhat Southern flora, and it seems true that the further south we go the more pronounced does this become.

"(2) Although Cape May county has never been botanically explored to the extent that discoveries already made should warrant, yet it has already yielded a number of species of more southern distribution, and, so far as known, is the northern limit of the following six: *Œnothera humifusa* Nutt., *Diodia virginica* L., *Conoclinium cœlestinum* D.C., *Galium hispidulum* Michx., *Pluchea bifrons* D.C., *Paspalum walterianum* Schultes.

"(3) In addition to the above list, it may be stated that there are other species of a Southern character which probably occur in greater abundance in Cape May County than in any other part of New Jersey." *Pinus tæda* of the South has also been recently found near Cape May City.

Meteorological Record.

The data given in the accompanying tables represent the meteorological record of one year, that of 1898. The tables are compiled from the ninth annual report of the Board of Directors of the New Jersey Weather Service.

[13] Britton, *A Preliminary Catalogue of the Flora of New Jersey.*

Temperature, 1898.

The Sea Coast.	Elevation above Sea.	Length of Record, Years.	Annual Mean.	Departure from Normal.	Highest.	Date.	Lowest.	Date.
Barnegat.........	36	1						
Atlantic City...	53	16	53.1	+ 1.2	94	July 1	7	Feb. 2
Cape May.......	11	4	54.1	— 0.3	88	June 26 July 1	15	Jan. 30 Feb. 2

The record for Barnegat Lighthouse is not complete for the year, because no record was made for the months of January, February, June and July.

ANNUAL MONTHLY SUMMARY FOR THE THREE STATIONS GIVEN ABOVE.

Temperature.

Month.	Station.	Mean.	Maximum.	Date.	Min.	Date.	Mean of Max.	Mean of Min.	Mean Daily Range.
Jan.	Barnegat....								
	Atlantic City	36.0	60	13	12	2	42.3	29.6	12.7
	Cape May...	38.0	59	13	15	30	43.0	33.0	10.0
Feb.	Barnegat....								
	Atlantic City	34.6	59	10	7	2	41.4	27.8	13.6
	Cape May...	35.5	50	12	15	2	40.6	30.4	10.2
Mch.	Barnegat....	45.2	67	17	24	1	51.6	38.9	12.7
	Atlantic City	44.0	68	17	23	1	49.3	38.7	10 6
	Cape May...	44.8	64	20	26	1	48.9	40.6	8.3
Apr.	Barnegat....	48.1	74	17	25	6	55.9	40.3	15.5
	Atlantic City	46.9	77	17	24	6	53.7	40.1	13.6
	Cape May...	48.2	73	17	31	6	52.8	43.7	9.1
May	Barnegat....	54.2	84	20	41	9	60.6	47.8	12.8
	Atlantic City	55.5	76	20	42	9	60.7	50.3	10.4
	Cape May...	56.2	71	20	42	8	60.1	52.4	7.7
June	Barnegat....								
	Atlantic City	66.6	92	26	50	23	73.3	60.0	13.3
	Cape May...	67.8	88	26	55	6	72.4	63.1	9.3
July	Barnegat....								
	Atlantic City	73.2	94	1	58	12	77.9	68.6	9.3
	Cape May...	73.0	88	1	62	11	76.5	69.4	7.1
Aug.	Barnegat....	75.8	92	31	63	27	82.1	69.5	12.5
	Atlantic City	74.2	91	25	60	28	79.1	69.3	9.8
	Cape May...	74.4	83	2	65	28	77.3	71.4	5.9
Sept.	Barnegat....	70.8	94	3	53	21	78.3	63.2	15.1
	Atlantic City	68.0	89	3	50	21	74.3	61.7	12.6
	Cape May...	68.0	83	3	55	21	71.4	64.3	7.1
Oct.	Barnegat....	59.8	78	4, 5	37	28	66.6	52.9	13.7
	Atlantic City	57.5	75	3	35	28	63.9	52.1	11.8
	Cape May...	58.8	72	5, 6	35	28	62.5	55.0	7.5
Nov.	Barnegat....	45.5	66	4	24	27	52.9	38.1	14.8
	Atlantic City	44.1	62	2	24	28	50.5	37.7	12.8
	Cape May...	46.4	63	10	26	27	50.9	42.0	8.9
Dec.	Barnegat....	36.4	54	5, 31	20	9, 10	43.2	29.5	13.7
	Atlantic City	36.4	56	4	12	14	42.9	28.8	13.1
	Cape May...	37.8	50	31	21	14	42.4	33.2	9.2

The date of the last killing frost in spring for Barnegat City in 1898 was April 8; for Cape May City, April 7, and for Ocean City, April 8.

The first killing frost in autumn (1898) occurred at Barnegat City, Cape May City and at Ocean City on the same day, October 28. The length of the season in days at the several places was as follows:

Barnegat City, ...	203 days.
Ocean City, ...	203 "
Cape May City, ...	204 "

Precipitation, State of Weather, Wind, 1898.

Station.	Precipitation, in Inches.							State of Weather.				Wind.
	Total for Year.	Departure from Normal.	Greatest Monthly.	Month.	Least Monthly.	Month.	Total Snowfall.	Number of Rainy Days	Number of Clear Days.	No. Partly Cloudy D'ys	Number of Cloudy D'ys	Prevailing Direction of Wind.
Barnegat.	......	......	5.94	Nov.	1.52	Sept.						
Atlantic C'y	38.68	—4.13	5.51	Nov.	1.81	Sept.		127	123	139	103	N. W
Cape May.	40.80	+ 7.68	4.81	Apr.	1.55	Feb.		133	145	96	124	N. W.

Month.	Station	Precipitation.				State of Weather.			Wind.
		Total Precipitation.	Greatest in 24 Hours.	Date.	Numb'r Days 0.01 or more.	Clear	Partly Cloudy.	Cloudy.	Prevailing Direction
Jan.	Barnegat....								
	Atlantic City	3.39	0.97	15, 16	13	6	13	12	N.W.
	Cape May...	3.06	0.86	15	13	9	10	12	N.W.
Feb.	Barnegat....								
	Atlantic City	1.86	1.40	19, 20	8	15	8	5	N.W.
	Cape May...	1.55	0.97	19	8	15	6	7	N.W.
Mch.	Barnegat....	3.54	0.90	4, 5	8	7	19	5	N.E.
	Atlantic City	2.56	0.70	29, 30	11	7	12	12	E.
	Cape May...	3.00	0.94	4	14	8	9	14	N.E.
Apr.	Barnegat....	3.64	1.33	28, 29	7	11	12	7	N.E.
	Atlantic City	2.67	0.75	28, 29	13	4	16	10	N.W.
	Cape May...	4.81	1.98	28	13	9	9	12	N.W.
May	Barnegat....	5.63	1.50	15	17	11	11	9	N.E.
	Atlantic City	5.17	1.22	12, 13	16	6	13	12	S.W.
	Cape May...	3.92	0.93	16	17	10	6	15	N.E.
June	Barnegat....								
	Atlantic City	2.49	1.59	28, 29	10	13	14	3	S. W.
	Cape May...	2.02	0.60	20	11	15	9	6	S. W.
July	Barnegat....								
	Atlantic City	2.23	1.18	12, 13	8	11	14	6	S.W.
	Cape May...	4.13	1.15	13	12	11	11	9	S.
Aug.	Barnegat....	2.70	1.30	10, 11	5	18	10	3	S.W.
	Atlantic City	3.99	1.93	10, 11	6	14	13	4	S.W.
	Cape May...	4.76	1.21	12	6	15	8	8	S.
Sept.	Barnegat....	1.52	1.10	22, 23	4	19	10	1	N.E.
	Atlantic City	1.81	1.14	23	8	19	4	7	S.W.
	Cape May...	3.25	1.24	26	7	18	6	6	S.
Oct.	Barnegat....	5.25	1.30	26, 27	10	17	10	4	N.E.
	Atlantic City	4.60	1.75	26	11	9	14	8	N.W.
	Cape May...	3.94	1.42	26	10	13	8	10	N.W.
Nov.	Barnegat....	5.94	1.30	29, 30	11	11	11	8	N.W.
	Atlantic City	5.51	1.25	26, 27	13	9	9	12	N.W.
	Cape May...	3.83	0.72	29	12	9	8	13	N.W.
Dec.	Barnegat....	3.54	1.52	19, 20	9	14	8	9	N.W.
	Atlantic City	2.40	0.79	19, 20	10	10	9	12	N.W.
	Cape May...	2.53	0.54	20	10	13	6	12	W.

THE PLANT FORMATIONS, THEIR COMPOSITION AND PHYSIOGNOMY.

The various areas which are definitively marked by the character of the vegetation pass in some cases insensibly into each other, so that they overlap or are dove-tailed like wedges, these physiographical features being brought about by the sort of topography which prevails in a given area. For example, a mile below the town of Seaside Park the dune complex, almost entirely bare of trees, stretches completely across the beach, which is here about half a mile wide. In making the ecological reconnoissance at the four points chosen for study—namely, Seaside Park on Barnegat Beach, South Atlantic City on Absecon Beach, Ocean City on Peck's Beach, and Wildwood on Five-mile Beach—the following belts or zones of the different formations may be given in outline, the exceptions to the typical disposition of the belts or zones being due to the physiographic changes brought about by the closure of inlets, the drifting of sand, and the wearing action of the waves on the beach front and their scouring action upon the tide marsh:

I. Sea-strand vegetation.
  1. Treeless open.
    A. Beach formation.
      (*a*) Succulent zone (middle beach).
        Cakile–Ammodenia society at Seaside Park, South Atlantic City and Ocean City.
        Salsola society at Ocean City and Wildwood.
        Atriplex society at Wildwood.
      (*b*) Œnothera humifusa zone (upper beach only at Wildwood).
    B. Dune formation.
      (*a*) Ammophila zone at Seaside Park, South Atlantic City, Ocean City and not clearly at Wildwood.
      (*b*) Myrica zone at Seaside Park, South Atlantic City, Ocean City.
      (*c*) Hudsonia zone, comprising the greater part of the dune complex, at Seaside Park only.
        Rhus radicans–Ampelopsis society at Seaside Park and Wildwood.
        Dune-marsh society at Seaside Park and Ocean City.

Baccharis–Rosa society, bordering the dune-marsh society and growing upon the captured slopes of the dunes of the dune complex (Hudsonia zone), at Seaside Park only.

2. Tree clad (trees and shrubs).

A. Thicket formation at Seaside Park, South Atlantic (on high dune in middle of salt marsh), Ocean City and most luxuriantly at Wildwood, comprising two zonal areas, the second surrounding the following associations (Kearney), or societies:

(*a*) Juniper zone.

(*b*) Zone of mixed vegetation.

Thicket marsh society at Seaside Park and Wildwood.

Hudsonia society at Seaside Park and Wildwood.

Scirpus society at Seaside Park.

Cat-tail society at Seaside Park.

Marsh Shield–fern society at Seaside Park and Wildwood.

Osmunda society at Wildwood.

Ptilimnium society at Wildwood.

Polygonum society at Wildwood.

B. Marsh-dune formation at Seaside Park and elsewhere on the coast, where isolated rounded hills of sand arise from the centre of the marsh and are covered with a variety of shrubs and occasionally one or two trees, evergreen or deciduous. At South Atlantic City such a dune island exists in the marsh, but its length and the complexity and size of the growth upon it compel us to classify it under 2. *A*. Thicket formation proper.

II. Salt-marsh vegetation.

A. Tidal-flat formation, covered at exceptionally high tides, along the entire coast.

B. Saline-marsh formation at South Atlantic City and Wildwood and many other places back of the beaches.

C. Converted saline-marsh formation (fresh), redeemed from the effect of the tidal brackish waters of the bays by the formation of a sandy beach and a low dune along its bay side. This sandy beach and dune completely closes off the marsh from salt water, except where the so-called slues are found which permit the ingress and egress of the tidal water to limited areas of the marsh. Such areas of the marsh, therefore, are covered with vegetation more truly adaptive in character. Such a marsh is found at Seaside Park about 700 feet wide, and from the drier portions of it salt hay is cut periodically.

III. Bay-strand vegetation (absent where the saline-marsh formation exists).

A. Dune formation as at Seaside Park, where the dune supports a variety of plants. This formation one mile below Seaside Park merges itself insensibly with the thicket formation proper. In fact, no line of demarcation between these two formations can be drawn at that point.

B. Bay-beach formation at the limit of high tide, covered with the dead and dried leaves of eel-grass, *Vallisneria spiralis* washed up by the waves.

IV. Bay-water vegetation.

(*a*) The Plankton (not investigated).

(*b*) Ruppia zone in the shallow waters along the eastern shore of the bays (investigated at Seaside Park).

(*c*) Nereid zone, comprising the algæ which grow on the pilings sunk into the sand for landings and as jetties to prevent wave action. These algæ exist in considerable abundance, especially near the inlets and open bays communicating with them, where the salt water of the ocean has full effect. This zone was not investigated. A number of other zones and societies might be delimited, but the above indicate that a careful study of them would amply repay the ecologist.

I. Sea-Strand Vegetation.

1. treeless, open formations.

A. Beach Formation.

The beach formation exists at the several places investigated in several modifications of the typical one, which exists at Seaside Park, N. J. The lower beach is limited by the reach of the higher tides and is marked by the constant shifting and grinding of the particles of sand against each other by wave action. No plants can exist under such trying conditions—the pounding action of the waves, the grinding of the beach sand, the desiccating effects of the sun and wind when the beach is exposed at low tide. The middle beach, where driftwood collects, supports a considerable number of herbaceous annuals, which show in a striking way their adaptation to unpropitious surroundings. They possess in the extreme a xerophytic character of succulence, and this permits them to exist in a porous soil of drifting sand and within the influence of the salt spray.[14] The most abundant plant of the middle beach in all the localities studied is *Cakile edentula* (Bigel.) Hook., the sea blite, with long branching tap-root and jointed, indehiscent, fleshy fruit of two compartments. The leaves of this plant are thick and succulent and thus well adapted to the extreme xerophilous conditions to which beach plants are subjected. Associated with this succulent is also another, *Ammodenia peploides* (L.) Rupr., which grows in clumps, and is of a dark-green color with thick, fleshy leaves. It forms the so-called annual dunes which are piled up around its succulent stems, remaining as small hillocks of sand, through which this plant protrudes, until autumn, when upon the death of the sand-binder the sand is again caught up by the wind and carried away. *Cakile edentula* (Bigel) Hook. is also instrumental in catching the sand and holding it in the form of embryonic dunes. These two plants are the only ones found commonly on Barnegat Beach at Seaside Park.

At South Atlantic City, in addition to *Cakile* and *Ammodenia*, which are also found there, grow *Salsola kali* L., *Euphorbia polygonifolia* L. and *Cenchrus tribuloides* L. *Salsola kali* L. is ex-

[14] For physiological details the reader is referred to Kearney's "The Plant Covering of Ocracoke Island," *Contrib. U. S. National Herbarium*, Vol. V, p. 275, 1900.

tremely xerophytic with succulent stem and leaves and spinous habit. *Euphorbia polygonifolia* L., a prostrate herb, possesses latex, which is probably instrumental in reducing transpiration. *Cenchrus tribuloides* L., of annual habit, depends upon its prickly fruit for its distribution and very existence. It is abundant, as a character plant, at South Atlantic City, along the dune faces in the zone of succulents, and also as a component of the flora in the zones more distantly removed from the ocean front. This is true of this grass both at Ocean City and Wildwood, where it is not conspicuous by its presence on the middle beach.

The most interesting distribution of plants is met at Wildwood. Here the beach is extremely flat and very wide, trending to the northeast, where apparently it is widest. The lower beach consists of sand, packing well together, and when wet presenting a hard, firm, floor-like surface. Just above the ordinary limit of high tide are little hummocks of sand held in place by the stalks of grasses and other herbaceous plants which have been washed up by tidal action. This area of loose sand is succeeded by a line of more elevated sand bordering a tidal depression inside it. Upon this low ridge of sand *Salsola kali* L. grows in the greatest abundance, and an inspection indicates that the tide must flow at times between the *Salsola* patches. On the far side of the tidal pool are found, in association with isolated clumps of the marram grass, *Ammophila arenaria* (L.) Link., growths of an annual *Atriplex arenaria* Nutt., a chenopodiaceous plant with reddish-colored bushy-branched stem and fleshy leaves. Proceeding up the beach in a straight line, a wind-swept area tenanted by marram grass and isolated plants of *Xanthium Canadense* Mill. var. *echinatum* (Murr.) Gray, *Euphorbia polygonifolia* L., *Salsola kali* L. (not as a character plant), *Sesuvium maritimum* (Walt.) B. S. P., and *Strophostyles helvola* (L.) Britt., just in flower, trailing as a prostrate vine over the sandy soil, are passed. The only area which merits the name Ammophila zone occupies the portion of the beach adjoining that just described, but the sand grass, *Ammophila arenaria* (L.) Link., although abundant here, hardly can be called a zonal plant at present, although it has commenced to build a frontal dune, which when raised above the level of the beach (a stage which it has not yet reached) may separate the middle beach from the upper beach sufficiently to merit the application of the zonal name to this area of the Wildwood sea-strand. The sand grass growing here was found in full flower associated with *Ammodenia peploides* (L.) Rupr., gathering the sand about it, and *Strophostyles helvola* (L.) Britt., creeping out as a radiant plant in all directions. As an introduced stray, the tomato plant, *Lycopersicon Lycopersicon* (L.) Karst., was picked up in this area, much depauperate and beaten by the blasts of sand and wind and hardly recognizable except by its odor and the lobed leaves with smaller lobes interspersed in the sinuses.

The Œnothera humifusa zone, or upper beach, comprises the hollow place in front of the low frontal dune and the seaward face of the dune itself. Here grow in perfect harmony *Gerardia purpurea* (L.), *Strophostyles helvola* (L.) Britt. with narrower leaflets, *Solidago sempervirens* L. with thick leaves, which is found on the lee face of the sea dunes farther northward, *Leptilon canadensis* (L.) Britton and *Œnothera humifusa* Nutt.—the plant which gives name to this interesting assemblage of species. The latter is chosen as a character plant, because Cape May county represents the northern limit of its distribution, which extends to Florida. *Œnothera humifusa* Nutt. is essentially southern in its range, occurring on the sea beaches of the Southern States. Its presence is proof of the mild climate of Wildwood, which has already been referred to. The lower face of the dune here supports *Lactuca canadensis* L. and life-everlasting, *Anaphalis margaritacea* (L.) Benth. and Hook.

B. Dune Formation.

(*a*) Ammophila Zone.—Upon the top and lee side of the sea dune at Seaside Park, which extends in some places uninterruptedly there for a distance of half a mile, with a uniform height of about 15 feet, and at a uniform distance from the ocean front, grows the best of all sand-binders, *Ammophila arenaria* (L.) Link. A perennial dune such as at Seaside Park requires perennial dune-formers, which must be also plants which possess the power of growing out into the light when buried in the sand, and of spreading radially by rootstock propagation. These requirements of a successful dune-former and holder marram grass possesses in the highest degree. Cowles[15] gives an exhaustive account of how this grass accomplishes this object so perfectly. Associated

[15] 1899, Cowles, "Dune Floras of Lake Michigan," *Botanical Gazette*, p. 180.

in a remarkable ecological way with this grass is the sand pea, *Lathyrus maritimus* (L.) Bigel., which flourishes with it on the dune summit. It has long been known that with the numerous tubercles on their roots which store up nitrogen, leguminous plants can thrive apace in almost pure sand. The beach pea does this on these porous dunes and not only lives for itself, but upon its death enriches the sandy soil with nitrogenous compounds. The clumps of sand grass growing in immediate proximity to the leguminous perennial herb seizes hold of the nitrogenous products with avidity and becomes correspondingly thrifty, denser in growth and of a darker green color than the same grass in the neighborhood, growing outside of the benign influence of *Lathyrus maritimus* (L.) Bigel. That the beach pea is not in danger of extinction, but has a firm hold upon the dune, will be shown by a close inspection of the following statistics giving the result of the pollination of the flowers. Ten plants were chosen and a careful enumeration was made of the fruits and seeds produced.

Fruit and Seed Production Lathyrus maritimus (L.) Bigel.

a = abortive seeds; p = pierced; e = eaten; A, B, etc. = fruit clusters.

Plant.	Numb'r of Fruit Clust's.	Number of Pods in the Clusters.	Number of Seeds in Each Pod.	Total No. of Good Seeds.
I	1	1	1	1
II	2	A 1, B 2	A 1 = 0; B 1 = 4, B 2 = 3	7
III	2	A 1, B 2	A = 2; B = 0	2
IV	3	A 1, B 2, C 4	{A = 0; B 1 = 3, B 2 = 2 + 1*a*; C 1 = 1, C 2 = 2, C 3 = 0}	8
V	4	A 1, B 2, C 2, D 2	{A = 5; B 1 = 2, B 2 = 4; C 1 = 0, C 2 = 7; D 1 = 2, D 2 = 2}	22
VI	1	A 4	A 1 = 1, A 2 = 2, A 3 = 2 + 1*a*, A 4 = 4*a*	5
VII	1	A 5	A 1 = 1*a*, A 2 = 2 + 2*a*, A 3 = 0, A 4 = 0, A 5 = 0	2
VIII	3	A 6, B 3, C 3	{A 1 = 1, A 2 = 2, A 3 = 1, A 4 = 2 + 1*a*, A 5 = 2, A 6 = 2*p*; B 1 = 5, B 2 = 2, B 3 = 5; C 1 = 1, C2 = 2 + 3*a*, C 3 = 0}	22
IX	3	A 4, B 5, C 5	{A 1 = 4, A 2 = 1, A 3 = 2 + 1*a*, A 4 = 3; B 1 = 2, B 2 = 2 + 2*a*, B 3 = *e*, B 4 = 3 + 2*e*, B 5 = 1}	18
X	3	A 3, B 1, C 5	{A 1 = 2, A 2 = 2, A 3 = 2; B = 1*a*; C 1 = 2*a*, C 2 = 2, C 3 = 1, C 4 = 3, C 5 = 5}	17

At South Atlantic City the frontal dune is very much broken up into many summits, upon which and the lee side *Ammophila arenaria* (L.) Link. grows as the principal character plant. This is also true of the lower dunes at Ocean City, which are nowhere so bold or prominent as at South Atlantic City. The Ammophila zone at Wildwood, as previously stated, is doubtfully referred to as an area between the middle and upper beaches and constituting in reality the inner part of the middle beach. It seems apparent that a dune is just beginning to form at that point of the beach, and will grow much more rapidly as the timber is removed by the march of so-called improvements which threaten the beauty of Wildwood Beach.

(*b*) Myrica Zone.—Just behind the high dune which faces the ocean and on its lee slope, protected by the top of the dune, is met an extensive belt of *Myrica cerifera* L., which occurs normally at Seaside Park, South Atlantic City and Ocean City, but is absent at Wildwood. It occurs typically at Seaside Park and also clearly defined at South Atlantic City, but at Ocean City it is broken up into two parallel areas behind the second and third series of dunes. Normally it should occur behind the first or frontal dune. Isolated specimens of *Myrica cerifera* L. are found in the thicket formation, but as far as inspection showed it does not grow as a zonal plant. Associated with the waxberry bushes at Seaside Park is the ubiquitous sand grass (*Ammophila*), an occasional golden-rod (*Solidago sempervirens* L.) and a prostrate growth of *Euphorbia polygonifolia* L., but that is all. At Ocean City *Strophostyles helvola* (L.) Britton, *Panicum virgatum* L., *Baccharis halimifolia* L., *Rhus radicans* L. are mixed together by reason of the parallelism of the three dunes which occur there, and *Myrica*, therefore, becomes an element of the dune complex. In becoming an element in the dune complex (Hudsonia zone), *Myrica cerifera* L. has also become a component of the Rhus radicans–Ampelopsis society of the classification, and consequently it surrounds typical marsh plants, such as *Kosteletskya virginica* (L.) A. Gray, *Hibiscus moscheutos* L., *Sabbatia stellaris* Pursh., *Ptilimnium capillaceum* (Michx.) Hollick, *Scirpus debilis* Pursh., and the like, composing the dune-marsh society.[16]

(*c*) Hudsonia Zone—the Dune Complex.—This zone is of espe-

[16] This mixing of the several societies by the intrusion of the Waxberry is further proof of the difficulty of a strict classification.

cial interest. The topography is kaleidoscopic. The dunes are constantly changing their shape, being blown away on one side and built up on the other. The hollows between them are filled up and new valleys are scooped out by the resistless action of the wind. This is true of this belt along the entire New Jersey coast, where it is a dominant feature of the landscape, but the change is not so rapid in some places as in others. Some of the dune complexes change very slowly, others more rapidly; some, it may be, have become stationary. While there is a general advance of the complex as a whole in the direction of the prevailing winds, individual portions are advancing in all directions in which winds ever blow. All stages in the life-history of a dune may be seen—the beginning, the climax, the destruction. Here and there great hollows are formed, which reach down almost to the water level. Here and there vegetation has obtained a foothold on the complex, thus capturing such portions and forming them into established dunes. The most striking feature of the dune complex, then, is its topographic diversity. At Seaside Park, the dune complex extends from the limits of the Myrica zone already defined to the Juniper zone of the typical thicket formation. In it are found troughs running at all angles with the main troughs in the direction of the influential winds. The dune complex exists in all the places visited, but its vegetable covering is different. At South Atlantic City it does not exist; at Ocean City it is an area of established dunes clothed with a variety of plants; at Wildwood it is a narrow area of a low frontal dune and a hollow immediately behind it, encroached upon by tree growth, and is, therefore, not clearly demarcated at either of the places last mentioned.

At Seaside Park, where it typically exists, there is not an established series of dunes, but the change is a slow one, motion being arrested by the character plant, *Hudsonia tomentosa* Nutt., which forms clumps or cespitose clusters closely set together on the top and sometimes the slopes of the slowly moving dunes. This plant, which is so characteristic and definitive zonally speaking, is densely tufted, intricately branched, matted and hoary-pubescent with densely imbricated and appressed leaves. Each clump is separated from its neighbor by a narrow channel of sand, so that to the eye the belt has a hummocky appearance, such as to give it a desert aspect, as so well illustrated in Schimper's *Pflanzen-*

geographie auf Physiologischer Grundlage, fig. 359, opposite p. 658; fig. 375, p. 671. The common names, beach heather and poverty grass, are well chosen, and give expression, on the one hand, to the appearance of the plant itself, and, on the other, to its growth as influenced by surrounding conditions. Associated with this low-growing perennial herb are found *Solidago sempervirens* L., *Rhus radicans* L., trailing over the ground and with an etiolated appearance, expressive of its struggle for supremacy. *Linum medium* (Planch.) Britton, *Lechea maritima* Leggett and others, such as *Ampelopsis quinquefolia* Michx., which is an occasional intruder on the more established dunes.[17] However, along the geologic shore line of an old inlet which was gradually filled in and converted into marsh, a line of dunes stretches from the ocean to the bay front, forming a dune complex at right angles to the main one, which at Seaside Park runs parallel to the seashore. This dune complex is nearly stationary; even more so than the main complex, because lying to the north of the thicket formation, which it bounds in that direction; and the dunes are covered with beach heather to an extent which makes it the dominant plant of the transverse dune complex.[18] Upon this transversely placed Hudsonia belt exist isolated trees of the following species in considerable numbers, but nowhere growing together, except it may be in companies of twos or threes, usually, however, standing alone: *Quercus ilicifolia* Wang. (*Q. nana* (Marsh.) Sarg.) is a small tree of dense growth; *Ilex opaca* Ait. is strong-growing and dark green in color; *Quercus phellos* L., the willow oak, forms a dwarf tree about four feet high; *Vaccinium corymbosum* L., with smooth leaves, and *Vaccinium atrococcum* (A. Gray) Heller, with densely pubescent leaves and gnarled form, both loaded with berries, were found to exist here, with *Kalmia angustifolia* L., in fruit, and *Rubus canadensis* L. trailing at their base. *Pinus rigida* Mill. also is a component element of the transverse dune complex, growing with the sassafras on the dune slopes and drier

[17] *Prunus maritima* L., the beach plum, forms by its upward growth small dunes, comparatively steep. It usually grows in isolated patches on the slopes or summits of the dunes, near the centre or inside margin of the dune complex.

[18] In the subsequent descriptions of this transverse dune complex the geologic beach of the old inlet will be spoken of in these terms as it exists one mile below the town of Seaside Park.

dune hollows. *Juniperus virginiana* L. is also abundant here. The landscape has, therefore, somewhat of a park-like aspect.

The dune complex (not Hudsonia zone) at Ocean City is a succession of dunes and dune hollows. Upon the top of the dunes and covering their slopes to some extent the marram grass, *Ammophila*, has almost full sway, but occasionally *Sieglingia purpurea* (Walt.) Kuntze, *Strophostyles helvola* (L.) Britton and *Solidago sempervirens* L. are associated with the above-mentioned grass. In the hollows are found *Scirpus debilis* Pursh., *Strophostyles helvola* (L.) Britton, *Panicum virgatum* L., *Cyperus Nuttallii* Eddy, *Gerardia purpurea* L., with *Myrica cerifera* L. and *Baccharis halimifolia* L. growing upon the slopes of the sand hills and the drier depressions of the dune complex. The dune complex at Wildwood is a narrow belt (50 feet wide) of established dunes. It might be said to belong to the thicket formation, but for the fact that it is open. Upon the low dune, 4 or 5 feet high, flourish *Rosa carolina* L., *Rhus radicans* L., *Sieglingia purpurea* (Walt.) Kuntze, *Phytolacca decandra* L., and dead, badly wind-swept cedar trees. Immediately behind the dune front *Ampelopsis quinquefolia* Michx., *Panicum virgatum* L., *Andropogon virginicus* L., in clumps, and *Monarda punctata* L. make up the list of conspicuous plants of the narrow dune complex of Wildwood Beach. Several isolated trees, *Juniperus virginiana* L., *Quercus minor* (Marsh.) Sargent, of dwarf growth stand here, and form the vanguard of the tree growth which so completely covers the higher portion of Five-mile Beach.

The dune-marsh society is typically developed at Seaside Park, and to a less extent at Ocean City. The plants which form it inhabit the depressions of the dunes, which reach to water level. The species, therefore, associated together as a happy family are essentially of a marsh habit. The dune marshes at Seaside Park are somewhat different in character in different localities and under varying surroundings. In one such marsh situated near the Island Beach Life Saving Station grow *Ptilimnium capillaceum* (Michx.) Hollick, *Polygonum hydropiperoides* Michx., *Hypericum mutilum* L., *Scirpus debilis* Pursh., *Carduus spinossissimus* Walt., *Gyrostachys cernua* (L.) Kuntze, *Teucrium canadense* L., while as a bordering growth on the dune slopes of the marshy depressions occurs the Baccharis-Rosa society of our classification. Ecologically the Baccharis-Rosa society comprises three dominant species: *Rosa carolina* L., *Baccharis halimifolia* L., *Rhus copallina* L.

The marshy hollows of the transverse dune complex at Seaside Park resemble, physiognomically, a typical pine barren swamp in its constituent elements. Such a one, explored, yielded *Juncus effusus* L., *Panicum amarum* Ell., *Drosera filiformis* Raf., the cranberry, *Oxycoccus macrocarpus* (Ait.), Pers., as the character plants of such situations, while near by, as already mentioned, grow other pine-barren forms such as *Sassafras Sassafras* (L.) Karst., *Quercus nana* (Marsh.) Sarg., *Quercus phellos* L., *Vaccinium corymbosum* L., *Vaccinium atrococcum* (A. Gray) Heller, *Kalmia augustifolia* L., and *Pinus rigida* L. The character of the dune-marsh growth of the dune complex at Ocean City has already been described, and it is therefore not necessary to consider it further in detail.

2. TREE-CLAD STRAND.

A. Thicket Formation.

The thicket formation developed typically at Seaside Park and Ocean City reaches its greatest proportions at Wildwood. At South Atlantic City it covers a long, high dune, which is situated, as an island, in the middle of the salt marsh which everywhere surrounds it. It will, therefore, be described in sequence with the others, although it is misplaced, zonally speaking.

One mile below the town of Seaside Park the beach thicket covers a considerable area, many acres in extent and quite impenetrable in some places. It is fronted by a belt or zone of juniper trees, which are wind-tossed and gnarled by their long struggle with the elements.

(*a*) Juniper Zone.—The vanguard consists of cedars, which never rise above the dunes of the dune complex upon which they grow. Young trees in the dune hollows are spire-shaped, but upon reaching the general level of the dune summit they become flat-topped, incline in the direction opposite to the prevailing wind, and become gnarled and weather-beaten. The cedars of the zone proper form an almost pure growth in front of the main thicket, grow much larger and seem to be more independent of their surroundings. Several well-marked varieties of this tree are met with. The young trees have sharp, aculeate leaves, widely divergent and loosely set on the twigs. In color they are either dark green or yellowish green; the dark green specimens have longer leaves than the light green ones, the twigs of which are more elongated and widely spreading. Spire-shaped trees of the vanguard have a close growth, the leaves are closely appressed and overlapping, and are obtuse. The young twigs are essentially similar in appearance, but more elongated. Another spire-shaped tree of the same size and from the same locality showed leaves of the closely appressed type on the older twigs, but more acuminate, while on the younger twigs the primary leaves were large acuminate, as were also the smaller appressed leaves of the same region. This tree had a bluish green cast of foliage. The wind-swept trees show the struggle they wage, not only in their gnarled, inclined and flat-topped growth, but also in the closeness of the twigs, the appressed condition of the leaves, which are small, short and blunt. The younger twigs are also extremely abbreviated, as if the tree had to conserve all of its energies for the apparently unequal struggle. The Juniper zone, clearly defined, is not met with at South Atlantic City, Ocean City or Wildwood, and is apparently absent from those places.

(*b*) Zone of Mixed Vegetation.—This at one mile below the town of Seaside Park is a veritable jungle, composed of trees, shrubs and lianes, broken there by dry or swampy open glades. The thicket is impenetrable in a number of places owing to the thick growth, and to *Smilax rotundifolia* L., covered with spines, and *Ampelopsis quinquefolia* Michx., which grow as climbing vines, looping themselves from limb to limb and from tree to tree. The most notable species entering into the formation are *Juniperus virginiana* L., *Ilex opaca* Ait., *Iva frutescens* L. along the margins, *Quercus nana* (Marsh.) Sarg., *Rosa carolina* L., *Pinus rigida* Mill., *Rhus copallina* L., and the climbing form of *Rhus radicans* L. It is worthy of note that here the holly trees are larger, more open and provided with larger leaves than the trees of the exposed, wind-swept transverse dune complex.

The thicket at South Atlantic City covers the high insular dune and the hollows and minor dunes behind it. The crest of the dune is probably 30 or 35 feet above the level of the salt marsh, and the hollow behind it is correspondingly depressed. *Pinus* *rigida* Mill., *Quercus minor* (Marsh.) Sarg., *Cassia chamæcrista* L., *Vitis æstivalis* Michx., *Viburnum dentatum* L., *Juniperus virginiana* L. of three varieties are found, with *Monarda punctata* L. on the front face and summit of the dune, while in the valley behind grow *Quercus digitata* (Marsh.) Sudw., *Ilex opaca* Ait., one form with spiny margined leaves of the usual type and another with spineless entire leaves, revolute margins, smaller in size and ovate acuminate, *Pinus rigida* Mill., densely filled with old cones, *Sassafras Sassafras* (L.) Karst., and persimmon, *Diospyros virginiana* L. These trees reach a large size, but when they reach the height of the dune summit become flat-topped and wind-swept. The ground of the valley is open, almost entirely destitute of smaller growth, except the smaller trees of the species just mentioned, and the bracken, *Pteris aquilina* L. The thicket at Ocean City is formed of *Prunus maritima* L., which occupies the front of it, *Ilex opaca* Ait., *Juniperus virginiana* L., *Quercus nana* (Marsh.) Sarg., *Rhus copallina* L., *Smilax rotundifolia* L., *Ampelopsis quinquefolia* Michx., and *Vitis æstivalis* Michx., growing upon the open sandy places in front, and among the trees a number of herbaceous plants flourish, such as *Monarda punctata* L., *Cenchrus tribuloides* L., etc.

Wildwood forest, using a dignified term for a remarkable growth of trees and shrubs, is part of the thicket formation on Five-mile Beach, constituted by the association of the following arborescent species: *Juniperus virginiana* L., *Prunus maritima* Wang., *Quercus minor* (Marsh.) Sarg., *Quercus alba* L. x *Q. minor* (Marsh.) Sarg., *Myrica cerifera* L., *Sassafras Sassafras* (L.) Karst., *Nyssa sylvatica* Marsh., *Magnolia virginiana* L., *Acer rubrum* L., *Prunus serotina* Ehrh., *Quercus digitata* (Marsh.) Sudw., and *Vitis Labrusca* L. The vine which grows here reaches a foot in diameter, and is a true liane. Upon the ground, usually in the sandy open places, abound *Cassia chamæcrista* L., *Strophostyles helvola* (L.) Britton, *Solidago odora* Ait., *Solidago fistulosa* Mill., *Panicum amarum* Ell., *Eupatorium hyssopifolium* L., *Willughbæa* (*Mikania*) *scandens* (L.) Kuntze, *Lespedeza capitata* Michx., *Lycopus sinuatus* Ell., *Lippia lanceolata* Michx., *Ambrosia artemisiæfolia* L., near the railroad, *Helianthus giganteus* L., *Meibomia paniculata* (L.) Kuntze, along the railroad, with many other species, most native, some introduced.

There are many peculiar growths in this forest area, due, it seems, to a combination of causes. Vigor and density of growth are due to a mild, moist climate and a soft, moist soil, which Wildwood is known to possess. Strong winds and the work of cattle, no doubt, in part account for the close, jagged growths which are common there. Cattle for many years ran wild on this island, which two hundred and thirty-six years ago Charles II of England granted to his brother James, Duke of York, March 12, 1664. The last of these wild herds were shot only a few years ago. They may have roamed unmolested for two hundred years since the great native chiefs Hohan Topatrapanning, Hohan Kepanectamto, Takamony and Mothant Takomis by deed perfected the title in the white grantees of the king, March 30, 1688. Or they may have been left by the fifty-two whalers who lived here one hundred and thirty-five years ago, or be the descendants of the domestic cattle of the shipbuilders who built craft here to resist the British. However they came here, they without doubt influenced the character of the growth by eating leaves and twigs and by crushing the young growth under foot. Holly disports itself peculiarly. It is not uncommon to find two hollies grown together, or a limb of one grown fast to another holly, or one limb uniting with another limb of the same tree, or joining the trunk to form the so-called "jug-handles."[19] In one instance two hollies are embracing and slowly killing a red cedar, several of the dead limbs of which have been surrounded by the trunks of the hollies. Here are countless examples of tree contention. The limbs of the hollies are matted and zigzag. The trees are full of limb-holes, favorite nesting-places for flickers, which, with the robins, are potent agents in tree distribution. This forest was at one time very dense and the underbrush a mass of green briars. Freak trees are abundant. The "Siamese Twins," two monster hollies, grow up to a height of sixty-five feet. About fifteen feet from the ground, years ago, a branch nearly a foot in diameter grew out from one tree and into the other, solidly joining them together. A short distance from the curiously joined holly trees grows "Crookedness," a cedar tree which has assumed a most fantastic shape. "Before Columbus" is a huge cedar tree nearly

[19] 1894, Gifford, "Report on Forestry," *Annual Report of N. J. State Geologist*, 1894, p. 263.

three feet in diameter, fifty feet high, with gnarled branches. "Methusaleh" is another huge cedar disputing with "Before Columbus" for preëminence as a wonder. "Contwisted" is a name given by painted signboard to two large trees with trunks one and one-half feet in diameter, twisted about each other. "Laocoon" appropriately describes an oak tree supporting an enormous liane or grapevine, *Vitis Labrusca* L. The stem of this liane is as thick as a man's leg. Another liane denominated "Giant Grapevine" is fully one foot in diameter. A magnolia tree growing up through the hollow trunk of an old cedar is another noteworthy sight. A wild cherry is called the "arch or rainbow tree," its trunk assuming the shape of a perfect half-circle. Many of the branches of the trees have been removed for rustic work. Some perfectly represent the letters of the alphabet, as x, w, z, i and o.[20] Many of the larger trees, especially the red maples, are draped with long festoons of the lichen, *Usnea barbata*, reminding one of the live oaks of the South draped with the gray Florida moss, *Tillandsia usneoides* L.

Within the area of the thicket formation are open spaces representing the depressions of the surface, as well as more elevated sandy glades. Several well-marked associations of plants, or societies, take possession of these spaces, varying in ecological composition according to the physiography.

At Seaside Park (one mile below town) several such societies can be delimited. Near the ocean front adjoining the old hotel, long since abandoned, is a hollow accommodating the cranberry and *Drosera intermedia* Hayne. Somewhat farther back is the Marsh Shield-fern society, composed almost entirely of dense growths of *Dryopteris Thelypteris* (L.) A. Gray, surrounded by jungles of Juniper, Baccharis, etc. A third hollow supports in its damp, marshy soil a dominant growth of the sedge *Scirpus debilis* Pursh., which forms the "Scirpus society." A fourth depression, removed some distance from the other, is a favorable place for the Hibiscus society, composed of three character plants, *Hibiscus moscheutos* L., *Scirpus debilis* Pursh., and *Dryopteris Thelypteris* (L.) A. Gray. Still another open space, much wetter than the others mentioned, forms a nidus for *Typha latifolia* L.,

[20] *Forest Leaves*, VII, pp. 67 and 92. Two articles describing the remarkable tree growths on Five-mile Beach.

the margin consisting of drier ground having the marsh shield-fern, *Dryopteris Thelypteris* (L.) A. Gray (Cat-tail society). The higher open sand glades are covered with clumps of *Hudsonia tomentosa* Nutt. Such an assemblage might be denominated the Hudsonia society.

This diversity is the more striking when one considers the small number of plants which enter into the composition of the different associations. The number of possible societies which might exist under the varying conditions of dune and thicket life can be determined mathematically by the rules of permutations and combinations, thus: If we have 10 plants which we wish to combine into different societies, using 6 plants for each society, we find by the rule of combinations that theoretically 210 such societies are possible. If we have 8 plants, taken 4 at a time, 70 societies are possible; if 6 plants, taken 3 at a time, theoretically 20 associations are within the possibility. This number of societies does not exist in a state of nature, because, although within a mathematical possibility, yet specific characters, the condition of the soil, air and illumination all prevent the theoretical realization of the mathematical expression of the possibility of such combinations taking place.

Occurring in the jungle of Wildwood are a number of well-defined societies classified as follows, with the names of their component character plants:

Osmunda society = *Osmunda regalis* L., *Scirpus sp.*, *Impatiens biflora* Walt., *Lobelia cardinalis* L.

Ptilimnium society = *Ptilimnium capillaceum* (Michx.) Hollick.

Oxypolis society = *Oxypolis rigidus* (L.) Britton, *Hibiscus moscheutos* L.

Polygonum society, along the borders of a swampy area = *Polygonum lapathifolium* L.

The following species also occur in the thicket formation of Wildwood, but from the notes taken it is impossible to place them in their proper association: *Asclepias pulchra* Ehrh., *Cassia chamæcrista* L., almost pure, *Dryopteris Thelypteris* (L.) A. Gray, *Triadenum virginicum* (L.) Raf., *Juncus acuminatus* Michx., *Carex lupulina* Muhl., *Cyperus strigosus* L.

B. Marsh-dune Formation.

This formation consists of rounded hills of sand, which arise from the centre of the salt marsh, are covered with a variety of shrubs and occasionally one or two trees. At Seaside Park, such elevated patches of sand support the following plant species: *Prunus maritima* Wang., *Baccharis halimifolia* L., *Iva frutescens* L., *Rosa humilis lucida* Ehrh., *Rhus radicans* L., *Juniperus virginiana* L., *Rhus copallina* L., *Myrica cerifera* L., and some herbaceous plants, as *Achillea millefolium* L., *Eupatorium rotundifolium* L.

II. Salt-marsh Vegetation.

A. Tidal-flat Formation (not studied).

B. Saline-marsh Formation.

The saline marsh at South Atlantic City was the only marsh of this class visited on the New Jersey coast, and nothing in a comparative way can be said of this formation, as it exists on the New Jersey coast in general. Most of the species collected show a xerophytic habit. *Salicornia herbacea* L., *Tissa marina* (L.) Britton, *Limonium carolinianum* (Walt.) Britton, *Juncus scirpoidea* Lam., *Juncus Gerardi* Loisel, *Spartina patens* (Ait.) Muhl., *Distichlis spicata* (L.) Greene and *Sabbatia stellaris* Pursh. are all components of the vegetation of the South Atlantic City salt marsh. In the general list at the end of the paper other species inhabitants of the New Jersey saline marshes will be given, but they are excluded from the descriptive portion, because they were not observed by the writer, and nothing can, therefore, be said of their ecological relationships. In the near future an appendix will be issued giving an account of the peculiar salt-marsh zones of the New Jersey coast.

C. Converted Saline-marsh Formation.

Formation C. consists of marsh which has been redeemed from tidal salt water by the formation of a sandy beach and a low dune along its bay side. The low dune owes its origin to the western winds which blow over the wide and shallow bays behind the beach. This dune rises usually to a height of two or three feet and is unbroken, as it runs parallel to the bay shore. The marsh proper has been raised above the level of high tide by the blowing in of sand uniformly over its entire surface, and by the collection of humus in the soil by the decay of the vegetable covering. In very dry weather this marsh can be traversed at Seaside Park in any direction without wetting the feet; but when a rainy spell sets in, it becomes flooded with two or three inches of fresh water, which in ordinary seasons remains constantly on the surface, forming a shallow swamp. Even if the surface is not flooded, one's feet sink into the surface of the marsh sufficiently for the water to penetrate to the interior of the shoes.

The list of plants found here comprise the following species, none of which show any remarkable xerophytic adaptation, except such as is coincident with a marsh life anywhere:

Panicum amarum Ell.
Panicum proliferum Lam.
Rhyncosphora glomerata (L.) Vahl.
Juncus Gerardi Lois.
Verbena hastata L.
Limonium carolinianum (Walt.) Britton.
Gyrostachys cernua (L.) Kuntze.
Ptilimnium capillaceum (Michx.) Hollick.
Asclepias pulchra Ehrh.
Sabbatia stellaris Pursh.
Sabbatia lanceolata (Walt.) T. and G.
Gerardia purpurea L.
Hypericum canadense L.
Triadenum virginicum (L.) Raf.
Drosera intermedia Hayne.
Kosteletskya virginica (L.) A. Gray. Very commom as isolated plants, never growing in ecological groups.

This last malvaceous plant, common farther south, seems to hold its own with the other components of the converted saline-marsh formation, as the following statistical table shows:

STATISTICS OF FRUIT AND SEED PRODUCTION OF KOSTELETSKYA VIRGINICA, GRAY.[21]

The plants for this enumeration were gathered in the salt marshes at Seaside Park, N. J.

The ratio of the perfect to the abortive seeds is given.

[21] 1898, Harshberger, "Statistical Information Concerning the Production of Fruits and Seeds in Certain Plants," *Contrib. Bot. Lab. Univ. of Pa.*, Vol. II, p. 102.

Number of Plant.	Number of Capsule.	CAPSULE NUMBER.																					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Plant 1	5	5	3	5	3 : 2	1 : 3	–	–	—	—	—	—	—	—	—	–	–	–	—	–	–	–	–
" 2	14	5	5	3	5	5	3	5	3 : 2	5	1 : 4	5	0 : 5	4	3	–	–	–	—	–	–	–	–
" 3	12	1 : 3	–	5	5	4	5	5	4 : 1	4	5	5	5	—	—	–	–	–	—	–	–	–	–
" 4	13	5	5	5	4	0 : 4	5	4	2 : 2	3	5	2 : 3	4 : 1	1 p.	—	–	–	–	—	–	–	–	
" 5	22	3 : 1	5	4 : 1	5	5	4	4	4	4	3 : 2	4	2 : 2	5	5	5	4	5	3 : 2	2	4	4	–
" 6	18	4	5	5	4	5	5	5	5	4 : 1	5	5	5	4	2 p.	5	2	5	5	–	–	–	–

Hibiscus moscheutos L. forms societies over extensive areas to the exclusion of most other plants. This plant grows abundantly at Seaside Park, on the west side of the railroad at Fourteenth avenue, covering several acres, and when in full flower is a remarkable sight worth a long journey to see. The large bell-shaped flowers, three and four inches across, are of a bright pink or white color, through albinism. The plants grow so thickly that at a distance the meadows seem one mass of color, and this predominance is due to the large number of seeds produced.

STATISTICS OF FRUIT AND SEED PRODUCTION OF HIBISCUS MOSCHEUTOS, L.[22]

The ripe capsules on a number of plants of this species were counted in 1894 at Seaside Park, N. J., where it grows abundantly in the salt-water marshes. The results statistically are displayed in the subjoined table (p = pierced by larvæ):

No. of Plant	CAPSULES.																	
	One.			Two.			Three.			Four.			Five.			Six.		
	Seeds.		No. of Cells.	Seeds.		No. of Cells.	Seeds.		No. of Cells.	Seeds.		No. of Cells.	Seeds.		No. of Cells.	Seeds.		No. of Cells.
	Perfect.	Abortive.		Perfect.	Abortive.		Perfect.	Abortive.		Perfect.	Abortive.		Perfect.	Abortive.		Perfect.	Abortive.	
1	71	55	3	137	14	4	117	30	5	102	46	5	—	—	-	—	—	-
2	82	34	5	105	11	5	*47	64	4	82	36	5	—	—	-	—	—	-
3	68	23	5	*40	51	5	52	46	5	51	49	5	*38	57	5	—	—	-
4	113	5 + 12 p	5	*49	57	5	—	—	-	—	—	-	—	—	-	—	—	-
5	107	15	5	88	33	5	114	12	5	78	39	5	110	10	5	110	16	5
6	*50	70	5	61	61	-	113	12	5	115	10	5	—	—	-	—	—	-
7	59	53	5	84	25	5	105	4	5	97	5	5	87	11	5	—	—	-
8	115	1	5	110	1 + 15 p	5	46	36	5	109	14	5	—	—	-	—	—	-

The slues at Seaside Park, where at every high tide the brackish waters of the bay pass into a channel leading to a lower part of the meadow, are breeding places for mosquitoes and the haunts of the mud turtle. Along their edges grow *Baccharis halimifolia* L., *Iva frutescens* L. and *Scirpus robustus* Pursh., the salt-marsh bulrush, and floating upon the surface of the water a mass of *Scirpus nanus* Spreng. torn away by tidal action from the undermined bank.

III. Bay-strand Vegetation.

A. Bay-dune Formation.

The dune along the bay at Seaside Park has, as said before, been formed by the action of western winds in piling up the sand along the bay front. It consists of loose sand, and upon its top and slopes flourish a considerable number of plants found nowhere

[22] Harshberger, *l.c.*, p. 105.

else on Barnegat Beach. These peculiar plants are therefore of ecological interest. One mile below Seaside Park on the bay side, opposite the Island Beach Life Saving Station, the bay dune and its vegetation merges itself insensibly with the thicket formation proper. In fact, no line of demarcation can be drawn at that point, where the height of the dune rises four or five feet above tide level. The bay dune supports, among other plants, *Baccharis halimifolia* L., *Iva frutescens* L., *Teucrium canadense* L., *Ammophila arenaria* (L.) Link which binds the sand, but is not a character plant, *Rhus radicans* L., with common prolification of the inflorescence, *Rosa humilis* Marsh., an extremely spinous form, and *Convolvulus sepium* L. trailing over the ground and climbing up over the higher plants.

B. Bay-beach Formation.

This formation and its ecological constitution was studied only at Seaside Park. At exceptionally high tides the whole beach is subject to tidal action, but ordinarily, high-water mark is removed several feet from the limit of vegetation. Along Barnegat Bay large quantities of eel-grass, *Vallisneria spiralis* L., is washed ashore. At low-tide mark it is still green, but at high-tide mark it has become dry, hay-like, and of a chocolate-brown color. The supply is derived from the fresh-water rivers which empty into Barnegat Bay. The dried plant is gathered by the cartload and spread upon graded areas to prevent the action of the wind upon the sand. The high beach, out of reach of ordinary tides, supports the following plants: *Amaranthus retroflexus* L., *Suæda linearis* var. *ramosa* S. Wats., *Chenopodium album* L., *Salsola kali* L., *Atriplex hastata* L., *Cakile edentula* (Bigel.) Hook., *Xanthium canadense* Mill., *Erechtites hieracifolia* (L.) Raf. and *Spartina patens* (Ait.) Muhl., which is extremely abundant. All of these are xerophytes and are mostly succulents, provided in this way against the danger of death by transpiration. The only plant of doubtful xerophytic habit is *Erechtites hieracifolia* (L.) Raf. Its morphological appearance belies the possibility of its occurrence on this beach, constantly bathed by salt water—it is true somewhat diluted by the fresh water of the rivers, but nevertheless strongly saline.

IV. Bay-water Vegetation.

(*a*) *The Plankton* (not investigated).

(*b*) *Ruppia Zone.*

Ruppia maritima L. grows in the salt and brackish waters of Barnegat Bay, just beyond the bay-beach wave action. The plant is anchored in the sandy bottom, and at low tide floats in about twelve to eighteen inches of water. It is a graceful plant, as it moves backward and forward by wave action. The pollen from the two naked flowers of the spike is discharged, as geniculate, cylindrical grains, which float to the surface, and are carried by the water to the pistillate flowers with sessile, peltate stigmas, which now reach the surface at the end of a coiled peduncle and are ready to receive the pollen carried by the wind. After fertilization, the fruit which begins to form is drawn below the surface of the water by the coiling peduncle.

(*c*) *Nereid Zone* (not investigated), comprising those algæ attached to the piles of landings or jetties, especially in the neighborhood of the inlets.

This survey endeavors to present the fundamental facts concerning the zonal distribution of the New Jersey strand plants and their ecological relationship. A more detailed inspection of the entire coast would doubtless reveal other peculiarities of the seabeach flora, but it is believed and hoped that the descriptive account given above presents an outline sketch of the more important facts relating to the sand-strand vegetation of New Jersey.

Phyto-Geography.

The affinities of the New Jersey coast flora may be briefly summed up by presenting in the following list the range of some of the character plants which have been referred to in the above ecological description. Of the total number of species of plants collected, 228 in number, 5 are pteridophytes, 2 conifers, 66 monocotyledons, and 155 dicotyledons, as compared with 135 plants collected by Kearney on Ocracoke Island, N. C.

1. The following plants of the New Jersey strand flora have been collected on Presque Isle, Lake Erie:[23]

Ammophila arenaria (L.) Link. *Lathyrus maritimus* (L.) Bigel.

[23] Porter, T. C., *Rare Plants of Southeastern Pennsylvania*, Mch., 1900.

Sieglingia purpurea (Walt.) Ktze.
Cakile edentula (Bigel.) Hook.
Euphorbia polygonifolia L.
Strophostyles helvola (L.) Britt.
Hibiscus moscheutos L.

2. The dunes of Lake Michigan[24] are occupied by the following Atlantic coast plants:

Cakile edentula (Bigel.) Hook.
Euphorbia polygonifolia L.
Ammophila arenaria (L.) Link.
Polygonum ramossissimum Michx.
Lathyrus maritimus (L.) Bigel.
Hudsonia tomentosa Nutt.
Rhus copallina L.
Lespedeza capitata Michx.
Monarda punctata L.

3. Species of plants found on the New Jersey coast and ranging southward to North Carolina and Florida:

Juniperus virginiana L.
Typha latifolia L.
Spartina patens (Ait.) Muhl.
Distichlis spicata (L.) Greene.
Cyperus nuttallii Eddy.
Juncus scirpoides Lam.
Myrica cerifera L.
Atriplex hastata L.
Salicornia herbacea L.
Salsola kali L.
Sesuvium maritimum (Walt.) B. S. P.
Tissa marina (L.) Britton.
Meibomia paniculata (L.) Kuntze.
Linum medium (Planch.) Britton.
Euphorbia polygonifolia L.
Rhus radicans L.
Ilex opaca Ait.
Vitis æstivalis Michx.
Kosteletskya virginica.
Hibiscus moscheutos L.
Œnothera humifusa Nutt.
Limonium carolinianum (Walt.) Britton.
Monarda punctata L.
Gerardia maritima Raf.
Solidago sempervirens L.
Baccharis halimifolia L.
Pluchea camphorata (L.) D. C.
Iva frutescens (L.) Raf.
Carduus spinosissimus Walt.

4. Species ranging northward. The northern limit is taken from Britton and Brown's *Illustrated Flora*:

Spartina patens (Ait) Muhl. (Nova Scotia).
Distichlis spicata (L.) Greene (Maine).
Iva frutescens L. (Massachusetts).
Solidago sempervirens L. (New Brunswick).

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[24] Cowles, *l. c.*

Sesuvium maritimum (Walt.) B. S. P. (New York).

Euphorbia polygonifolia L. (Rhode Island).

Kosteletskya virginica (L.) A. Gray. (New York).

Limonium carolinianum (Muhl.) Britton (Labrador).

Aster subulatus Michx. (New Hampshire).

Baccharis halimifolia L. (Massachusetts).

Hudsonia tomentosa Nutt. (New Brunswick).

Lechea maritima Leg. (Massachusetts).

5. Species occurring also on the sea coast of the northern hemisphere in the Old World:[25]

Spartina stricta (Ait.) Roth.

Atriplex hastata L.

Salicornia herbacea L.

Salsola kali L.

Tissa marina (L.) Britton.

Ammophila (*Psamma*) *arenaria* (L.) Link.

Lathyrus maritimus (L.) Bigel.

6. The plants which may be said to have been recently introduced and to occur here, as elsewhere, as weeds are:

Holcus lanatus L.

Oenothera laciniata Hill.

Daucus carota L.

Achillea millefolium L.

Ambrosia artemisiæfolia L.

Anthemis cotula D. C.

Carduus arvensis (L.) Robs.

Lactuca canadensis L

Leptilon canadensis (L.) Britton and others.

7. The following plants, mentioned in the descriptive text, also occur on the dune formations near the Lake of the Woods:[26]

Hudsonia tomentosa Nutt.

Rhus radicans L.

Lathyrus maritimus (L.) Bigel.

List of Plants.

This list comprises the names of those plants known to occur on the beaches and salt marshes of the New Jersey coast. It is made as complete as possible, so that the plants peculiar to the region are brought together for ready reference. The nomenclature used is that found in Britton and Brown's *Illustrated Flora of the Northern United States, Canada and the British Possessions*, but for purposes of comparison the names according to Gray's *Manual of*

[25] Kearney, *l. c.*, p. 313.

[26] MacMillan, "Observations on the Distribution of Plants Along Shore at Lake of Woods," *Minn. Bot. Studies Bulletin*, 9, p. 949.

Botany (sixth edition, 1890) are given in parentheses. The source of information is designated as follows: Unmarked, collections made by the writer at Seaside Park, July 19, 20 and 21; at South Atlantic City and Ocean City on August 21; at Wildwood, August 31, 1900; marked by asterisk (*), plants collected by members of the Philadelphia Botanical Club;[27] with a dagger (†), plant names given in Britton's *Catalogue of New Jersey Plants.*[28] In all cases omitting the dates, the locality where the species were found is given by way of geographically fixing the plants. A large number of plants from Wildwood in the herbarium of the Philadelphia Botanical Club were collected July 4, 1897. When only one name is given without accompanying synonym, it is common to the manuals mentioned above.

OPHIOGLOSSACEÆ.

*OPHIOGLOSSUM ARENARIUM E. G. Britton. Wildwood.

OSMUNDACEÆ.

OSMUNDA REGALIS L. Wildwood.

POLYPODIACEÆ.

DRYOPTERIS MARGINALIS (L.) A. Gray (*Aspidium marginale* Sw.). Seaside Park.

DRYOPTERIS THELYPTERIS (L.) A. Gray (*Aspidium thelypteris* Sw.). Seaside Park, Ocean City, Wildwood.

PTERIS AQUILINA L. South Atlantic City.

CONIFERÆ.

PINUS RIGIDA Mill. Seaside Park, South Atlantic City.

JUNIPERUS VIRGINIANA L. Seaside Park (6 varieties), South Atlantic City, Wildwood.

TYPHACEÆ.

TYPHA LATIFOLIA L. Seaside Park.

NAJADACEÆ.

RUPPIA MARITIMA L. Seaside Park. †Brackish water, common.

†ZOSTERA MARINA L.

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[27] For names of collectors the investigator is referred to the labels on the herbarium sheets at the Acad. Nat. Sci. of Phila.

[28] The marks of designation, when a species collected by the writer are also mentioned in the two floras, are placed before the name of the locality instead of before the name of the plant.

ALISMACEÆ.

*Alisma plantago-aquatica L. Cape May.

GRAMINEÆ.

*Agrostis alba L. Wildwood

*Aira præcox L. Anglesea.

Ammophila arenaria (L.) Link. (*Ammophila arundinacea* Host.). Seaside Park, South Atlantic City, Ocean City, Wildwood, *Cape May.

Andropogon virginicus L. Wildwood.

*Aristida purpurascens Poir. Anglesea.

*Bromus asper Murr. (*Bromus asper* L.). Wildwood.

Cenchrus tribuloides L. Ocean City, *Wildwood. †Sandy soil on sea beaches.

Distichlis spicata (L.) Greene (*Distichlis maritima* Raf.). South Atlantic City, *Atlantic City. †Salt meadows, common.

*Diplachne fascicularis (Lam.) Beauv. (*D. fascicularis* Beauv.). Sea Isle City.

*Festuca ovina L. Wildwood.

*Festuca ovina var. duriuscula (L.) Hack. (*F. ovina* var. *duriuscula* Koch). Holly Beach.

*Holcus lanatus L. Wildwood.

*Muhlenbergia diffusa Schreb. Anglesea.

*Panicularia fluitans (L.) Kuntze (*Glyceria fluitans* R. Br.). Anglesea.

Panicum amarum Ell. Seaside Park, Wildwood.

*Panicum barbulatum Michx. Wildwood.

*Panicum columbianum Scribner. Wildwood.

Panicum crus-galli var. hispidum (Muhl.) Torr. Seaside Park, *Sea Isle City. †Salt or brackish marshes, common.

Panicum proliferum Lam. Seaside Park. †Common along borders of salt or brackish meadows.

*Panicum verrucosum Muhl. Anglesea.

Panicum virgatum L. Seaside Park, Wildwood.

*Panicum viscidum Ell. Five-mile Beach.

†Savastana odorata (L.) Scribn. (*Hierochloë borealis* R. and S.). Borders of salt or brackish meadows. Seabright.

Sieglingia purpurea (Walt.) Kuntze (*Triodia purpurea* Hack.). Seaside Park, *Atlantic City. †Common on sea beaches.

Spartina cynosuroides (L.) Willd. (*Spartina cynosuroides* Willd.). Ocean City, Longport.

Spartina patens (Ait.) Muhl. (*S. juncea* Willd.). Seaside Park, South Atlantic City, *Sandy Hook, *Anglesea, *Wildwood, *Cape May. †On salt marshes, common.

Spartina polystachya (Michx.) Ell. (*S. polystachya* Willd.). Seaside Park. †Salt marshes, common.

*SPARTINA STRICTA MARITIMA (Walt.) Scribn. (*S. stricta* var. *glabra* Gray). Cape May. †Ditches, salt marsh, common. *Seaside Park, *Atlantic City, *Cape May.

CYPERACEÆ.

CAREX LUPULINA Muhl. Wildwood, *Five-mile Beach.

CAREX MONILIFORMIS (Tuck.) Britton (?). †Sea beaches, common.

†CAREX MUHLENBERGII Schk. Atlantic City.

*CAREX PSEUDO-CYPERUS L. var. AMERICANA Hochst. (*Carex comosa* Boott.). Five-mile Beach.

†CAREX ALATA Torr. (*Carex straminea* Schk. var. *alata* (Torr.) Bailey). Atlantic City, Cape May.

†CAREX ALBOLUTESCENS Schwein (*Carex straminea* Schk. var. *fœnea* (Willd.) Torr.). Edges salt or brackish marshes, common.

*CAREX VIRESCENS Muhl. Wildwood.

*CYPERUS CYLINDRICUS (Ell.) Britton (*Cyperus Torreyi* Britton). Wildwood.

†CYPERUS GRAYII Torr. Sea beaches, common.

CYPERUS NUTTALLII Eddy (*C. Nuttallii* Torr.). Seaside Park, Ocean City, *Cape May. †Salt or brackish marshes.

CYPERUS STRIGOSUS L. Wildwood.

*ELEOCHARIS OVATA (Roth.) R. and S. (*E. ovata* R. Br.). Anglesea.

FIMBRYSTYLIS CASTANEA (Michx.) Vahl. (*F. spadicea* var. *castanea* Gray). *Anglesea, *Sea Isle City, *Cape May. Salt or brackish marshes.

*FUIRENA SQUARROSA Michx. Cape May.

FUIRENA SQUARROSA HISPIDA (Ell.) Chapm. *Cape May, †Ocean Beach.

RHYNCHOSPORA GLOMERATA (L.) Vahl. (*R. glomerata* Vahl.). Seaside Park.

*SCIRPUS AMERICANUS Pers. (*S. pungens* Vahl.). Wildwood.

SCIRPUS DEBILIS Pursh. Seaside Park.

*SCIRPUS LACUSTRIS L. Anglesea.

†SCIRPUS NANUS Spreng. Salt or brackish meadows.

SCIRPUS ROBUSTUS Pursh. (*S. maritimus* L.). Seaside Park, *Holly Beach, *Anglesea.

XYRIDACEÆ.

*XYRIS FLEXUOSA Muhl. Anglesea.

JUNCACEÆ.

JUNCUS ACUMINATUS Michx. Wildwood, *Holly Beach.

*JUNCUS BUFONIUS L. Wildwood.

JUNCUS EFFUSUS L. Seaside Park.

JUNCUS GERARDI Loisel. Seaside Park, South Atlantic City, *Holly Beach, *Atlantic City.

*JUNCUS MARGINATUS Rostk. Wildwood.

†JUNCUS ROEMERIANUS Scheele. Brackish marshes New Jersey; reported by Pursh, but not found certainly since.

JUNCUS SCIRPOIDES Lam. South Atlantic City.

*JUNCUS TENUIS Willd. Holly Beach.

LILIACEÆ.

SMILAX ROTUNDIFOLIA L. Seaside Park.

*LILIUM SUPERBUM L. Cape May.

*POLYGONATUM COMMUTATUM (R. and S.) Dietr. (*P. giganteum* Dietr.). Five-mile Beach.

ORCHIDACEÆ.

GYROSTACHYS PRÆCOX (Walt.) Kuntze (*Spiranthes præcox* Wats.). Seaside Park, *Anglesea.

MYRICACEÆ.

MYRICA CERIFERA L. Seaside Park, South Atlantic City, Ocean City, Wildwood, *Atlantic City.

FAGACEÆ.

QUERCUS ALBA L. × *Q. minor* (Marsh.) Sarg. Wildwood.

QUERCUS DIGITATA (Marsh.) Sarg. (*Q. falcata* Michx.). South Atlantic City, Wildwood.

QUERCUS MINOR (Marsh.) Sarg. (*Q. stellata* Wang.). South Atlantic City, Wildwood.

QUERCUS NANA (Marsh.) Sarg. (*Q. ilicifolia* Wang.). Seaside Park.

QUERCUS PHELLOS L. Seaside Park.

POLYGONACEÆ.

*POLYGONUM DUMETORUM L. Anglesea.

*POLYGONUM SCANDENS L. (*P. dumetorum* var. *scandens* Gray). Holly Beach.

*POLYGONUM ERECTUM L. Anglesea.

POLYGONUM HYDROPIPEROIDES Michx. Seaside Park.

POLYGONUM LAPATHIFOLIUM L. Wildwood.

†POLYGONUM MARITIMUM L. Sandy sea beaches.

POLYGONUM RAMOSISSIMUM Michx. *Sea Isle, †Cape May, †Atlantic City.

*RUMEX BRITANNICA L. Holly Beach, Anglesea.

†RUMEX PERSICARIOIDES L. (*R. maritimus* L.). Salt marshes, not rare.

*RUMEX SALICIFOLIUS Weinm. Wildwood.

CHENOPODIACEÆ.

Atriplex arenaria Nutt. Wildwood, *Anglesea, *Ocean City, *Cape May. ‡Sea beaches, common.

Atriplex hastata L. (*A. patulum* L. var. *hastatum* Gray). Seaside Park.

Chenopodium album L. Seaside Park.

†Chenopodium leptophyllum (Moq.) Nutt. (*C. leptophyllum* Nutt.). Atlantic City, Sandy Hook. Adventive from west.

†Chenopodium rubrum L. Salt meadows.

Dondia americana (Pers.) Britton (*Suæda linearis* Moq.). Seaside Park, *Ocean City, *Sea Isle City, *Cape May.

†Salicornia ambigua Michx. Wet sands of seashore. *Atlantic City.

Salicornia herbacea L. South Atlantic City, *Sea Isle City.

†Salicornia Bigelovii Torr. (*S. mucronata* Bigel.). Salt meadows.

Salsola kali L. Seaside Park, Wildwood, *Atlantic City, *Cape May.

AMARANTACEÆ.

†Acnida cannabina L. Brackish marshes.

†Amaranthus pumilus Raf. Sandy sea beaches, frequent.

Amaranthus retroflexus L. Seaside Park.

AIZOACEÆ.

Sesuvium maritimum (Walt.) B.S.P. (*S. pentandrum* Ell.). Wildwood. †Sea beaches, frequent. *Ocean City.

CARYOPHYLLACEÆ.

Ammodenia peploides (L.) Rupr. (*Arenaria peploides* L.). Seaside Park, *Atlantic City, *Anglesea.

Mœhringia lateriflora (L.) Fenzl. (*Arenaria lateriflora* L.). *Anglesea, *Atlantic City, †Anglesea.

*Sagina decumbens (Ell.) T. and G. Wildwood.

Tissa marina (L.) Britton (*Buda marina* Dumort). South Atlantic City, *Cape May, *Holly Beach. †Salt or brackish marshes, common.

*Tissa rubra (L.) Britton (*Buda rubra* Dumort). Sea Isle City, Atlantic City.

MAGNOLIACEÆ.

Magnolia virginiana L. (*M. glauca* L.). Wildwood.

RANUNCULACEÆ.

†Oxygraphis cymbalaria (Pursh.) Prantl. (*Ranunculus cymbalaria* Pursh.). Borders of salt marsh, Atlantic City.

LAURACEÆ.

Sassafras sassafras (L.) Karst. (*S. officinale* Nees). Seaside Park, Wildwood.

CRUCIFERÆ.

Cakile edentula (Bigel.) Hook. (*C. americana* Nutt.). Seaside Park, *Cape May, *Anglesea, *Sea Isle City.

DROSERACEÆ.

Drosera filiformis Raf. Seaside Park.
Drosera intermedia Hayne. Seaside Park.

ROSACEÆ.

Prunus maritima L. Seaside Park, Wildwood, *Five-mile Beach.
Prunus serotina Ehrh. Wildwood.
Rosa carolina L. Seaside Park, Wildwood.
Rosa humilis Marsh. Seaside Park, *Five-mile Beach.
Rubus canadensis L. Seaside Park.

LEGUMINOSÆ.

Cassia chamæcrista L. South Atlantic City, Wildwood.
Lathyrus maritimus (L.) Bigel. Seaside Park.
Lespedeza capitata Michx. Wildwood.
Meibomia paniculata (L.) Kuntze (*Desmodium paniculatum* D. C.). Wildwood.
Strophostyles helvola (L.) Britton (*S. angulosa* Ell.). Ocean City, Wildwood.

GERANIACEÆ.

†Geranium Robertianum L. In old forest, Sandy Hook.

LINACEÆ.

Linum medium (Planch.) Britton. Seaside Park.

POLYGALACEÆ.

†Polygala cruciata L. Abundant along the borders of salt marshes with upland.

EUPHORBIACEÆ.

†Euphorbia humistrata Engelm.

Euphorbia polygonifolia L. Seaside Park, *Wildwood, *Cape May.

ANACARDIACEÆ.

Rhus copallina L. Seaside Park, *Cape May.

Rhus radicans L. (*Rhus toxicodendron*). Seaside Park.

AQUIFOLIACEÆ.

Ilex opaca Ait. Seaside Park, South Atlantic City (form with spineless leaves), Wildwood.

ACERACEÆ.

Acer rubrum L. Wildwood.

BALSAMINACEÆ.

Impatiens biflora Walt. (*I. fulva* Nutt.). Wildwood.

VITACEÆ.

Parthenocissus quinquefolia (L.) Planch. (*Ampelopsis quinquefolia* Michx.). Seaside Park.

Vitis æstivalis Michx. South Atlantic City, Ocean City.

Vitis labrusca L. Wildwood, forming lianes ; stem over one foot in diameter.

MALVACEÆ.

Hibiscus moscheutos L. Seaside Park, Wildwood, *Cape May.

Kosteletzkya virginica (L.) A. Gray. Seaside Park.

GUTTIFERÆ.

Hypericum canadense L. Seaside Park.

Hypericum mutilum L. Seaside Park.

Triadenum virginicum (L.) Raf. (*Elodes campanulata* Pursh.). Seaside Park, *Cape May.

CISTACEÆ.

Hudsonia tomentosa Nutt. Seaside Park, *Five-mile Beach, *Atlantic City.

Lechea maritima Leggett (*L. minor* var. *maritima* A. Gray). Seaside Park. †Sands of seashore, common.

LYTHRACEÆ.

†Lythrum lineare L. Borders of salt marshes.

MELASTOMACEÆ.

*Rhexia mariana L. Cape May.
*Rhexia virginica L. Anglesea, Cape May.

ONAGRACEÆ.

Œnothera humifusa Nutt. Wildwood.
*Œnothera laciniata Hill (*Œ. sinuata* L.). Five-mile Beach.
*Kneiffia pumila (L.) Spach. (*Œnothera pumila* L.). Five-mile Beach.

HALLORAGINACEÆ.

*Myriophyllum pinnatum (Walt.) B. S. P. (*M. scabratum* Michx.). Shallow ditches, Wildwood.

UMBELLIFERÆ.

*Eryngium virginianum Lam. Cape May.
*Caucalis anthriscus Hudson. Wildwood.
*Hydrocotyle verticillata Thunb. Wildwood.
*Hydrocotyle umbellata L. Cape May.
Oxypolis rigidus (L.) Britton (*Tiedemannia rigida* Coult. and Rose). Wildwood, *Anglesea.
Ptilimnium capillaceum (Michx.) Hollick (*Discopleura capillacea* D. C.). Seaside Park, Ocean City, Wildwood, *Five-mile Beach.
Sium cicutæfolium Gmel. Five-mile Beach.

CORNACEÆ.

Nyssa sylvatica Marsh. Wildwood.

ERICACEÆ.

Kalmia angustifolia L. Seaside Park.
Oxycoccus macrocarpus (Ait.) Pers. (*Vaccinium macrocarpon* Ait.). Seaside Park.
Vaccinium atrococcum (A. Gray) Heller (*V. corymbosum* var. *atrococcum* A. Gray). Seaside Park.
Vaccinium corymbosum L. Seaside Park.

PRIMULACEÆ.

†Glaux maritima L. Deal Beach.
*Trientalis americana Pursh. Anglesea.
*Anagallis arvensis L. Cape May.
*Samolus floribundus H. B. K. (*S. valerandi* var. *americanus* Gray). Five-mile Beach.

PLUMBAGINACEÆ.

LIMONIUM CAROLINIANUM (Walt.) Britton (*Statice limonium* var. *carolinianum* A. Gray). Seaside Park, South Atlantic City, *Ocean City, *Cape May.

GENTIANACEÆ.

*SABBATIA ANGULARIS (L.) Pursh. Wildwood, Cape May.

†SABBATIA CAMPANULATA (L.) Torr. (*Sabbatia gracilis* Salisb.). Ocean Beach, Ocean Grove, Cape May.

SABBATIA LANCEOLATA (Walt.) T and G. Seaside Park.

SABBATIA STELLARIS Pursh. Seaside Park, South Atlantic City, *Cape May.

ASCLEPIADACEÆ.

ASCLEPIAS PULCHRA Ehrh. (*A. incarnata* var. *pulchra* Pers.). Seaside Park, Wildwood.

CONVOLVULACEÆ.

CONVOLVULUS SEPIUM L. Seaside Park.

VERBENACEÆ.

LIPPIA LANCEOLATA Michx. Wildwood.

VERBENA HASTATA L. Seaside Park.

LABIATÆ.

LYCOPUS AMERICANUS Muhl. (*L. sinuatus* Ell.). Wildwood.

MONARDA PUNCTATA L. Ocean City, *Cape May, Wildwood.

TEUCRIUM CANADENSE L. Seaside Park, *Anglesea.

SOLANACEÆ.

LYCOPERSICON LYCOPERSICON (L.) Karst (*Lycopersicum esculentum* Miller). Wildwood, in beach sand ; evidently introduced by fruit brought as luncheon.

SCROPHULARIACEÆ.

GERARDIA PURPUREA L. Seaside Park, Ocean City, Wildwood, *Cape May.

*GERARDIA MARITIMA Raf. Sea Isle City, Ocean City, Atlantic City, Cape May.

GRATIOLA PILOSA Michx. Cape May.

PLANTAGINACEÆ.

*PLANTAGO VIRGINICA L. Anglesea.

*PLANTAGO MARITIMA L. Atlantic City.

RUBIACEÆ.

*DIODIA VIRGINIANA L. Cape May.

CAPRIFOLIACEÆ.

*LONICERA SEMPERVIRENS L. Anglesea.
VIBURNUM DENTATUM L. South Atlantic City.

CAMPANULACEÆ.

LOBELIA CARDINALIS L. Wildwood.
LOBELIA PUBERULA Michx. Cape May.

COMPOSITÆ.

ACHILLEA MILLEFOLIUM L. Seaside Park.

AMBROSIA ARTEMISIÆFOLIA L. Wildwood.

ANAPHALIS MARGARITACEA (L.) Benth. and Hook. Wildwood.

*ANTHEMIS COTULA D.C.

†ARTEMISIA STELLERIANA Bess. Sea beaches, Sandy Hook.

*ASTER LATERIFLORUS (L.) Britton (*Aster diffusus* L.) Sea Isle City.

*ASTER LATERIFLORUS THYRSOIDEUS A. Gray (*A. diffusus thyrsoideus* Gray). Sea Isle City.

*ASTER TENUIFOLIUS L. (*A. flexuosus* Nutt.). Cape May, Ocean City, Atlantic City.

*ASTER SUBULATUS L. (*A. linifolius* Gray). Cape May, Wildwood.

BACCHARIS HALIMIFOLIA L. Seaside Park, *Cape May.

BIDENS CONNATA Muhl. Ocean City.

*BIDENS LÆVIS (L) B. S. P. (*B. chrysanthemoides* Michx.). Cape May.

*CARDUUS ARVENSIS (L.) Robs. (*Cnicus arvensis* Hoff.). Anglesea.

CARDUUS SPINOSISSIMUS Walt. (*Cnicus horridulus* Pursh.). Seaside Park. †Junction salt or brackish marshes and upland.

*CHRYSOPSIS MARIANA Nutt. Cape May.

ERECHTITES HIERACIFOLIA (L.) Raf. Seaside Park.

*EUPATORIUM ALBUM L. Anglesea.

*EUPATORIUM CŒLESTINUM L. Cape May.

EUPATORIUM HYSSOPIFOLIUM L. Wildwood, *Cape May.

EUPATORIUM ROTUNDIFOLIUM L. Seaside Park, Atlantic City.

HELIANTHUS GIGANTEUS L. Wildwood.

HIERACIUM MARIANUM Willd. Five-mile Beach.

*IONACTIS LINARIIFOLIUS (L.) Greene (*Aster linariifolius* L.). Cape May.

IVA FRUTESCENS L. Seaside Park, *Atlantic City.

LACTUCA CANADENSIS L. Wildwood, *Holly Beach.

*LACTUCA FLORIDANA (L.) Gaertn. Anglesea.

†LACTUCA HIRSUTA Muhl. Atlantic City.

*LACINARIA SQUARROSA (L.) Hill (*Liatris squarrosa* Willd.). Anglesea.

LIATRIS SPICATA (L.) Willd. (*L. spicata* Willd.). Bay Head.

LEPTILON CANADENSIS (L.) Britton (*Erigeron canadensis* L.). Wildwood.

PLUCHEA CAMPHORATA (L.) D. C. Seaside Park, *Atlantic City, *Ocean City, *Cape May.

SOLIDAGO FISTULOSA Mill. (*S. pilosa* Walt.). Wildwood.

SOLIDAGO ODORA Ait. Wildwood.

SOLIDAGO SEMPERVIRENS L. Seaside Park, Wildwood, *Ocean City.

*SOLIDAGO STRICTA Ait. Anglesea.

WILLUGHBÆA SCANDENS (L.) Kuntze (*Mikania scandens* Willd.). Ocean City, Wildwood.

XANTHIUM CANADENSE Mill. Seaside Park.

XANTHIUM CANADENSE var. ECHINATUM Gray. Wildwood.

ADDITIONS TO THE JAPANESE LAND SNAIL FAUNA. III.

BY HENRY A. PILSBRY.

The Japanese fauna is proving very prolific in Clausilias, and may yet rival the richer portions of Eastern Europe in degree of specific differentiation. It is obvious that until much more merely descriptive work is done, no sound generalization upon the Japanese species is possible. I have therefore been satisfied to add to the accumulation of facts which can tell their story only when collections from many more localities come to our hands. Many of the species of *Clausilia* seem to be of restricted geographic distribution. Thus, the fauna of southern Hondo, Shikoku and Awaji seems to have but few Clausiliæ in common with the Nikko region.

The fruitful researches of Mr. Y. Hirase now enable me to add several species to the fauna of Shikoku Island, and a remarkable *Euphædusa* to the Hokkaido fauna, the first *Clausilia* known from that island. Moreover, he has discovered a very remarkable modification of the Euphædusan type, *C. mikado*, in the region of Lake Biwa.

In a former paper I described two species, *C. Hirasei* and *C. hyperoptyx*, remarkable among Asiatic Clausiliæ for their complicated internal armature. It is now proposed to erect a section for the reception of these species.

Section ZAPTYX nov.

Clausilium tongue-shaped, about twice as long as wide, with subparallel lateral margins, the apex much thickened on the columellar side; posteriorly emarginate or auriculate on both sides of the filament or on the columellar side only; straight distally, but abruptly and strongly curved near the filament.

Shell small, the superior lamella widely separated from the spiral lamella; a fulcrum and parallel lamella developed; sutural plicæ present; upper palatal plica independent from or united with the well-developed lunella; no lower palatal plica.

Type *C. Hirasei* Pils.

Distribution: Southern Kiusiu and the Loo Choo Islands.

The general shape of the clausilium is somewhat Hemiphædusoid, but the abruptly bent and emarginate posterior end and heavily thickened apex differ strikingly from those parts in the clausilium of Hemiphædusa.

In *C. Hirasei* the clausilium (Pl. XXV, figs. 33, 34) is biemarginate behind. In *C. hyperoptyx* the columellar side only is distinctly emarginate.

Section EUPHÆDUSA Bttg.

(*Group of C. shanghaiensis.*)

Clausilia comes n. sp. Pl. XXIV, figs. 1, 2, 3.

Shell small, rimate, slenderly fusiform, rather weakly striate, the last whorl with delicate rib-striæ; olivaceous brownish. Apex slightly obtuse. Whorls 9, strongly convex, separated by deep sutures. Aperture not oblique, pyriform, with a distinct sinulus above, the peristome white, expanded and subreflexed, scarcely thickened. Superior lamella rather small, though rather higher than in *C. digonoptyx*, diconnected from or barely continuous with the spiral lamella. Inferior lamella converging strongly toward the superior, though somewhat less so than in *C. digonoptyx*, strongly spiral within. Subcolumellar lamella immersed very deeply. Principal plica short and small, wholly lateral. Lunella shaped as in *C. aculus*, but so slight as to be all but imperceptible except at the ends, which appear as small, short, irregular, upper and lower palatal folds. Clausilium of the typical form for *Euphædusa*, short and wide, broadest distally, strongly curved, moderately thickened at the apex, the columellar side emarginate behind (Pl. XXV, figs. 35, 36).

Alt. 10, diam. 2.3 mm.

Kashima, Harima (Mr. Y. Hirase).

Belonging to the little group of *C. aculus, digonoptyx* and *tau*, this form is smaller and deficient in palatal armature. *C. aculus*, which probably does not occur in Japan north or east of Kiusiu, has a less developed superior lamella. In *C. digonoptyx* the lamellæ converge more, the lunella is better developed, and the striation is stronger. *C. tau* is a widely distributed species with long upper palatal plica and stronger lunella, etc.

Clausilia monelasmus n. sp. Pl. XXIV, figs. 4, 5, 6.

Shell rimate, slender, fusiform, strongly striate, brown. Apex rather acute, but the nuclear whorl is somewhat swollen; spire attenuated above. Whorls $8\frac{1}{2}$ to 9, quite convex, the sutures well impressed, the last whorl narrower than the penultimate. Aperture hardly oblique, pyriform, with rather indistinctly defined, retracted sinulus. Peristome thickened, expanded, continuous, white. *Superior lamella wanting*, represented by a slight thickening of the peristome at its position; spiral lamella arising so far within that it is not visible from the aperture, but becoming high and continued to the ventral side, being longer within than the other lamellæ. Inferior lamella obsolete below, not emerging, but high within, as in *C. digonoptyx*. Subcolumellar lamella deeply immersed. Principal plica very short and small, lateral. Upper palatal plica strong, its lower end bent downward; lunella wanting; lower palatal plica short, well developed. Clausilium (Pl. XXV, figs. 26, 27, 28, 29) short and broad, strongly curved, not emarginate behind, and only slightly thickened apically.

Alt. 10.5, diam. 2.3 mm.

Kayabe, Ojima (Mr. Y. Hirase).

This is the first *Clausilia* to be made known from Hokkaido (Yesso), to my knowledge. It occurred with a small *Hemiphædusa*. It is remarkable for the obsolete condition of the superior lamella, the deeply immersed spiral lamella and the wide interruption of the lunella, the remaining ends of which appear merely as upper and lower palatal folds. A white line may be seen on the parietal wall, on looking into the aperture, caused by the subcolumellar lamella showing through.

(*Group of C. jos.*)

Clausilia iotaptyx n. sp. Pl. XXV, figs. 7, 8, 9.

Shell rimate, turrited, the penultimate whorl widest, those above nearly regularly tapering, then becoming almost cylindrical, the apex obtuse; rather solid, finely striate, a little more coarsely so on the back of the last whorl. Whorls nearly 11, but slightly convex, the last compressed. Aperture hardly oblique, ovate-pyriform, the peristome well expanded, slightly thickened, whitish, a little emarginate above. Sinulus high. Superior lamella rather small, oblique, contiguous to the spiral lamella. Inferior lamella deeply placed, but continued and emerging upon the peristome, straightened within and giving off a branch toward the spiral lamella. Subcolumellar lamella emerging, and with the inferior lamella, continued to the margin. Principal plica strong and long, nearly reaching the lip, and extending inward well beyond the lateral lunella. Palatal plicæ two, short, the upper parallel with the principal plica, the lower one oblique, a straight lunella connecting them, inserted near the middle of each, and with the plicæ forming an I-like figure. Clausilium (Pl. XXV, fig. 40), trapezoidal-oblong, not much curved, somewhat thickened at the sides, and especially thick on the columellar side near the apex, strongly emarginate posteriorly on the columellar side. It is shaped very much like that of *C. mikado.*

Alt. 18, diam. 3.8, longest axis of aperture 3.6 mm.

Alt. 16.3, diam. 3.3 mm.

Ibuki, Omi (Mr. Y. Hirase).

A solid, opaque species, with peculiarly thick though attenuated spire. The clausilium seems far too thick at the end for a *Hemiphædusa,* though it is more elongate than usual in *Euphædusa,* being a good deal like that of *C. mikado;* and as in that species the superior and inferior lamellæ are very widely separated, even within. Viewed from the back, in a specimen broken open, the inferior lamella is but very weakly spiral, much as in many Hemiphædusas, and is thickened below. The spiral and subcolumellar lamellæ both enter very deeply and equally, while in *Euphædusa* the spiral lamella should extend inward beyond the other, according to Dr. Boettger, confirmed by the species I have examined. This point is not very reliable perhaps, for in two specimens of *C. mikado* opened, one has the spiral lamella distinctly longer, the other has the inferior a little longer. I fear, therefore, that the sectional position of this species must be left in uncertainty. I place it in Boettger's *Formenkreis von C. jos,* of *Euphædusa,* but probably it belongs elsewhere.

Compared with the *Hemiphædusa* species, *C. iotaptyx* is nearest to *C. aurantiaca;* but the closing apparatus is lateral, the superior lamella is very low inside (while in *C. aurantiaca* it is high), and the spire is thick and clumsy above. The lunella and associated palatal plicæ are much as in *C. aurantiaca*, but the clausilium denies *C. iotaptyx* entrance in any group of *Hemiphædusa*.

Section TYRANNOPHÆDUSA *nov.*

Many-whorled, with distinct sinulus, deeply placed inferior lamella, very remote throughout from the superior lamella, the clausilium narrower than in *Euphædusa*, tapering and oblique at the much-thickened apex. Other characters as in the *C. jos* group of *Euphædusa*. I propose this section for the following remarkable species:

Clausilia mikado n. sp. Pl. XXIV, figs. 10, 11, 12.

Shell rimate, the lower half swollen, *upper half exceedingly attenuated;* livid gray, becoming dull red where worn, and overgrown with alga in most specimens seen.

Sculptured with crowded, very fine striæ, on the last two whorls becoming very much coarser, last whorl rather irregularly rib-striate. Apex obtuse and globose; *whorls 18,* the earlier 8 or 10 not increasing in diameter, even decreasing a little; the next few whorls gradually, slowly increasing, the last 4 whorls forming the rather swollen lower half of the shell's length; last whorl decidedly higher than the preceding, tapering, compressed at the sides. Sutures impressed. Aperture small, oblique, retracted above and below, irregularly pyriform, the sinulus strongly developed, high and narrow; peristome white, expanded and thickened, continuous, emarginate above, where it is built out far beyond the whorl. Superior lamella marginal, vertical, well developed, continuous with the spiral lamella. Inferior lamella not visible in a front view, deeply immersed, continuing very distant from the superior lamella within, but giving off a low branch toward it. Subcolumellar lamella emerging, sometimes continued to the margin of the peristome, and more or less distinctly bounded by grooves. Principal plica strong and long, extending nearly to the lip, and inward to the ventral side of the whorl. Upper and lower palatal plicæ short, oblique and parallel, connected by a nearly straight, narrow, rather weak lunella, which, however, is hardly connected with the upper palatal, and is lateral in position. Clausilium (Pl. XXV, figs. 37, 38, 39) strongly thickened at the sides and end, and especially along the columellar margin near the apex (fig. 38), abruptly emarginate on the columellar side posteriorly, the apex oblique, angular at the outer-lower or palato-apical extremity, rounded at the inner-lower or columellar-apical part.

Alt. 23, diam. 3.5, longest axis of aperture 3.5 mm.

Ibuki, Omi (Mr. Y. Hirase).

Remarkable for its many-whorled, slender spire, solute aperture and peculiar clausilium. This species is the first one of its kind to be made known, and is one of the most remarkable of Mr. Hirase's discoveries.

Section STEREOPHÆDUSA Bttg.

Clausilia oostoma Mölldff.

C. oostoma Mölldff., Journ. Asiat. Soc. Beng., LI, pt. 2, p. 4, Pl. 1. fig. 2 (1882).

C. japonica var. *surugæ* Pils., Proc. Acad. Nat. Sci. Phila., 1900, p. 447, Pl. 14, fig. 4.

In my former paper on Japanese Clausilias I did not recognize this species in my *C. japonica* var. *surugæ*. I am now satisfied that my variety is identical with the form defined by von Moellendorff.

Clausilia brevior var. **addisoni** nov.

Larger than *C. brevior*, alt. 16–18½, diam. 4½ mm., more coarsely striated, especially on the last whorl; three palatal plicæ only. This form I at first considered to be the var. *tetraptyx* Mlldff., having received but one specimen from Mr. Hirase. A large series in the collection of Mr. Addison Gulick shows it to be distinct. It is viviparous.

Kagashima, Satsuma, in southern Kiusiu (Gulick coll.).

Clausilia hondana n. sp. Pl. XXIV, figs. 13–18.

Shell rimate, fusiform, dark brown, sculptured with fine but sharp striæ, which are sometimes perceptibly coarser on the back of the last whorl; apex globose, the first three whorls of about equal diameter, second whorl higher than the third. Whorls 10½ to 11½, the last compressed laterally. Aperture but little oblique, a trifle retracted above and below, pyriform or quadrangular-pyriform, the sinulus high and well defined; peristome rather widely reflexed, somewhat thickened, continuous, the upper margin shortly free and slightly or not emarginate. Superior lamella subvertical, compressed, continuous with the spiral lamella. Inferior lamella transversely converging to the other, strongly spiral within, not emerging upon the lip. Subcolumellar lamella emerging, nearly or quite attaining the margin. Principal plicæ rather long; palatal plicæ seven or fewer, the upper two curved, diverging forward from the principal, longer than the others except the lower one. Clausilium strongly curved, short, broader and thickened distally, emarginate posteriorly on the columellar margin (Pl. XXV, figs. 42, 43, 44).

Alt. 21, diam. 4.5, longest axis of aperture 4.6 mm.

Alt. 18, diam. 4, longest axis of aperture 4 mm.

Boshiu; Suruga coast (F. Stearns).

This species stands between *C. oostoma* and *C. brevior* in size, and has the slender apical whorls and therefore concave-sided spire of the latter, which differs in being more obese with a different-shaped aperture. It is probably nearest to *C. nikkoensis* Mlldff., but that species, from the description, must be even more slender and with the inferior lamella reaching the margin of the peristome, which is not at all the case in *C. hondana.* Were it not for this differential feature I would not distinguish my shells from Dr. von Moellendorff's species. The clausilium is much like that of *C. brevior.*

Of five specimens opened, no two quite agree in the palatal folds, and some are so different that one could scarcely believe them variations of one species were not all the other characters, including the clausilium, quite identical in the series. The following variations occurred:

(*a*) Palatal plicæ seven, as above described (figs. 13–15).

(*b*) Palatal plicæ three, two above, one below, the third, fourth, fifth and sixth wanting (fig. 18).

(*c*) Palatal plicæ four, the lower and two upper undiminished, the third small, a foldless space below it (fig. 17).

(*d*) Palatal plicæ three, a very low but distinct, straight lunella running from the second to the lower plica (fig. 16).

These variations seem enough to make several species of, but I feel confident that they belong to one species. Specimens *a* and *b* are from Boshiu, *c* and *d* from Suruga.

Clausilia subjaponica n. sp.

General appearance of *C. japonica* Crosse. Whorls 12 to 13½, the apex very obtuse, not tapering as in *japonica*, and the attenuated portion of the spire is thicker. Aperture with thickened, reflexed peristome, the superior lamella separated by a hiatus from the spiral lamella; subcolumellar lamella emerging, running to the margin. Principal plica short, extending but slightly or not at all inward beyond the upper palatal plica. Palatal plicæ four, the upper quite long, the lower bow-shaped or arched, the two ends bent downward; the two intermediate plicæ short. Clausilium narrower than in *C. japonica,* the palatal margin obliquely sloping toward the apex, which is thickened and obtusely rounded; columellar margin slightly excised or subemarginate near the filament, or merely tapering there.

Length 28, diam. 6 mm.

Length 28, diam. $5\frac{1}{2}$ mm.

Length 23, diam. $5\frac{1}{2}$ mm.

Ibuki, Omi (Mr. Y. Hirase).

The shell does not differ strongly from *C. japonica,* certain forms of which have the superior and spiral lamellæ disconnected, and sometimes there are four palatal plicæ; but the shape of the lower palatal plica or fold is different, it being short and oblique in *C. japonica,* not arched as in this species. The shape of the clausilium, however, is strikingly unlike in the two species, that of *C. japonica* (+ *nipponensis* + *kobensis*) being constantly broader, with pointed apical end, in specimens examined from some fourteen localities. This will be suitably illustrated in a future communication, as the space on my plates does not allow figuring at this time.

Section HEMIPHÆDUSA Bttg.

(*Group of C. validiuscula.*)

Clausilia Nolani n. sp. Pl. XXV, figs. 19, 20, 21.

Shell rimate, fusiform, attenuated above, solid, of a dark-brown color; distinctly but finely striate. Whorls 10, moderately convex, separated by impressed sutures, the outlines of the spire somewhat concave above; last whorl a little compressed. Aperture squarish-ovate, hardly oblique; sinulus short, retracted; peristome brownish, expanded, subreflexed and thickened, continuous and free above, and slightly or not emarginate there. Superior lamella somewhat oblique, *very widely separated from the spiral lamella,* attaining the margin. Inferior lamella scarcely emerging, but slightly visible from in front, bifurcate and straightened within. Subcolumellar lamella not emerging. Principal plica strong, visible within the aperture, where it even approaches the lip, extending inward but slightly beyond the palatal plicæ. Palatal plicæ two, parallel, rather long, diverging from the principal plica anteriorly, and nearly ventral in position. No lunella.

Alt. 15.5, diam. 3.5, longest axis of aperture 4 mm.

Fukura, Awaji Island (Mr. Y. Hirase).

This species has much the form and color of the otherwise very different *C. aurantiaca.* It differs from *C. caryostoma* Mlldff. in having no punctiform plica between the two palatals, and in having the superior lamella very widely separated from the spiral lamella; from *C. interlamellaris* v. Mart. in the wholly immersed subcolumellar lamella, disconnected superior and spiral lamellæ, and in having two, not four, palatal plicæ. *C. gracilispira* Mlldff., described from Kobe, differs in being smaller, with three palatal plicæ, and continuous superior and spiral lamellæ. *C. validiuscula* var. *bilamellata* Bttg., of Kiusiu, has three palatal plicæ and is a larger shell.

The wide hiatus between the superior lamella and the spiral lamella is characteristic of this species, which is named in honor of the editor of the *Proceedings* of the Academy of Natural Sciences of Philadelphia.

Clausilia tosana n. sp. Pl. XXV, figs. 22, 23, 24, 25, 41.

Shell small, slender, fusiform, solid, distinctly attenuated and with concave outlines above; light brown; finely, rather irregularly striate. Whorls 9 to $10\frac{1}{2}$, the upper ones convex, last three less so, the last whorl compressed, tapering, *becoming free for a short distance* in front (like a "*Cylindrella*"). Aperture slightly oblique, pyriform, the sinulus a little retracted; peristome continuous, expanded, somewhat reflexed, thickened and white. Superior lamella small and rather low, oblique, attaining the margin, continuous with the spiral lamella, though there is a depression at their junction. Inferior lamella not emerging, hardly visible in a front view, but seen to be strong when viewed obliquely; inside it ascends almost vertically, and is stouter below. Subcolumellar lamella very deeply immersed. Inside the spiral and subcolumellar lamellæ terminate on the ventral side and are of about equal length, while the inferior lamella is slightly shorter. Principal plica strong, visible within the aperture, ascending to a lateral position. Palatal plicæ lateral, the upper rather long and curved down at its outer end, lower plica shorter but well developed, two small, short, contiguous plicæ (or sometimes one plica) midway between them. Clausilium rather long, with parallel sides and thin rounded apex; posterior end tapering (Pl. XXV, fig. 41).

Length 12.2, diam. 2.5 mm.

Length 10.5, diam. 2.5 mm.

Ushirohawa, Tosa, Shikoku Island (Mr. Y. Hirase). This little species differs notably from the allied *C. caryostoma* and *C. gracilispira* in the produced last whorl, the aperture standing out somewhat like that of a *Diaphora* or *Urocoptis*, though only shortly. The spire is more attenuated than in those species. It is very solid and strong for so small a *Clausilia*. The specimens vary a good deal in size. Types are No. 79,320 coll. Acad. Nat. Sciences, from No. 550 of Mr. Hirase's register.

(*Group of C. aurantiaca.*)

Clausilia shikokuensis n. sp. Pl. XXV. figs. 30, 31, 32.

Shell rimate, fusiform, somewhat inflated, attenuated and with concave outlines above; solid; of a rather bright orange-brown color; finely, rather obsoletely striated, the last whorl more strongly and sharply so. Whorls about $10\frac{1}{2}$, moderately convex, separated by impressed sutures, the last whorl compressed laterally, shortly solute. Aperture ovate, somewhat oblique, the sinulus rather high and retracted; peristome orange-brown, reflexed and thickened, continuous, slightly emarginate above. Superior lamella somewhat oblique, rather strong, continuous with the spiral lamella. Inferior lamella scarcely emerging, inconspicuous in the front view, but becoming strong and thickened within; viewed obliquely from below it is seen to be distinctly bifurcate. Subcolumellar lamella not emerging, invisible from in front, but seen in an oblique view. Principal plica visible within the mouth, extending inward a little beyond the lunella. Lunella lateral, well curved, especially above, where it is continued backward in and quite united with the anterior end of a short upper palatal fold, being thus somewhat irregularly bow-shaped. Clausilium narrow, tongue-like.

Alt. 16, diam. 3.8, longest axis of aperture 3.5 mm.

Ushirohawa, prov. Tosa, Shikoku Island (Mr. Y. Hirase).

This species seems most nearly allied to *C. ignobilis* Sykes and *C. subaurantiaca* Pils. The former species, also from Shikoku Island, differs in the emerging inferior and subcolumellar lamellæ; is rather less attenuated above, judging by the figure, but is of about the same size.[1] *C. subaurantiaca* is a more slender, smoother species, in which the straighter lunella is united with the middle of the upper palatal plica. In *C. aurantiaca* Bttg. the lunella is I-shaped, and ventral in position, quite unlike the bow-like and lateral lunella of *C. shikokuensis*.

EXPLANATION OF PLATES.

(Figs. 2, 5, 8, 10, 14, 20, 23, 24, 31 are natural size; the others enlarged.)

Plate XXIV.

Figs. 1, 2, 3. *Clausilia* (*Euphædusa*) *comes* n. sp.
Figs. 4, 5, 6. *Clausilia* (*Euphædusa*) *monelasmus* n. sp.
Figs. 7, 8, 9. *Clausilia* (section ?) *iotaptyx* n. sp.
Figs. 10, 11, 12. *Clausilia* (*Tyrannophædusa*) *Mikado* n. sp.
Figs. 13, 14, 15. *Clausilia* (*Stereophædusa*) *hondana* n. sp., type.
Figs. 16, 17. *Clausilia* (*Stereophædusa*) *hondana* varieties, prov. Suruga.
Fig. 18. *Clausilia* (*Stereophædusa*) *hondana* variety, Boshiu.

Plate XXV.

Figs. 19, 20, 21. *Clausilia* (*Hemiphædusa*) *Nolani* n. sp.
Figs. 22, 23, 24, 25. *Clausilia* (*Hemiphædusa*) *tosana* n. sp.
Figs. 26, 28. *Clausilia monelasmus*. Inner view of clausilium.
Fig. 27. *Clausilia monelasmus*. Columellar view of clausilium.
Fig. 29. *Clausilia monelasmus*. Outer and basal view of clausilium.
Figs. 30, 31, 32. *Clausilia* (*Hemiphædusa*) *shikokuensis* n. sp.
Figs. 33, 34. *Clausilia* (*Zaptyx*) *Hirasei* Pils. Clausilium in profile from palatal side, and view of inside.

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[1] In the figure of *C. ignobilis*, Proc. Malac. Soc. Lond., I, p. 262, fig. 5, the lunella is represented as connected with the *plica principalis*. Such a structure would be unique in Japanese *Hemiphædusæ*, but I think it is probably an error of the artist, and no such connection really exists.

Figs. 35. 36. *Clausilia* (*Euphædusa*) *comes.* Inner views of the clausilium.

Fig. 37. *Clausilia* (*Tyrannophædusa*) *Mikado.* Inner view of the clausilium.

Fig. 38. *Clausilia* (*Tyrannophædusa*) *Mikado.* Clausilium from columellar side.

Fig. 39. *Clausilia* (*Tyrannophædusa*) *Mikado.* Clausilium from outside.

Fig. 40. *Clausilia* (section ?) *iotaptyx.* Clausilium from inside.

Fig. 41. *Clausilia* (*Hemiphædusa*) *tosana.* Clausilium from inside.

Fig. 42. *Clausilia* (*Stereophædusa*) *hondana.* Clausilium from columellar side.

Figs. 43, 44. *Clausilia* (*Stereophædusa*) *hondana.* Clausilium from inside.

NOVEMBER 6.

MR. CHARLES MORRIS in the Chair.

Fifteen persons present.

NOVEMBER 13.

The President, SAMUEL G. DIXON, M.D., in the Chair.

Thirty-three persons present.

DR. HENRY SKINNER made a communication on protective resemblances in insects. (No abstract.)

NOVEMBER 20.

The President, SAMUEL G. DIXON, M.D., in the Chair.

Thirty-seven persons present.

Papers under the following titles were presented for publication:

"A Review of the Genera and Species of American Snakes, North of Mexico," by Arthur Erwin Brown.

"Osteology of the Psittaci," by Dr. R. W. Shufeldt.

A paper by MISS CAROLINE A. BURGIN on the edible and poisonous mushrooms of the neighborhood was read by Dr. A. W. Miller. (No abstract.)

NOVEMBER 27.

The President, SAMUEL G. DIXON, M.D., in the Chair.

Sixty-nine persons present.

A paper entitled "Notes on a Geological Section from Iguala to San Miguel de Totolapa, State of Guerrero, Mexico," by Charles E. Hall, was presented for publication.

The death of Otto Staudinger, a correspondent, was announced.

PROF. OSCAR C. S. CARTER made a communication on the petrified forest and cave-dwellings of Arizona. (No abstract.)

T. Percival Gerson, M.D., was elected a member.

The following was ordered to be printed:

THE BIDDULPHOID FORMS OF NORTH AMERICAN DIATOMACEÆ.

BY CHARLES S. BOYER, A.M.

The following article was prepared at the request of the editors of the *Systematic Botany of North America*. It is intended to be a description of all forms of the group found along the coast, excluding the West Indies, and of the fossil diatoms of California, Virginia, Maryland and New Jersey. Some, although not new, have not been hitherto described, while others have appeared in volumes difficult of access or long out of print. In the examination of the bibliography the confusion appeared to be so great that it was thought best to describe all forms from specimens in my collection. This labor has been lightened by the use of the *Habirshaw Catalogue* and of the admirable *Sylloge Algarum* of De Toni. All citations given in either of these works have been, with a few exceptions, carefully examined. It has been my purpose to give the first description and figure published and to add one or two citations to the best illustrations, especially to Schmidt's *Atlas*.

The classification adopted is, for the most part, that of Dr. Van Heurck and Prof. H. L. Smith. No changes have been made in the nomenclature except those demanded by the law of priority.

My thanks are due to Mr. F. J. Keeley, for slides and photographs; to Mr. Lewis Woolman, for numerous deposits from the artesian wells and other localities, and, especially, to Mr. John A. Shulze, for many vials of finely prepared material and for specimens contributed from his collection.[1]

[1] For the history of the growth and reproduction of these forms the student is referred to Kützing, Rabenhorst, Van Heurck and Pfitzer. My own observations have been confined to *Biddulphia lævis*, a gathering of which, sent me by Mr. T. Chalkley Palmer, from Reedy Island, Delaware river, admirably illustrated the special cells corresponding to the "sporangium" of authors. Certain of the ordinary cells had apparently assumed a new function, expanding into spherical bodies three or four times the diameter

Family DIATOMACEÆ.

Sub-Family CRYPTO-RAPHIDIEÆ.

Tribe BIDDULPHIEÆ.

Frustules usually concatenate, more often found free. Zonal view well developed, generally quadrangular. Valvular view elliptical, angular or suborbicular. Surface varying from finely granular or punctate to coarsely reticulate. Angles well developed and usually conspicuous, frequently elevated into horns or processes.

Sub-Tribe I. Isthmiæ.

Frustules large, trapezoidal in zonal view, adherent to each other by short mucous stipes, forming irregularly zigzag filaments. Represented by but one genus.

1. Isthmia.

Characters of sub-tribe.

Sub-Tribe II. Biddulphiæ.

Frustules concatenate or attached by alternate angles. Valves with or without processes, spines or costæ, but without transverse internal septa. Surface definitely marked with reticulations, granules or puncta.

2. Biddulphia.

Angles usually elevated into horns or processes or distinguished by markings from the central portion.

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of the normal cell and terminating the filaments. These spherical cells contained granular masses and corresponded to the enlarged cells of *Melosira varians*. From observations made in *Eunotia pectinalis* for several years, I believe that the granular masses found in many cells while in an absolutely fresh condition are extruded by the partial separation of the connective zones, and that there are formed later either new frustules by rejuvenescence or by conjugation with other masses external to the filaments. The cells from which these granular bodies emerge, after forming into one or two larger spheres, are the fertile cells and are found in either larger or smaller filaments. Examinations of material gathered at hourly intervals for many successive days lead me to disbelieve in the theory of gradual diminution of the frustules, and rather to accept the conclusion that they really increase in size and that the flexibility of the connective zone will allow of a variation.

Sub-Tribe III. Terpsinoëæ.

Frustules regularly concatenate. Valves distinguished by the presence of transverse internal septa. Surface without spines.

3. Porpeia.

Valves elevated into a rounded projection at each end. Zonal view showing septa which are straight or curved.

4. Terpsinoë.

Surface of valve flat and indefinitely granulate. Outline more or less undulate. Septa curved at the ends and usually resembling musical notes.

5. Hydrosera.

Outline of valve elliptical or triangular, the angles separated from the centre by short septa. A single indefinite and indistinct septum usually found projecting from one of the sides.

6. Anaulus.

Valves elliptical or arcuate, with prominent and robust septa.

7. Huttonia.

Valves with truncate processes and transverse partial septa.

Sub-Tribe IV. Hemiaulidieæ.

Valves usually distinguished by the separation of central part from the ends or angles by costæ or depressions; processes often present, varying much in length and frequently tipped with a curved spine. Valves elliptical or angular, coarsely punctate.

8. Hemiaulus.

Valves elliptical or triangular, with or without transverse costæ. Processes prominent.

9. Ploiaria.

Valves without processes, inflated at the centre.

Sub-Tribe V. Eucampieæ.

Frustules concatenate in straight or spiral lines. Surface of valve undulating. Markings granular, generally indefinite. Connective zone frequently annulate.

10. Graya.

Valves elliptical, with undulating surface.

11. Eucampia.

Valves elliptical with undulating surface, and connected in a spiral chain.

Sub-Tribe I. Isthmiæ.

I. ISTHMIA Ag. (1832).

Valves dissimilar and unequal, elliptical or ovate. In one valve the surface is elevated at one end into a protuberance or "beak;" in the other there is simply a gradual elevation toward one end. Surface coarsely cellular, except at the "beak," where the cells are much smaller. The ultimate structure of each cell appears to be that of a "delicate, perforated membrane," of more or less elliptical outline and with various arrangements of the perforations.[2]

In zonal view the frustules are more or less rhomboidal or trapezoidal, without definite relation between the width and length.

Connective zone varies greatly in width and is frequently persistent, so that at the same time what appears at first to constitute one frustule may be found to contain the two older valves with their connective zones and two new valves with, possibly, their connective zones.

Analysis of Species.

Valves costate, ... 1. *nervosa.*
Valves not costate:
Rhomboidal in zonal view, ... 2. *obliquata.*
Irregularly ridged as to one valve, ... 3. *minima.*

1. Isthmia nervosa Kütz.

Isthmia nervosa Kütz., Bacill. (1844), 137, Pl. 19, fig. 5; Schmidt, Pl. 135; Pl. 145, figs. 10, 11.
Diatoma obliquatum Lyng, Hydrophyton Dan., 181, in part.
Isthmia obliquata (Lyng) Ag., Consp., 55, in part.

Valves traversed from the margin toward the centre by costæ, which vary in number from 10 to 50. Av. l. of fr. .264 mm., av. l. of v. .198 mm. Cells of the connective zone much larger on the border.

[2] For details of structure v. Nelson and Karop's "Notes of Finer Structure," etc., *Journal of Quekett Club,* Ser. 2, Vol. 2, p. 269, and Vol. 3, p. 41; also, Dr. Stokes on "Minute Structure of Certain Diatoms" in *Observer,* 1894, p. 369; and on "The Structure of the Diatom Girdle," by Palmer and Keeley, in the current volume of the PROCEEDINGS of the Academy, p. 465.

Coast of California, where it is abundant; Leete's Island, Conn. (Terry); Rockaway, L. I. (Terry); Rivière du Loup (Lewis); L. I. Sound (Lewis); Newport, R. I., *in situ* (Lewis); Boston Harbor (Bailey); Portland, Me. (J. A. Shulze); Hudson Strait (J. A. Shulze). Its occurrence on the Atlantic coast is extremely rare. Fossil in the Miocene deposits of California.

2. **Isthmia obliquata** (J. E. Smith).

Conferva obliquata Smith, Eng. Bot. (1814), Pl. 1869.
Diatoma obliquatum Lyng, Hydrophyt. Dan., 181, in part.
Isthmia obliquata (Lyng) Ag., Consp., 55.
Isthmia enervis Ehr., Inf., 209 ; Schmidt, Pl. 136, figs. 1, 3, 6, 7.
Isthmiella enervis (Ehr.) Cleve, Diat. Arct., 10.

Valves as in *nervosa*, except that the costæ are absent. The cells of the "beak" are not usually so small relatively as in *nervosa*, while those of the connective zone are smaller and the reticulations of the entire surface appear more angular.

Honduras (Janisch, Rabenhorst), and probably to be occasionally found southward. As Ralfs remarks, *nervosa* appears to be the northern and "*enervis*" the southern species.[3]

3. **Isthmia minima** B. and H.

Isthmia minima Bailey and Harvey, Wilkes' Expedition (1862), 176, Pl. 9, fig. 11; Schmidt, Pl. 145, fig. 9.
Isthmiella minima (B. and H.) De Toni, 835.
Isthmia Lindigiana Grun. and Eul., Hedwigia, 6, 29; Schmidt, Pl. 145, figs. 1, 2, 3.
Isthmia capensis Grun., Schmidt, Pl. 136, fig. 4, Pl. 145, fig. 4.

Frustules smaller and usually more elongated than in *nervosa* and *obliquata*. Opposite valves showing greater inequalities, one valve almost invariably having ridged elevations. Connective zone with rather minute cells and usually without a border of larger cells. Cells of valve average $1\frac{1}{2}$ in .01 mm. Cells of connective zone average 3 in .01 mm. L. of fr. .231 mm. L. of v. .013 mm. Secondary markings consist of minute puncta arranged in longitudinal rows within the reticulations. Certain valves from Barbados which appear similar to the present species are without doubt distinct, having a rather coarse cellular reticulation within the cells which thus appear beautifully stellate.

Not uncommon in Campeachy Bay, Honduras and southward.

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[3] The forms usually known as *nervosa* and *enervis* are, as remarked by Wm. Smith, "inextricably confused," but the figure given by J. E. Smith in *English Botany*, Plate 1869, under the name *Conferva obliquata*, is undoubtedly *enervis*, as it does not show the costæ, and, by the law of priority, the specific name of *obliquata* should be retained for the forms without costæ.

Sub-Tribe II. Biddulphiæ.

BIDDULPHIA Gray (1831) em. V. H. (1885).

Valves usually with processes which are globular, conical or cylindrical, obtuse or truncate, or with spines imitating slender processes. When processes are absent, the angles or ends of valves, either by elevation or by variation in punctation, resemble them.

The following analytical key to the species is artificial. While the uncertainty as to the relations of these forms exists, it is difficult to group them. At the same time, it will be seen that the genus divides itself, more or less naturally, into groups represented by such forms as *Biddulphiana, Mobiliensis, Favus, turgida, Circinus, arctica, vesiculosa, Tabellarium, trisulca, condecora, parvula* and *semicircularis.*

It seems unnecessary to separate the forms once included under *Denticella* and *Odontella.* The genus *Triceratium* is necessarily abandoned, the genus *Amphitetras* is no longer useful and the only two groups which appear to be sufficiently distinct are *Zygoceros* and *Cerataulus,* the former differing, however, from *Biddulphia* only in the absence of true processes, while the latter is Biddulphoid in form, but appears to be a transition to *Auliscus.* I have, therefore, followed Prof. H. L. Smith and Dr. Van Heurck in uniting all the genera mentioned under *Biddulphia.* Although, as has been remarked, an enormous number of species is thus included, the distribution of many, hitherto considered as belonging to *Triceratium,* under non-Biddulphoid genera will probably result in a greater restriction than would be the case if most angular forms are classified as *Triceratia.*[4]

Analysis of Species.

1. Valves divided into three or more parts. Processes globular (*Biddulphia* proper).
   - Divisions of valve not elevated, . . . 1. *Biddulphiana.*
   - Divisions of valve elevated into rounded protuberances:
     - Cells regularly disposed and rounded, . . 2. *tridens.*
     - Cells irregularly disposed, pustuliform, . 3. *pustulata.*

[4] Various authors give "Bermuda" as a locality of fossil species. Reference to the islands of Bermuda is a mistake, as they are of coral formation, and contain no fossil deposits. It should be regarded as indicating Nottingham, Md., and its immediate vicinity, which is situated in what is known as "Bermuda Hundred."

2. Valves not divided into parts. Usually furnished with spines. Processes more or less conical and obtuse. Surface not coarsely reticulate (*Odontella* and *Denticella*, in part):
   - Spines very numerous and prominent:
     - Valves broadly elliptical, ... 4. *multicornis.*
     - Valves narrowly elliptical, ... 5. *Brittoniana.*
   - Spines few but long and prominent:
     - Spines usually two on each valve:
       - Projecting from central elevation, . . 6. *longicruris.*
       - Projecting from small conical elevations near the extremities, ... 7. *Mobiliensis.*
     - Spines usually six or eight, ... 8. *longispina.*
   - Spines small, usually few, or sometimes wanting:
     - Valves elliptical:
       - With central elevation, ... 9. *aurita.*
       - Without marked elevation, ... 10. *obtusa.*
       - With central depression or simply convex:
         - Spines absent, ... 11. *Roperiana.*
         - Spines in circlet at centre, ... 12. *Argus.*
         - Spines one or two near opposite margins:
           - Surface with spurs, ... 13. *Edwardsii.*
           - Surface without fine spurs, . . 14. *Cookiana.*
           - Surface divided by two transverse hyaline lines, 15. *interrupta.*
   - Spines curved, one near each process, . . 16. *granulata.*
   - Spines three to six, valve divided longitudinally, 17. *seticulosa.*
     - Valves rhomboidal or angular, surface with small spurs:
       - Processes hornlike, obtuse, valves 3–4-angled, 18. *spinosa.*
       - Processes small, short, ... 19. *Rhombus.*
     - Valves suborbicular, ... 20. *suborbicularis.*
     - Valves orbicular, ... 21. *Smithii.*

3. Valves usually as in 2, but with surface coarsely reticulate (*Triceratium*, in part):
   - Processes conical and obtuse:
     - Valves angular:
       - 3–4-angled, l. of s. 15 mm. or less, . . 22. *Favus.*
       - 3–7-angled, l. of s. usually exceeding 15 mm., 23. *grandis.*

3-angled, small, with more acute processes, 24. *acuta.*
3–4-angled, sides convex, usually with stout spines, 25. *Robertsiana.*
5-angled, small, sides turgid, . . 26. *Campeachiana.*
Valves elliptical or rhomboidal:
Without spines:
Rhomboidal with turgid sides, reticulations 2 in .01 mm., ... 27. *dubia.*
Rhomboidal or elliptical, reticulations 1 to 1½ in .01 mm., ... 28. *reticulata.*
With two or three spines near the margin:
Surface depressed at centre, . . 29. *Peruviana.*
Surface not depressed, ... 30. *Keeleyi.*

4. Valves with cylindrical, truncate processes, appearing hyaline at the apex (*Cerataulus,* in part):
Valves angular:
Reticulations coarse, hexagonal, . . . 31. *consimilis.*
Reticulations fine:
Processes short, truncate, . . . 32. *convexiuscula.*
Processes large, elevated, ... 33. *orbiculata.*
Valves elliptical (or rarely angular):
Reticulations coarse, ... 34. *verrucosa.*
Reticulations fine:
With two stout spines, surface spurred, . 35. *turgida.*
Without strong spines, ... 36. *Californica.*
Surface without spurs:
Valves small, without spines, . . 37. *ovalis.*
Valves small, with two small spines, one near each side, ... 38. *lævis.*
Valves large, without spines, . . 39. *Thumii.*

5. Valves with processes replaced by spines (*Zygoceros*):
Valves elliptical, ... 40. *Circinus.*
Valves suborbicular, ... 41. *quadricornis.*

6. Valves without true processes. Reticulations more or less angular or irregular, those of the angles differing from those of the central portion (*Triceratium*):
Valves elliptical, ... 42. *Balæna.*
Valves angular, with or without central elevations, 43. *arctica.*

Valves triangular, with central and angular elevations,
44. *Heilpriniana.*

7. Valves mostly as in 6, but usually with very short, truncated processes, which are hyaline at the ends (*Amphitetras*):
 Valves without web-like markings:
 4–5-angled, ... 45. *vesiculosa.*
 Rhomboidal, ... 46. *decipiens*
 Valves with web-like markings:
 Markings producing appearance of inscribed square:
 Reticulations about 5 in .01 mm., . . 47. *elegans.*
 Reticulations about 2½ in .01 mm., . 48. *biquadrata.*
 Markings not producing appearance of square:
 Valves 4–5-angled, ... 49. *Pentacrinus.*

8. Valves angular, the angles not elevated, separated from central part by more or less definite costæ (*Triceratium*):
 Costæ dividing angles from centre, . . . 50. *Kainii.*
 Costæ extending but short distances from sides:
 Of the same length, usually curved, . 51. *Tabellarium.*
 Indefinite in length and direction, . . 52. *alternans.*

9. Valves with round, scattered puncta. Angles elevated into rounded processes (*Triceratium*):
 Without septa, ... 53. *trisulca.*
 With partial septa, ... 54. *costulata.*

10. Valves without marked elevation of surface and not divided by costæ or otherwise. Angles without processes. Spines usually absent. Puncta generally indefinite, irregular and unequal (*Triceratium*):
 Valves flat:
 Puncta in radiating, undulating rows, . 55. *condecora.*
 Puncta rounded or subquadrate, not undulating, outline suborbicular, ... 56. *subrotundata.*
 Outline triangular, with more or less unequal sides which are often sinuous, . . . 57. *Americana.*
 Outline 5–6-angled, ... 58. *Antillarum.*
 Puncta interspersed with much finer puncta,
59. *interpunctatum.*
 Puncta of one angle much smaller than those in the other two, ... 60. *hebetata.*

Puncta crowded at the angles and in parallel rows at the margin, ... 61. *heteropora.*

Valves with slight elevations at the angles and often at the centre:

Puncta much finer at the angles, . . . 62. *tessellata.*

Puncta nearly equal, ... 63. *Reticulum.*

Puncta irregular, unequal and scattered, . 64. *inelegans.*

11. Valves as in 10, but with surface mostly hyaline, except at the centre and angles where the puncta are minute, 65. *parvula.*

12. Valves semicircular or arcuate, more or less elevated at the ends, and with mostly coarse, radiant puncta, 66. *semicircularis.*

13. Valves elliptical, coarsely punctate, usually traversed by hyaline lines:

Hyaline lines prominent, ... 67. *Testudo.*

Hyaline lines indistinct, one at each end, . 68. *Shulzei.*

1. Biddulphia Biddulphiana (Smith).

Conferva Biddulphiana Smith, Eng. Bot. (1807), Pl. 1762, (upper figs).
Biddulphia pulchella Gray, Arr. Brit. Plants, I, 294; Schmidt, Pl. 118, figs. 26–32, Pl. 121, figs. 1, 2,
Diatoma Biddulphianum Ag.
Diatoma interstitiale Ag.
Diatoma liberum Ag.
Denticella Biddulphia Ehr.
Biddulphia trilocularis, quinquelocularis and *septemlocularis* Kütz.
B. Australis Mont.
B. elongata Menengh.
B. fasciata, unifasciata and *transversa* Wigand.

Valve, in general outline, elliptical. Surface convex, divided tranversely by two or more costæ. Sides undulating, the undulations, which are sometimes angular, corresponding to the divisions of the surface. At each end a process rises which is more or less globular, constricted at the base. The centre of the valve, usually not so elevated as the processes, bears a few rather short spines. Surface reticulated, the reticulations coarse, equalling .003 mm. in diam., except at the centre, where they are usually smaller and arranged more or less concentrically around a somewhat elliptical, panduriform or oblong space which is transverse to the major axis of the valve. On the processes the reticulations are minute. Between the coarse reticulations occur minute puncta.

Zonal view quadrangular, the connective zone having smaller reticulations, about 5 in .01 mm., arranged in nearly parallel vertical rows. L. of v. averages .115 mm.

A species variable in size, outline and the number of costæ. In a specimen from Campeachy Bay the costæ are connected by anastomosing lines.

Common along the Atlantic coast, especially southward. Fossil in the Miocene deposits of California and New Jersey, and in later deposits at Pensauken, N. J., and the blue clay of the Delaware river.

2. **Biddulphia tridens** Ehr.

Biddulphia tridens Ehr., Abhand. Ber. Akad., 1838, 129.
Denticella tridens Ehr., Abhand. Ber. Akad. (1839), 73.
Denticella tridentata Ehr., Abhand. Ber. Akad. (1844), 79.
Denticella polymera E., Abhand. Ber. Akad. (1844), 266.
Odontella polymera Kütz., Bacill., 137.
Zygoceros Tuomeyi Bail., Sil. Jour. (1844), Pl. 3, figs. 3, 4, 8.
Denticella polymera (Ehr.) Bail., Sil. Jour. (1845), 342.
Denticella simplex Shadb., T. M. S (1854), Pl. 1, fig. 16.
Denticella margaritifera Shadb., T. M. S., Pl. 1, fig. 17 (1854).
Biddulphia tridentata Ehr., Mik., Pl. 18, fig. 52.
Biddulphia Tuomeyi (Bail.), Roper, T. M. S. (1859), 8; Schmidt, Pl. 118, figs. 1–7, Pl. 119, figs. 1–7, 15, 17.
Biddulphia elegantula Grev., T. M. S. (1865), 50.

Valves rhombic-lanceolate, divided by septa into three or more divisions, the centre one always largest, the undulations of the sides corresponding to the divisions. Surface coarsely granular. In zonal view the divisions of the valves are seen to consist of more or less hemispherical elevations, becoming gradually smaller as a rule toward the ends. Processes usually rising higher than the elevations, varying from short to slender and generally inflated at the base. From the central elevation two or more slender, rather short spines arise, and frequently smaller spines are seen in the other elevations.

Variable in size, the valve, in the form of *elegantula*, reaching a length of .3 mm.

The distinction between *B. pulchella* and *B. tridens* may be said to consist chiefly in the surface reticulation, in the elevation of the septate divisions and in the outline. In *tridens*, all of the septate divisions are usually more or less elevated, while in *pulchella* the central one only is so found. The outline of *tridens* is rhombic, while that of *pulchella* is elliptical. There are forms, especially in the Redondo Beach (Cal.) material, which appear to be intermediate.

Common along the South Atlantic coast of North America. Fossil in the Miocene deposits of California, Virginia, New Jersey and St. Augustine, Fla.

In a note on "Ehrenberg's Observtions on the Fossil Infusoria of Virginia and Maryland," etc., in *Sil. Jour.* (1845), Prof. Bailey states (p. 204) that, in a letter received, Ehrenberg says that *Zygoceros* (*Biddulphia*) *Tuomeyi* equals *Denticella tridentata*. Ehrenberg (*Mik.*, Pl. 21, fig. 24) gives *Biddulphia tridentata* as equaling *Denticella tridens*. The figure prevents it from being considered as *Biddulphia pulchella*, as suggested by De Toni (*Syll.*, p. 870).

Roper remarks: "In examining the synonymy of this species, Ehrenberg's name of *Denticella tridens* appears to have the priority as to date, but as it occurs not infrequently with only one lobe and occasionally with ten or twelve, as shown in the *Denticella polymera* of *Am. Jour. of Science*, Vol. xlviii, tab. iv, fig. 20, clearly only a large specimen of the present form, the designation *tridens* is so decidedly inapplicable that I am induced to retain that of *Tuomeyi*, given by Prof. Bailey." The reason for the violation of the law of priority I do not consider sufficient, because, in the first place, a descriptive specific name cannot, in many cases, apply to all variations, and, in the second place, because, if all the variations included by Roper and others are accepted as forms of one species, it will be found that Ehrenberg's form of *tridens* is so abundant in recent and fossil deposits that it may be considered a type form.

Greville states that the form of *elegantula* differs from *B. Tuomeyi* "in the almost filiform horns, not inflated at the base, and which form a right angle with the base of the valve as in *Hemiaulus*." In a specimen from the artesian well at Atlantic City I have noticed that while one process is not inflated, the other is as much so as in many type forms of *B. tridens*. It would appear that in some cases the process is extended after the valve apparently intended to expand merely into an elevation, and that the inflation is occasionally accidental. As *elegantula* is variable in the number of inflations or lobes, there appears to be no way of separating it from *B. tridens*. I have, therefore, concluded to unite all the forms.

A peculiar form, the photograph of which was kindly sent me by Dr. Ward, of Poughkeepsie, shows the valve with three elevations and with short slender processes extending from much-inflated bases which appear similar to the usual elevations. The valve is arched longitudinally. In a form from Szakal, Hungary, the arching of the valve is lateral. It may be considered doubtful whether the numerous variations in *B. tridens* exceed those found in many other species of *Biddulphia.*

3. Biddulphia pustulata Brun.

> *Biddulphia pustulata* Brun, Diat. Esp. Nouv., 13 (1891), Pl. 13, fig. 10.

Valves rhombic-lanceolate, divided by septa into three or more divisions, as in *B. tridens*, with the central division turgid. Surface "with coarse, large, pustuliform granules, irregularly placed or grouped," which extend to the apices of the processes. Silex robust and very thick, as in *B. vittata* Gr. and St. In zonal view the appearance of valve approaches very closely *B. tridens.* L. of v. .09 to .11 mm. (From Brun's *Diat. Esp. Nouv.*, in part.)

Fossil in Miocene deposit of Atlantic City, N. J. (Brun).

4. Biddulphia multicornis Grun.

> *Biddulphia multicornis* Grun., V. H. Syn. (1881), Pl. 102, fig. 7.
> *Biddulphia multicornis* var. *Templum* Brun., Schmidt's Atlas, Pl. 173, figs. 13, 14.

Valve broadly elliptical-lanceolate, with rounded ends. Processes short, obliquely truncate. Surface convex, finely reticulated, the reticulations about 5 in .01 mm., with minute spurs at intervals, as in *B. turgida.*

Arranged in a single row along each edge of the valve are about twelve large, flattened spines, tumid at the base, extending to the opposite valve, which they closely embrace. L. of v. .2 mm.

A rare and singular species. The spines, which have the appearance of coming from the interior of the valve, are so firmly attached to the opposite valve that they leave scars upon it when separated.

Fossil in Miocene deposit of Redondo Beach, Cal.

As no illustration of the valve view of either type form or variety has been given, I am unable to distinguish between them. In the very few specimens sent me by Mr. John A. Shulze, the variations appear to be chiefly in size and in relative width of valve.

5. Biddulphia Brittoniana K. and S.

Biddulphia Brittoniana Kain and Schultze, Bull. Torr. Bot. Club (1889), 208, Pl. 102, fig. 1.

Valves elliptical-lanceolate, slightly convex. Surface traversed by transverse rows of indistinct puncta, about 10 in .01 mm., extending to the ends of processes which are large, cylindrical, truncate and curved in opposite directions. At the base of each process one or two strong curved spines extend, meeting the surface of the opposing valve of the next frustule and apparently acting as braces. Around the margin and along the middle of the valve extend rows of fine hairs which, meeting and interlacing with those of the next valve, unite the two valves of different frustules.

L. of v. .214 mm.

Fossil in the Miocene deposit of Atlantic City, N. J.

6. Biddulphia longicruris Grev.

Biddulphia longicruris Grev., T. M. S. (1859), 163, Pl. 6, fig. 10; Schmidt, Pl. 118, fig. 10.

Valve elliptical-lanceolate. Surface with a rounded elevation from which project two or more long spines. Processes long, obtuse, slightly inflated at the base. Surface with rows of puncta radiating from the centre. On the connective zone the puncta are in vertical rows.

L. of v. averages .033 mm.

Near *B. aurita*, from which it is chiefly distinguished by the much longer processes.

Occasional on the Pacific coast—"Californian guano," Grev.

7. Biddulphia Mobiliensis (Bail.) Grun.

Biddulphia Mobiliensis (Bail.) Grun., V. H. Syn., Pl. 101, figs. 4–6, Pl. 103, fig. *A*; Schmidt, Pl. 122, figs. 20, 21.

Zygoceros (*Denticella?*) *Mobiliensis* Bail., Mic. Obs., 40 (1850).

Biddulphia Baileyi Wm. Smith, Brit. Diat., 2, 50, Pl. 45, fig. 322, Pl. 62, fig. 322.

Zygoceros Mobiliensis (Bail.) Ralfs, *Biddulphia tenuis* L. W. Bail., *Biddulphia trinacria* L. W. Bail., *Denticella Mobiliensis* (Bail.) Grun., *Zygoceros occidentalis* L. W. Bail., *Denticella trinacria* Bail.

Valve elliptical-lanceolate. Surface convex with a flat central portion, separated from the other part of valve by a slightly elevated ridge which extends in two more or less sigmoidal lines from one process to the other. On opposite sides of this central portion, and placed at distances variable in different specimens from each process, is a small, conical projection from which extend one and occasionally two long, slender spines or bristles. Processes slender, capitate, about .023 mm. in length or about half the length of the spines. Surface of valve "delicately decussately-punctate," the markings resembling those of *Pleurosigma*, about 15 in .01 mm. In zonal view the valve converges toward the central elevation. Frustules delicate, of a yellowish color, variable in size, the length of valve in American specimens averaging .066 mm.

Common in the Gulf of Mexico and southward; Savannah (Bail.); St. Augustine, Fla. (Bail.); Trichoplankton of the North Atlantic (Cleve); Fossil at Richmond, Atlantic City artesian well and in the Pleistocene clay from artesian well at Norfolk, Va.

8. **Biddulphia longispina** Grun.

Biddulphia longispina Grun., V. H. Syn., Pl. 102, fig. 6 (1881).
Odontotropis longispina (Grun.), De Toni.

Valve elliptical or elliptical-lanceolate, tapering as a frustum into a narrowly elliptical-lanceolate flattened elevation surrounded by a hyaline, unevenly notched ridge from which project robust, hollow spines, 6 or 8 in number, about .092 mm. in length. From each end of valve a slender, capitate process, about .046 mm. in length, extends. Surface of valve traversed by rows of minute granules, about 9 in .01 mm. on the elevation and 12 in .01 mm. at the sides. The granules extend in transversely parallel rows from a narrow median line to the edge of the crest and then radiate toward the circumference.

L. of v. .072 mm.

The hyaline ridge in this species is not strictly a single keel, as in *Odontotropis cristata* and *O. carinata* from the Mors deposit, but is a double elevation enclosing an elliptical central portion of valve. The general structure, in this respect, resembles that of *B. Mobiliensis* (Bail.) Grun.

Fossil at Redondo Beach and Santa Monica, Cal., and Atlantic City, N. J.

9. **Biddulphia aurita** (Lyng) Brèb.

Biddulphia aurita (Lyng) Brèb., Consid. Diat., 12 (1838); Wm. Smith, Brit. Diat., 2, 49, Pl. 45, fig. 319, front, fig. 319; V. H. Syn., Pl. 98, figs. 4–9.
Diatoma auritum Lyng, Hydrophyt. Dan., 182 (1819), Pl. 62, fig. *D.*
Odontella aurita (Lyng) Ag., Consp., 56.
Denticella aurita Ehr.
Denticella gracilis Ehr.
Zygoceros margaritaceum B. and H.

Valve elliptical-lanceolate. Surface with an elevation at centre, generally more or less flattened at the top, from which usually a few short spines project. Processes obtuse, inflated at the base. Surface covered with rounded puncta, about 6 in .01 mm., radiating from an obscure centre. In zonal view the frustule is quadrangular, the connective zone having vertical rows of parallel puncta about 5 in .01 mm. Length of v. .082 mm. A variable species.

Common on the Atlantic and Pacific coasts.

10. Biddulphia obtusa (Kütz.) Ralfs.

Biddulphia obtusa (Kütz.) Ralfs, Prit. Inf., 848 (1861).
Odontella obtusa Kütz., Bacill., 137 (1844), Pl. 18, 8, figs. 1-3, 6-8.

Valve elliptical-lanceolate. Surface without marked central elevation, the centre appearing usually flattened or somewhat depressed. Processes obtuse and short, somewhat inflated at the base.

Very near *B. aurita*, from which it is chiefly distinguished by the absence of central spines and by the shortness of the processes.

As *B. obtusa* appears to include, however, according to various authors, about all the forms whose processes are not acute, the name is not particularly significant.

Atlantic and Pacific coasts.

[**Biddulphia subæqua** (Kütz.) Ralfs.]

Biddulphia subæqua (Kütz.) Ralfs, Prit. Inf., 848; Schmidt, Pl. 141, fig. 11 (not var. *Baltica*, V. H. Syn., Pl. 100, figs. 5, 6).
Odontella subæqua Kütz., Bacill., 137, Pl. 18, figs. 4, 5.

"Frustules oblong, very smooth, with minute lateral spines and without any median elevation" (Kütz.).

Campeachy Bay (Schmidt).

Prof. Smith remarks that both *B. obtusa* and *B. subæqua* "are merely forms" of *B. aurita*, and, as Ralfs says, he "is probably right."

11. Biddulphia Roperiana Grev.

Biddulphia Roperiana Grev., T. M. S. (1859), 163, Pl. 8, fig. 11-13; Schmidt, Pl. 120, fig. 20-24.
Odontella Roperiana (Grev.) De Toni, Syl. Alg., 868.
Triceratrium (*Odontella discigera* var.?) *Californicum* Grun.? V. H. Syn., Pl. 108, fig. 11 (?).

Valve broadly elliptical-lanceolate or triangular (?). Surface convex, with a central depression, punctate, the puncta averaging 7 in .01 mm., radiating from the centre. Zonal view quadrangular, the connective zone having puncta in vertical parallel rows. L. of v. .165 mm.

Distinguished by its prominent central depression from *B. aurita*, which it very nearly approaches.

Common on the Pacific coast. Fossil in the California deposits.

12. **Biddulphia Argus** Boyer.

Biddulphia Argus Boyer, Proc. Acad. Nat. Sci. Phil. (1898), 469, Pl. 24, fig. 6. Schmidt's Atlas, Pl. 120, fig. 27, apparently represents an intermediate form.

Valve broadly elliptical, convex, with an elliptical depression at centre, which is encircled by from 10 to 12 short spines. Processes rather short and obtuse. Surface with reticulations hexagonal, about 3 in .01 mm. at the border and 5 in .01 mm. at the centre, from which they radiate in curved lines. L. of v. .165 mm.

Port Antonio, Jamaica.

Distinguished chiefly by the central spines and by the size of the reticulations. It approaches *B. Roperiana* Grev. and *B. Peruviana* Grun.

13. **Biddulphia Edwardsii** Febiger.

Biddulphia Edwardsii Febiger (MSS.).
Odontella Edwardsii (Feb.) Grun., Diat. Fr. Jos. Land, 5, Pl. 2, fig. 20; V. H. Syn. Pl. 100, figs. 9, 10.

Valve suborbicular or orbicular-lanceolate. Surface with puncta from 5 to 7 in .01 mm., radiating from centre and with numerous evenly distributed short spurs, by which adjacent frustules are united. One or two small spines usually occur near each side. Processes short, truncate or obtuse. The prickly surface, under low powers, somewhat resembles that of *B. turgida*. Connective zone with puncta in parallel lines.

L of v. .033 mm. to .105 mm.

Pacific coast. Occasional on the Atlantic coast.

Prof. H. L. Smith (*A. J. M.*, 4, p. 101) considers this form to be " a hirsute variety of *B. Roperiana* Grev." It is probably intermediate between *B. Roperiana* and *B. primordialis* Brun. In large specimens a hyaline ring is quite distinct in the connective zone, as mentioned by Brun in his description of the latter species (*Esp. Nouv.*, 13). See also under *B. polyacanthos* Brun, *l. c.*, p. 12.

14. Biddulphia Cookiana K. and S.

Biddulphia Cookiana K. and S., Torr. Bull. (1889), 73, Pl. 89, fig. 4.
Odontella Cookiana (K. and S.) De Toni.
Biddulphia tumida (E.) Roper? T. M. S. (1859), 15, Pl. 2, figs. 18, 19.

Roper gives as the synonymy of his species *Denticella tumida?* E. and *Odontella tumida* Kütz., and states that the form agrees with Ehrenberg's description of a valve from "Bermuda" [Nottingham]. Roper's figures and description appear to show the identity of his form with *B. Cookiana* K. and S., an examination of the "Old Well" deposit of Richmond showing a large number of specimens, the smaller of which illustrate the globose character of the valves.

Valve suborbicular or elliptical-lanceolate, convex, with processes tumid at the base and small and obtuse at the apex. Surface with radiating, unequal, hexagonal reticulations, about 4 in .01 mm. One or two stout spines are placed on each side near the margin. Connective zone with parallel rows of puncta about 7 in .01 mm.

L. of v. .105 mm.

Fossil in the Miocene deposits of the Atlantic coast.

15. Biddulphia interrupta Boyer.

Biddulphia interrupta Boyer, Proc. Acad. Nat. Sci. Phila. (1898), 468, Pl. 24, fig. 2.

Valve elliptical, with small, rounded processes. Surface convex, finely punctate, the puncta about 10 in .01 mm., radiating in scattered lines from the centre, at which are three minute spines. About one-third of the distance from centre to processes, at each end, a hyaline band, produced by the interruption of puncta, crosses the valve transversely extending nearly to the sides. L of v. .112 mm.

Campeachy Bay. Rare.

16. Biddulphia granulata Roper.

Biddulphia granulata Roper, T. M. S. (1859), 13, Pl. 1, figs. 10, 11, Pl. 2, fig. 12.

This form has been identified with *Denticella turgida* Ehr. = *Odontella turgida* Kütz. = *Biddulphia turgida* (Ehr.) Ralfs (not Wm. Sm.), and it appears to be equivalent, in outline at least, to *Denticella dubia* Bail. "It is impossible," as Roper remarks, "to speak with certainty."

Valve elliptical-lanceolate. Surface convex with diagonal rows of fine puncta about 12 in .01 mm., and with sparsely scattered small spurs. Processes slightly inflated at the base, obtuse at the ends, which are curved outward toward alternate sides. Near each process and on opposite sides of the longitudinal axis is placed a long, stout spine, bent or curved inward near the middle. Connective zone with rows of diagonal puncta slightly smaller than those on the valve. L. of v. .108 mm.

Vera Cruz. Fossil in the Pleistocene clay from the Norfolk artesian well. Not common.

17. Biddulphia seticulosa Grun.

Biddulphia seticulosa Grun., V. H. Syn., Pl. 101, figs. 7, 8.
Denticella seticulosa (Grun.) De Toni.

Valve elliptical, acuminate at the ends, from which arise horn-like, obtuse processes. Surface of valve divided longitudinally by an indefinite, irregular line which does not reach the extremities and from which proceed the rows of puncta parallel at the middle, but radiating toward the ends. Minute spurs are scattered over the surface in addition to longer spines, indefinite in number, but usually three to six on each side near the margin. Puncta, about 6 in .01 mm., are arranged in vertical rows on connective zone and also extend almost to the end of processes.

L. of v. .198 mm. Width of v. .082 mm. L. of frustule .072 mm.

Fossil in the Petersburg, Va., deposit.

Van Heurck considers this as probably a form of *Triceratium tridactylum* Brightw. (= *Biddulphia spinosa* (Bail.)), and as probably near *B. reticulata* var. *b.* Roper. See remarks under *B. spinosa.*

18. Biddulphia spinosa (Bail.).

Triceratium spinosum Bail., Sil. Jour. (1844), 139, Pl. 3, fig. 12; Schmidt, Pl. 87, figs. 2, 3, 4, 5.
Triceratium tridactylum Brightw.
Triceratium armatum Roper.
Triceratium setigerum Bail.
Triceratium serratum Wallich.
Not *Biddulphia spinosa* Grev. = *Denticella spinosa* (Grev.) Grun.

Schmidt (*Atlas*, Pl. 87) considers this form equivalent to *Triceratium Pileus* Ehr. (*Mikrogeologie*, Pl. 19, fig. 18), but Ehrenberg's figure certainly does not represent this form. Grunow states that *Triceratium spinosum* is a triangular form of *Biddulphia* *granulata* Roper. Specimens in my collection from Vera Cruz and the Norfolk artesian well of *Biddulphia granulata* have a finer reticulation than *Biddulphia spinosa*, but the two forms are quite similar. Prof. Smith attributes Bailey's *Triceratium setigerum* to *Triceratium comptum* Ehr., but Bailey's figure appears to represent a form nearer *spinosum*.

Valve triangular or quadrangular, with straight or concave sides. Angles produced into horn-like, obtuse processes. Surface convex, reticulated, the cells hexagonal, 3 to 5 in .01 mm. at centre, and slightly smaller toward the angles. At intervals of three or four cells small spurs usually occur giving a prickly appearance to the valve. Two to six or rarely more stout spines, in length about one-third to one-half the width of valve, and often forked at the ends in perfect specimens, are placed at unequal distances from the angles, two on each side, if of the usual number. In fossil forms most if not all of the spines are frequently broken off. In zonal view, the valve, as Bailey remarks, is constricted beneath the processes. The reticulations of the connective zone are similar to those of valve. L. of side .013–.156 mm. L. of frustule occasionally reaching .201 mm.

The dove-tailing of the lateral margins of the connecting zone at the angles, as described by Wallich in reference to *Triceratium serratum*, is well exhibited also in triangular forms in my collection from Yucatan. It is, however, merely the "postage stamp" fracture of the corners of the valve and is not always as regular as shown by Wallich.

West coast of Florida; Campeachy Bay; Yucatan.

Fossil in the Miocene deposits of the Atlantic coast and the St. Augustine artesian well.

19. Biddulphia Rhombus (Ehr.) Wm. Sm.

Biddulphia Rhombus (Ehr.) Wm. Sm., Brit. Diat., 2, 49, Pl. 45, fig. 320, Pl. 61, fig. 320; Schmidt, Pl. 120, figs. 11-13.
Zygoceros Rhombus Ehr.
Denticella Rhombus Ehr.
Triceratium Biddulphia Heib.
Triceratium striolatum Ehr.
Triceratium membranaceum Brightw.

Valve orbicular-rhomboidal with produced ends, or triangular with convex sides. Surface convex, with fine hexagonal reticulations from 7 to 9 in .01 mm., which are irregular on an elliptical or triangular central part, but which radiate thence to the margins and continue nearly to the ends of processes. Scattered over the surface are minute spurs. Processes small, short and obtuse. Near the convex margins strong, short spines occur, usually three on each side near the middle and two additional ones next each process. L. of v. .165 mm. W. of v. .112 mm.

The triangular form (var. *trigona* Cleve) differs apparently only in outline. The reticulations are not always radiate. In a specimen from an artesian well at Harvey Cedars, N. J., they occur in short, decussate, intermediate rows.

Common along the Atlantic coast. Fossil in the Miocene and later deposits of the Eastern States.

20. Biddulphia suborbicularis Grun.

Biddulphia suborbicularis Grun., V. H. Syn., Pl. 100, figs. 15, 16.
Biddulphia angulata A. S., Schmidt, Pl. 141, figs. 7, 8.
Denticella? suborbicularis (Grun.) De Toni.
Odontella angulata (A. S.) De Toni.

Valve suborbicular, frequently with several irregular, angular projections. Processes frequently unequal, inflated at the base and truncate. Surface elevated half-way between the processes and centre, at which a depression occurs, with reticulations from 5 to 8 in .01 mm., increasing in size toward the circumference and radiating in slightly undulating lines. Two, rarely three or four, stout spines are placed obliquely opposite half-way between centre and circumference. L. of v. .089 mm.

Fossil in the Nottingham deposit.

21. Biddulphia Smithii (Ralfs.) V. H.

Biddulphia Smithii (Ralfs.) V. H. Syn., 207.
Eupodiscus radiatus Wm. Sm. = *Biddulphia radiatus* = *Eupodiscus velatus* Grev.
Cerataulus Smithii Ralfs., Schmidt, Pl. 116, figs. 5, 6.
Cerataulus (*Odontella*) *Smithii* Ralfs., V. H. Syn., Pl. 105, figs. 1, 2
Zygoceros hemitropus L. W. Bail.
Biddulphia hemitropa L. W. Bail.
Not *Auliscus radiatus* (Ehr.) Jan. and Rab.

Valve orbicular, convex. Surface with reticulations 5 in. .01 mm., radiating from the centre and smaller near the processes which are tapering and truncate. A short spine is usually found on each side near the circumference about half-way between the processes. Connective zone narrow, with vertical rows of puncta, 12 in .01 mm. Diam. of v. .059 mm.

Charleston, S. C., and southward. Common at Vera Cruz, Honduras and Campeachy Bay.

22. Biddulphia Favus (Ehr.) V. H.

Biddulphia Favus (Ehr.) V. H. Syn., 208, Pl. 107, figs. 1, 2, 3, 4.
Triceratium Favus Ehr., Schmidt, Pl. 82, figs. 1, 2, 3, 4.
Triceratium comptum Ehr.
Triceratium muricatum Brightw.
Triceratium megastomum Brightw.
Triceratium scitulum Brightw.
Triceratium fimbriatum Wallich.
Triceratium orientale Bail. and Harv.
Triceratium cuspidatum Janisch.
Amphitetras cuspidata L. W. Bail.

Valve three or four-angled, with straight or slightly concave or convex sides. Angles obtuse, occasionally somewhat constricted, each with an obtuse, horn-like process. Surface slightly convex, divided into large hexagonal cells. Inner or lower surface of valve finely punctate, the puncta radiating in undulating rows from the centre and extending to processes, about 18 in .01 mm. in the common forms. Zonal view quadrangluar, the connective zone marked with puncta in quincunxes. Frustules attached by alternate angles zigzag in a chain, usually found free. L. of s. averages in the common forms .15 mm.

Common in the triangular form along the Atlantic coast, more especially southward, where it is associated with the smaller triangular and quadrangular forms known as *Triceratium scitulum*. Rare on the Pacific coast in the quadrate form. Fossil in the Eastern States in deposits later than the Miocene.

23. Biddulphia grandis (Br.).

Triceratium grande Br., M. J. (1853), 250, Pl. 4, fig. 8; var. *pentagona* Grun., Schmidt, Pl. 86; var. *septangulata* Kitton, Schmidt, Pl. 85, figs. 1, 2, Pl. 86, figs. 11, 12, 13.
Triceratium ponderosum Edwards, Lens, 2, 105.
Triceratium Favus septangulatum Kitton.
Triceratium Strabo, Schmidt, Pl. 86, figs. 6, 7.

Valve as in *B. Favus* but larger, varying from triangular to septangular, the sides occasionally reaching .281 mm. in length, while the puncta of the lower surface of the valve are frequently about 7 in .01 mm.

Colon. Fossil in the Miocene deposits of California.

24. Biddulphia acuta (Ehr.).

Triceratium acutum Ehr., V. H. Syn., Pl. 108, fig. 1.

The form known as *Triceratium acutum* (Ehr.) is sometimes confounded with acute forms of *Triceratium punctatum* Br.

Valve triangular, sides slightly convex and processes at the angles somewhat acute. Surface flat, reticulated, cells hexagonal, 2 in .01 mm. at the centre, 3 in .01 mm. at the border, not radiate. L. of s. .04 mm. to .122 mm.

Fossil in the Miocene deposits of the Eastern States.

It is possible that *B. grandis* and *B. acuta* may be considered as varieties of *B. Favus*. It is to be noted that *B. Favus* is recent, not occurring in the Miocene deposits, while *B. grandis* occurs fossil in California Miocene and recent in the south Atlantic.

25. Biddulphia Robertsiana (Grev.).

Triceratium Robertsianum Grev., M. M. J. (1863), 231, Pl. 9, fig. 9 (?); ib. (1886), Pl. 2, fig. 22; Schmidt, Pl. 83, figs. 2, 3, 4, 5, 6, 7.
Triceratium Robertsianum Grev. var. *macracantha* Grun., Schmidt, Pl. 82, figs. 14, 15.

Valve triangular or quadrangular, with convex sides. Surface convex with hexagonal reticulations averaging .008 mm. in diameter, scarcely longer toward the sides. Angles very slightly produced, with elevated, obtuse processes. Inner plate of valve finely but distinctly punctate as in *B. Favus*. One or more short, stout spines are frequently found on each side near the border. W. of v. .148 mm.

Gulf of Mexico (Gründler in Schmidt); Pacific soundings, 20° 10′ N., 158° 14′ W., 2507 fathoms. Rare.

26. Biddulphia Campeachiana (Grun.).

Triceratium Campeachianum Grun., M. M. J. (1874), 319; Schmidt, Pl. 78, figs. 18, 19, 20.
Amphipentas Campeachiana (Grun.) De Toni.

Valve pentagonal with sides tumid at the middle, producing a decagonal outline. Processes at the angles conical, obtuse. Surface almost flat, reticulated, the cells hexagonal, nearly equal, 2 in .01 mm. The inner plate of valve is punctate as in *B. Favus*. W. of v. .072 mm. to .125 mm.

Campeachy Bay.

27. Biddulphia dubia (Br.) Cleve.

Biddulphia dubia (Br.) Cleve. "Vega," 508.
Triceratium dubium Br., T. M. S. (1859), 180, Pl. 9, fig. 12; Schmidt, Pl. 78, figs. 26–30.
Triceratium bullosum Witt.
Triceratium (*or Biddulphia*) *bicorne* Cleve, Diat. West Ind., 17, Pl. 5, fig. 30; Schmidt, Pl. 78, figs. 24, 25.
Amphitetras bicornis (Cleve) De Toni.

Valve rhombic-lanceolate, the ends produced into obtuse processes, while the sides are turgid and extended into rounded projections. Abnormal forms are frequent. Surface reticulate, the unequal, usually hexagonal cells averaging .005 mm. in diameter. Within the cells indistinct granulations are seen. L. of v. .075 mm.

Atlantic coast, southward, not common; California (Cleve).

28. Biddulphia reticulata Roper.

Biddulphia reticulata Roper, T. M. S. (1859), 14, Pl. 2, figs. 13, 14, 15; Schmidt, Pl. 78, figs. 21–23, Pl. 121, figs. 11–15.
Odontella? reticulata (Roper) De Toni.

Valve elliptical-lanceolate or rhombic with turgid sides. Processes conical and obtuse. Surface coarsely reticulate, the reticulations 1 to 1½ in .01 mm., the inner layer with puncta from 6 to 9 in .01 mm., resembling those of *B. Favus*. Connective zone with parallel rows of puncta about 5 in .01 mm. L. of v. .122 mm.

Honduras; Pacific coast.

29. Biddulphia Peruviana Grun.

Biddulphia (*tumida* Roper, var.?) *Peruviana* Grun., V. H. Syn., Pl. 101, figs. 2, 3.
Biddulphia tumida var.? *Peruviana* (Grun.) De Toni. (Appears to differ from *B. tumida* (Ehr.?) Roper in the greater prominence of the hyaline band.)

Valve orbicular-rhomboidal or elliptical-lanceolate, convex, with depressions at the centre and toward the processes, slightly constricted above the connective zone and surrounded by a narrow, apparently hyaline, band. Processes swelling near the base and small and obtuse at the apex. Surface with unequal, hexagonal reticulations, from 2 to 4 in .01 mm., extending to the apices of the processes on which they are smaller. The inner plate or floor of cell wall is distinctly punctate. Two or three strong spines are usually found on each side near the margin. Connective zone with diagonal reticulations about 7 in .01 mm. L. of v. 138 mm.

Peruvian guano (Grun.); Callao, Peru. Possibly to be met with northward.

30. Biddulphia Keeleyi Boyer.

Biddulphia Keeleyi Boyer, Proc. Acad. Nat. Sci. Phila. (1898), 469, Pl. 24, fig. 4.

Valve broadly rhombic-elliptical, rounded at the ends. Surface slightly convex, without depression, with unequal, hexagonal reticulations, about 2 in .01 mm.; puncta within the reticulations about 8 in .01 mm. Three stout spines are placed on each side near the margin. Processes inflated at the base, small at the apex and placed, not at the ends of the valve, but obliquely opposite, near the ends. L. of v. .148 mm.

U. S. S. "Tuscarora," soundings, Lat. 36° 12′ N., Long. 123° 11′ W., 1605 fathoms. Coast of California (F. J. Keeley); Monterey Bay (J. A. Shulze). Rare.

31. Biddulphia consimilis (Grun.).

Triceratium consimile Grun., V. H. Syn., Pl. 108, fig. 2; Schmidt, Pl. 84, figs. 13, 14.

Valve triangular, with sides slightly convex. Angles rounded, filled with the prominent cylindrical, short and rounded processes. Surface nearly flat, with reticulations which average .008 mm. in diam., varying from triangular to hexagonal, with unequal sides. The inner plate of the valve is rather coarsely punctate, the puncta being about 5 in .01 mm.

L. of s. .120 mm. to .198 mm.

Campeachy Bay. Fossil in Santa Monica deposit.

32. Biddulphia convexiuscula (Grun.).

Triceratium convexiusculum Grun., Schmidt, Pl. 151, figs. 5, 6.

Valve triangular, sides convex. Angles rounded, with short, truncate processes. Surface convex, with puncta about 7 in .01 mm., radiating from the centre. On one or both sides of each angle is a short spine. On the connective zone the puncta are in diagonal rows. L. of s. averages .052 mm.

The general appearance is that of a three-sided form of *Biddulphia lævis*, from which it differs in the puncta of the connective zone which are usually larger in the former.

Campeachy Bay; Honduras; stomachs of fish from coast of South Carolina; Tampa Bay, Fla.

33. Biddulphia orbiculata (Shadb.).

Triceratium orbiculatum Shadb., T. M. S. (1854), 14, Pl. 1, fig. 6.
Triceratium (*orbiculatum* Shadb. var.) *elongatum* Grun.
Triceratium Shadboltianum Grev., Schmidt, Pl. 80, fig. 18-20.
Triceratium gibbosum Bail and Har., Schmidt, Pl. 80, fig. 13.
Triceratium gibbosum var. *elongatum* Grun., Schmidt, Pl. 80, fig. 21.
Lampriscus Kittoni A. S., Schmidt, Pl. 80, fig. 11.
Biddulphia crenulata W. C. Walker.

Valve triangular, with convex sides, or orbicular. Outline entire or crenulate. Processes three or more, large, considerably elevated and truncate. Surface slightly convex, with puncta radiating from the centre, about 11 in .01 mm., becoming much finer at the apex of the processes. A short strong spine is frequently found quite near one or more of the processes. Connective zone occasionally much elongated and annulate, with puncta in longitudinal rows. Diam. averages .092 mm.

Honduras; Colon.

Both Greville and Ralfs separate *Triceratium orbiculatum* Shadb. from the form described under that name by Brightwell and named by Greville *T. Shadboltianum* on account of the absence of spines in the former. In material from Honduras many variations occur in forms which, I believe, belong to one species. In some valves no spines are seen, in others one or more may be noticed, and occasionally two spines are found near one process. Some valves are quite orbicular and occasionally somewhat elliptical, while others, chiefly the smaller, are more nearly triangular. It is in the smaller, triangular valves that the great extension of the connective zone is seen, as in the form named *T. gibbosum* var. *elongatum* Grun. Owing to the incomplete description by Bailey and Harvey, who state that forms from Tahiti have " a surface as in *T. Wilkesii*," and to the uncertain figure, it is difficult to reach an absolute conclusion as regards the identity of their form with the present species. The description above given is from valves found at Honduras, where occur also forms with three or four processes and with crenulate margins, as in *Lampriscus Kittoni*, but otherwise similar to the triangular forms.

34. Biddulphia verrucosa Boyer.

Biddulphia verrucosa Boyer, Proc. Acad. Nat. Sci. Phila. (1898), 468, Pl. 24, fig. 5.

Valve suborbicular, convex. Processes very large, cylindrical, truncate. Surface coarsely reticulate, the reticulations unequal, irregular, about 2 in .01 mm. Within the reticulations are coarse puncta about 3 in .01 mm.

L. of v. .138 mm.

Fossil at Redondo Beach. Very rare.

This form, which approaches the *Cerataulus* group, is distinguished by the encrusted or warty appearance of the surface.

35. Biddulphia turgida (Ehr.) Wm. Sm.

Biddulphia turgida (Ehr.) Wm. Sm., Brit. Diat., 2, 50, Pl. 62, fig. 384.

Cerataulus turgidus Ehr. Schmidt, Pl. 116, figs. 1–3, Pl. 115, figs. 12–14.

Odontella turgida Wm. Sm. (?), De Toni.

Valve elliptical, convex. Surface with undulating rows of fine puncta about 9 in .01 mm., and with numerous minute spurs at irregular intervals. Processes very large, cylindrical, truncate, placed obliquely opposite near the ends, and, owing to the torsion of the frustule, directed sideways. Between the processes two stout spines, frequently forked at the ends in perfect specimens, are placed, one on each side, obliquely opposite, near the border. Around the margin a row of very short spines frequently occurs. L. of v. .132 mm.

In zonal view the frustule appears subglobose and twisted on its longitudinal axis in such a way that the edges of the valves appear undulating and the connective zone "sigmoid." Puncta on the connective zone in diagonal rows about 11 in .01 mm. In var. *multispina* Grun. the two large spines are usually replaced by from two to four shorter ones on each side, and numerous short, stout spines are found on the circumference, but variations occur. (*Biddulphia turgida* (Ehr.) Ralfs, *Denticella turgida* Ehr. and *Odontella turgida* Kütz. are not equivalent. They are, possibly, forms of *Biddulphia granulata* Roper.)

Atlantic and Pacific coasts. Fossil in the deposits of California, Atlantic City and Bridgeton, N. J.

In the Californian deposits numerous variations occur. The form figured in Schmidt's *Atlas*, Pl. 115, fig. 15, under the name of *Cerataulus Johnsonianus* var. appears to me to approach nearer to *turgida* than to Greville's form. Both it and var. *multispina* Grun. are not uncommon in the Redondo Beach deposit.

36. Biddulphia Californica (A. S.).

Cerataulus Californica A. S., Schmidt, Pl. 115, figs. 2, 3, 4.

Valve broadly ovate-elliptical or suborbicular, with very short, truncate, hyaline processes. Surface somewhat flat, studded with minute spurs, finely reticulated, the reticulations hexagonal, about 8 in .01 mm. Border of valve with a row of small spurs. Two very short spines are usually found on each side near the border.

L. of v. .198 mm.

Numerous forms are found in the Redondo Beach deposit, which merely differ in outline and in the number and prominence of the spines which are sometimes absent.

Fossil on the Pacific coast.

37. Biddulphia ovalis (A. S.).

Ceratanlus ovalis A. S., Schmidt, Pl. 115, figs. 5, 6, 7.

Valve broadly elliptical with short, truncate processes. Surface flat, with fine, hexagonal reticulations about 8 in .01 mm., without spines or spurs. L. of v. .039 mm.

Fossil at Redondo Beach, Cal., and Weymouth, N. J.

38. Biddulphia lævis Ehr.

Biddulphia lævis Ehr., Berl. Akad. (1843), 122.
Ceratanlus lævis (Ehr.) Ralfs, Prit., 847.
Ceratanlus lævis (Ehr.) Schmidt, Pl. 116, figs. 13, 14, 15.
Denticella lævis Ehr.
Ceratanlus lævis thermalis Grun., Schmidt, Pl. 116, figs. 8–11.
Isthmia polymorpha Mont., Kütz. Bacill., 138.
Odontella polymorpha Kütz.
Ceratanlus thermalis (Menengh.) Ralfs.
Pleurosira thermalis Menengh.
Melosira thermalis Menengh.
?*Gallionella* ? —— Bail., Sil. Jour. (1842), 104, Pl. 2, fig. 8.
(*B. subæqua* K.? and *B. obtusa* (K.) Grun., of some authors, have been confounded with *B. lævis* Ehr.)

Valve suborbicular or occasionally subtriangular, convex, with short, truncate processes. Surface with fine puncta, averaging 13 in .01 mm., which radiate in more or less curved lines from the centre. Two small spines are placed obliquely opposite about half the radius from the centre. Entire surface apparently covered with very minute spur-like elevations which are usually invisible under ordinary illumination. The puncta on the connective zone are slightly smaller than those on the valve. L. of v. .066 mm.

Generally distributed along the Atlantic and Pacific coasts. Abundant at Port Townsend, Wash. Fossil in salt marsh deposits of Kansas, Utah, Nebraska and Michigan. Also occurs in fresh-water lakes.

39. Biddulphia Thumii (A. S.).

Ceratanlus Thumii A. S., Schmidt, Pl. 115, fig. 1.
Ceratanlus Hungaricus Pant.? Foss. Bacill. Ung., 2, Pl. 26, fig. 375?

Valve suborbicular, with large, short, truncate processes. Surface with fine puncta confused and scattered at the centre, from which they radiate in undulating lines toward the processes and the circumference where they average 11 in .01 mm. In large specimens the surface slightly undulates between the processes. L. of v. .204 mm.

Fossil at Redondo Beach, Cal. Rare.

The Californian form is not distinct, I think, from the Hungarian, except that in the latter, in the few specimens I have seen, the puncta are larger and more confused.

40. Biddulphia Circinus (Bail.) V. H.

Biddulphia Circinus (Bail.) V. H., Diat., fig. 200.
Zygoceros Circinus Bail., N. Sp., Pl., figs. 19, 20; V. H. Syn , Pl. 105, fig. 13.

Valve elliptical, rising into the form of a truncated cone, from the top of which, at each end, extends a long, inwardly bent spine. A few much smaller, intermediate spines are scattered over the surface which is slightly rugose and punctate, the puncta more or less radiate, averaging 7 in .01 mm. Processes wanting. Connective zone well developed, with fine puncta, from 9 to 13 in .01 mm., in longitudinal rows. L. of v. .083 mm.

Fossil at Richmond (Bail.); Santa Monica (Grun.). Rare.

41. Biddulphia quadricornis (Grun.).

Zygoceros quadricornis Grun., V. H. Syn., Pl. 105, figs. 5-7.

Valve orbicular or suborbicular, having four spines which rise from the four corners of the summit of the truncated cone. Otherwise apparently as in *B. Circinus*, of which it is, probably, a variety.

Fossil at Nottingham (Grun.).

42. Biddulphia Balæna (Ehr.) Br.

Biddulphia Balæna (Ehr.) Br., M. M. J. (1859), 181, Pl. 9, fig. 15; Schmidt, Pl. 121, figs. 5, 6.
Zygoceros Balæna Ehr., Mik., Pl. 35, A, 33, fig. 17.
Zygoceros radiatus Bail.
Triceratium formosum Br., and *Triceratium formosum pentagonalis* A. S., Schmidt, Pl. 79, figs. 2, 3, 4.

Valve elliptical or angular, in zonal view quadrangular. Surface flat or somewhat concave, slightly elevated at the ends or angles, finely reticulate, the hexagonal reticulations about 5 to 8 in .01 mm., radiating from the centre in the smaller valves, but in the larger, elliptical forms, transverse in the middle. Connective zone with parallel rows of puncta, smaller than those on the valve, about 5 in .01 mm. L. of v. in elliptical form .231 mm.

Near *Biddulphia arctica* (Br.), but with much finer reticulations. Cleve states (*Arct. Diat.*, 15) that these forms are not specifically distinct, as he has seen a transitional form between *Zygoceros Balæna* E. and *Triceratium arcticum* Br. I have noticed a triangular form in material from McCormack Bay, Greenland. The elliptical form of the same locality shows markings closely resembling those of *B. arctica*, each reticulation containing 3 or 4 puncta on the upper surface of valve.

Greenland (Cleve); Nova Scotia; McCormack Bay, Greenland; fossil at San Luis Obispo, Cal. (J. D. Cox); Nottingham (Br.).

43. Biddulphia arctica (Br.).

> *Triceratium arcticum* Br., M. M. J. (1853), 250, Pl. 4, figs. 10, 11; Schmidt, Pl. 79, figs. 5–13, Pl. 81, figs. 3, 4, Pl. 94, figs. 1, 2, 3.
> *Triceratium Wilkesii* var. Bail. and Harv.
> *Amphitetras Wilkesii* Bail. and Harv.
> *Trigonium arcticum* Cleve.

Valve elliptical (?) or angular. Sides straight, convex or concave, with rounded angles which are scarcely elevated. Surface of valve rather coarsely reticulate or cellular, the cells irregularly pentagonal or hexagonal, radiating from centre and usually slightly larger near the semi-radius, distinctly punctate near the perimeter. Angles finely punctate, the rows of puncta slightly converging toward the apex where they are smaller. Connective zone with coarse puncta in longitudinal rows. Zonal view usually quadrangular but occasionally showing the surface much elevated. A species quite variable in size and outline.

By careful examination a fine hexagonal punctation may be seen around the margin of the cells and upon the *upper* surface of the valve, resembling the arrangement in certain forms of *Coscinodiscus* (see text of Pl. 165 of Schmidt's *Atlas*).

Abundant on the Pacific coast; Campeachy Bay (Grun.); fossil in California and very rarely at Asbury Park, N. J.

The following are considered varieties:

B. arctica Campeachiana (Grun.) = *Triceratium arcticum* forma *Campeachiana* Grun., triangular, with straight sides.

B. arctica Californica (Grun.) = *Triceratium arcticum* var. *Californica* Grun., with produced angles, concave sides and hyaline centre. Occurs three- and four-sided.

B. arctica Kerguelensis (Grun.) = *Triceratium arctica* var.

Kerguelensis Grun., differing from *Californica* in not having the angles produced.

B. arctica Montereyi (Br.) = *Triceratium Montereyi* Br., differs from the type merely in the elevation of the surface which is quite pronounced in certain specimens, but differs in valves of the same frustule. In specimens in my collection frustules show one valve with no elevation and the other with a very marked central protuberance. In another frustule both valves are much elevated at the centre as in those described by Grove and Stout (*Diat. Oamaru*, Pl. 11, fig. 25).

B. arctica quadrangularis (Grev.) = *Triceratium quadrangulare* Grev., which apparently differs only in a slight constriction of the angles from other quadrate forms.

B. arctica pentagona = *Triceratium arcticum*, forma *pentagona*, from Redondo Beach.

B. arctica sexangulata = *Triceratium arcticum sexangulatum*, a very beautiful six-sided form occurring in a sounding from the Pacific, west of California (not *T. sexangulatum* Grev.) (Coll. J. A. Shulze).

According to Van Heurck (*Diat.*, p. 61), the form known as *Triceratium formosum* Br. is equivalent to *Biddulphia Balæna*. The pentagonal form shows puncta within the reticulations similar to those in the type form of *B. arctica*. Owing to the numerous variations of *Balæna* and *arctica*, it becomes difficult to separate them satisfactorily.

44. Biddulphia Heilpriniana (K. and S.).

Triceratium Heilprinianum (K. and. S.) Torr. Bull. (1889), 208, Pl. 93, fig. 3.

Valve triangular, sides straight or but slightly convex or concave. Angles elevated into conical, obtuse processes to a height about equal to one-eighth of the width of valve. Surface, with its central portion having about the same elevation as the angles and flattened at the top, with rounded, unequal puncta, about 4 in .01 mm., and extending to the summit of the processes where they are slightly smaller. L. of v. .064 to .135 mm.

Atlantic City artesian well. Rare.

45. Biddulphia vesiculosa (Ag.).

Diatoma vesiculosum Ag., Sys., 7 (1824).
Isthmia vesiculosa Ag., Consp. Crit., 55.
Amphitetras antediluviana Ehr., Berl. Akad. (1839), Kütz. Bacill., 135, Pl. 19, fig. 3, Pl. 29, fig. 86.
Amphitetras crux Br.
Triceratium antediluvianum Grun.
Biddulphia antediluviana (Ehr.) V. H. Syn., 207, Pl. 109, figs. 4, 5, Pl. 100, figs. 3, 4.

Valve quadrangular, or rarely pentagonal, with more or less concave sides and rounded angles. Processes very short and truncate, frequently unequal. Surface with coarse, rounded, quadrate or hexagonal reticulations, smaller at the centre from which they radiate, and averaging 3 in .01 mm., their walls often considerably thickened. The secondary layer is punctate, but the puncta, owing to the thickness of the cell walls, are difficult to see in most specimens. Ends of processes very minutely and indistinctly punctate. L. of s. .059 mm. to .115 mm.

Edgarton Harbor (Bail.); L. I. Sound (Lewis); St. Mary's river, Ga. (Lewis); Savannah (Lewis); Provincetown, Mass.; Port Townsend, Wash. Fossil at Asbury Park, N. J. A pentagonal form occurs fossil at Asbury Park, which is not the same as *Amphipentas alternans* Ehr.

46. Biddulphia decipiens Grun.

Biddulphia decipiens Grun., V. H. Syn., Pl. 100, figs. 3, 4.
Amphitetras minuta Grev., M. M. J. (1861), 77, Pl. 9, fig. 11 ?.
Amphitetras (Biddulphia) alternans, H. L. Smith, Christian, in "The Microscope" (1887), 67, fig., p. 113; Schmidt, Pl. 98, fig. 23 (without name).

The equivalence of *Amphitetras minuta* Grev., as doubtfully given by Van Heurck, is too uncertain to give priority to the name, as Greville, in both description and figure, omits any reference to processes, surface or spines. The processes are, however, frequently quite indefinite and the spines are more often broken off.

Valve rhomboidal with the sides turgid and produced, giving, therefore, a cruciform outline. Surface rising suddenly from near the margin into an ellipsoidal elevation, the major diameter of which is at right angles to the major axis of valve, with hexagonal reticulations, about 5 in .01 mm., at the centre, from which they radiate toward the processes and rounded angles of the sides where they are about 9 in .01 mm. Processes inflated at the base, small and obtuse. At the margin of the elevation, placed obliquely on each side, a strong spine projects.

L. of v. .059 mm. to .072 mm.

Fossil at Nottingham and Atlantic City.

47. **Biddulphia elegans** (Grev.).

Amphitetras elegans Grev., T. M. S. (1866), 9, Pl. 2, fig. 24.
Triceratium elegans (Grev.) Grun., V. H. Syn., Pl. 109, fig. 1; Schmidt, Pl. 99, figs. 10–13.

Valve quadrangular, with sides slightly concave. Angles with short, cylindrical processes. Surface depressed at the centre, with rounded cells, averaging 5 in .01 mm., radiating toward the angles where they are smaller and more crowded. The absence of reticulation half-way between the centre and processes frequently produces, under low powers, the appearance of an inscribed square.

L. of s. .092 mm.

Campeachy Bay (Schmidt); fossil at Monterey, Santa Monica and Redondo Beach, Cal.

48. **Biddulphia biquadrata** (Jan.).

Triceratium biquadratum Jan., Schmidt, Pl. 98, figs. 4, 5, 6.

Valve quadrangular with slightly concave sides. Angles rounded, with short, truncate processes. Surface with coarse reticulations, about 2½ in .01 mm., the walls of which correspond, for the most part, with the meshes of a coarser network which is unequally but symmetrically distributed, producing, by its peculiar arrangement, the appearance, under low powers, of an inscribed square.

L. of s. .112 mm.

The chief distinction between this form and *B. Pentacrinus* is in the greater coarseness of the reticulations in the former and the closer correspondence of its anastomosing network and the cell walls. It is, apparently, intermediate between *B. vesiculosa* and *B. Pentacrinus*.

Yucatan; Gulf of California.

49. **Biddulphia Pentacrinus** (Ehr.).

Amphipentas Pentacrinus Ehr., Berl. Akad. (1840), 10; Mik., Pl. 19, fig. 59; Kütz., Bacill., 136, Pl. 29, fig. 92.
Triceratium Pentacrinus (Ehr.) Wall., Schmidt, Pl. 98, figs. 7-13, 18.
Amphipentas alternans Ehr.
Amphitetras arisata Shadb.
Amphitetras ornata Shadb.
Triceratium quadrinotatum A. S., Schmidt, Pl. 152, fig. 31.

Valve quadrangular or pentagonal, with concave sides. Angles obtuse with short, truncated processes. Surface nearly flat, with hexagonal reticulations, 5 to 7 in .01 mm., radiating from the centre. The walls of the reticulations being more robust in some parts than in others, there is produced an appearance of a coarse network of various design extending over the entire surface. A minute spur-like projection is frequently found between each angle and near the circumference in both the quadrangular and pentagonal forms.

L. of s. .092 mm.

Atlantic and Pacific coasts More abundant in Gulf of Mexico and southward.

50. Biddulphia Kainii (Schultze).

Triceratium Kainii Schultze, K. and S., Bull. Torr. Cl. (1889). 76, Pl. 89, fig. 5, Pl. 92, fig. 3.
Triceratium Kainii constrictum Schultze, K. and S., *l. c.*
Triceratium multifrons Brun., Diat. foss. Jap., 63, Pl. 6, fig. 2.

Valve triangular or quadrangular, with sides varying from straight to deeply convex. Angles more or less cuneate, obtuse, rarely constricted, separated from the other part of valve by strong costæ which are equidistant between centre and apices. Surface slightly convex, with puncta about 5 in .01 mm., radiating from a hyaline centre, or, occasionally, scattered L of s. .056 to .138 mm.

Fossil in the Miocene deposits of the Eastern States. A quadrate form has been found by Mr. John A. Shulze in material from Mays Landing artesian well, N. J.

51. Biddulphia Tabellarium (Br.).

Triceratium Tabellarium Br., M. M. J. (1856), 275, Pl. 17, fig, 15; Schmidt, Pl. 77, figs. 1–9.
Triceratium Tabellarium diplostictum Grun., Schmidt, Pl. 77, figs. 1, 2.
Triceratium Johnsonii Ralfs., Prit., 854.
Triceratium venulosum Grev.
Triceratium brevinervium Grev.
Triceratium pallidum Grev.

Valve triangular, with somewhat acute angles and straight or slightly convex sides having an indented or scalloped appearance caused by the extension inwards, for a short distance, of several costæ which are usually curved at the extremities. Surface slightly elevated at the centre and at the angles, with a few scattered puncta more numerous at the angles. L. of s. .06 mm. to .14 mm.

In certain specimens indistinct lines radiate from the centre and in conjection with two of the partial costæ from each side form a three-lobed figure. In most of the specimens each of the angles is distinctly separated from the centre by an irregular line.

Campeachy Bay; Honduras.

52. **Biddulphia alternans** (Bail.) V. H.

> *Biddulphia alternans* V. H. Syn., 208, Pl. 113, figs. 4–7.
> *Triceratium alternans* Bail., M. Obs., 40; Sil. Jour. (1845), Pl. 4, fig. 25; *ib.*, M. Ex. S., fig. 55, 56; Schmidt, Pl. 78, figs. 9–17.
> *Triceratium* sp.? Bail., Sil. Jour. (1845), 336.
> *Triceratium variabile* Br.

Valve triangular or rarely quadrangular, with sides straight or, usually, somewhat unevenly concave. Angles obtuse, slightly elevated, separated from central portion by costate lines. Central part hexagonal in outline, marked by several lines resembling costæ which extend indefinitely from the periphery in various directions, usually toward the centre. Surface with puncta of irregular shape, larger at the centre, about 5 in .01 mm., and diminishing toward the apices of the angles on which they are usually arranged in rows about 8 in .01 mm. Zonal view quadrate, angles not prolonged. Connective zone narrow. L. of s. .05 mm.

Abnormal variations occur with unequal sides.

Common along the Atlantic coast, especially in æstuaries, but not abundant; Puget Sound; fossil in rice fields of Georgia and California (Bail.), and in the Miocene deposits of the Eastern States and of California; Pleistocene clay, Harvey Cedars, N. J.

53. **Biddulphia trisulca** (Bail.).

> *Triceratium trisulcum* Bail., (Ms.) in Prit., 854; Schmidt, Pl. 78, figs. 5–8, Pl. 112, figs. 17, 18.
> *Triceratium validum* Grun., Schmidt, Pl. 94, fig. 5.

Valve triangular with concave sides and rounded angles which are elevated into large, globose processes. Surface with rounded, scattered puncta averaging 1 in .01 mm. Angles with indefinitely angular reticulations about 4 in .01 mm. Connective zone with puncta similar to those on the surface of valve. In one specimen observed, from Redondo Beach, in a continuation of an unusually well-developed connective zone overlapping one valve, the punctation assumed the character of large hexagonal reticulations about $2\frac{1}{2}$ in .01 mm. L. of s. averages .15 mm.

Triceratium tumidum Grev. from Barbadoes, is very near this form.

Campeachy Bay. Fossil at Redondo Beach, Cal.

54. Biddulphia costulata (Grun.).

Triceratium tumidum Grev. var. *costulata* Grun ; Schmidt, Pl. 78, fig. 1, Pl. 88, fig. 17.

Valve triangular with straight or slightly concave sides and rounded angles, elevated into large, rounded processes. Surface as in *B. trisulca*, except that the puncta on the angles in the specimens observed are about 9 in .01 mm. Partial costæ, two to four on each side, extend inwards for varying distances from the perimeter. L. of s. 148 mm.

Fossil at Redondo Beach, Cal. Rare.

55. Biddulphia condecora (Ehr.).

Triceratium condecorum Ehr., Berl. Akad. (1844), 272 ; Schmidt, Pl. 76, fig. 28 (not 27). See remarks under *B. Americana*.

Valve triangular, or irregularly quadrilateral, with sides straight or but slightly convex or concave, and obtuse angles. Surface flat or slightly depressed toward the centre, having rounded puncta arranged in rows which radiate in undulating lines from the centre at which and on the margin they are slightly smaller, averaging 4 in .01 mm. L. of s. in type specimens .145 mm., but occasionally much smaller. Distinguished from *B. Americana* not only by the undulations of the rows of puncta, but also by their more pearly character. Specimens from Nottingham vary considerably in outline, several having but two angles and others having the form of a trapezium.

Fossil in the Miocene deposits of the Eastern States.

56. Biddulphia (?) subrotundata (A. S.).

Triceratium subrotundatum A. S., Schmidt, Pl. 93, fig. 1.

Valve orbicular-triangular, with very convex sides and indefinite angles. Surface flat, with subquadrate or hexagonal reticulations, radiating from the centre, where they are about 5 in .01 mm., and increasing to about 3 in .01 mm., but suddenly diminishing at the circumference. W. of v. .092 mm. Scarcely differing, except in outline, from *Coscinodiscus*.

Fossil at Nottingham. Very rare.

57. **Biddulphia Americana** (Ralfs).

Triceratium Americanum Ralfs, Prit., 855 ; Schmidt, Pl. 76, fig. 3 (?), 27 (see note).
Triceratium obtusum Ehr., Amer., 137 (?); Mik., Pl. 18, fig. 48 (?) (not 49?).
Triceratium Amblyoceros Br.
Triceratium obscurum Grev. forma *minor* A. S., Schmidt, Pl. 76, fig. 5.

This is a smaller form of *B. Americana.* I have noticed several intermediate variations which differ only in size and the convexity of the sides. Greville remarks of his species from Naparima that it resembles *T. condecorum,* except that "the radiating lines of puncta are perfectly straight "[5]

Valve triangular or occasionally irregularly quadrangular, with straight, convex or slightly concave sides and obtuse angles. Surface flat, having rounded or subquadrate reticulations, 3 or 4 in .01 mm., which in well-developed specimens radiate from the centre. At the margin the cells are smaller.

L. of s. averages .115 mm. Quite variable in size and outline.

Fossil in the Miocene deposits of the Eastern States.

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[5] Much confusion has arisen as to the distinction between *Triceratium Americanum* Ralfs and *Triceratium condecorum* Br., due partly to Ralfs' description of the former as equivalent to *T. Amblyoceros* Br., which in turn has been confused with *T. Amblyoceros* Ehr., and to the mistake made by Schmidt, as suggested by Gr. and St., in numbering figs. 27 and 28 in Pl. 76 of the Atlas, fig. 27 being *T. Americanum* and fig. 28 *condecorum.*

As *T. condecorum* is described as having undulating rows of granules, and as *T. Americanum* is said to resemble *T. arcticum* (see Roper), except in the angles, it may be as well to base the distinction between the two forms upon the undulations of the rows of radiating granules and upon the coarseness of the granules. It becomes, however, difficult to separate the smaller forms of the two species. Some specimens from Nottingham vary considerably in outline, some approaching *T. subrotundatum* A. S., while others are near *T. parallelum* Grev., as has been noticed by Grove and Sturt in forms from Oamaru.

Triceratium Americanum Ralfs is, probably, the same as *T. Amblyoceros* of Brightwell, but as Brightwell's form is not *T. Amblyoceros* of Ehrenberg, which in outline, if not in its centre, is probably *Actinoptychus Amblyoceros* A. S., Ralfs' name must stand as representing form fig. 27, Pl. 76, of the Atlas. De Toni unfortunately (p. 1396) gives *Actinoptychus Amblyoceros* A. S., Atlas, Pl. 1, fig. 25, as equivalent to forms of Pl. 76, figs. 3 and 28. A glance at fig. 25, Pl. 1, will show that it is entirely different from figs. 3 and 28 in Pl. 76. In fact, fig. 25, Pl. 1, is an *Actinoptychus* as given by Schmidt, while the other figures belong to *Triceratium. Triceratium Amblyoceros* E. and *T. Marylandicum* Br. may be abolished as forms of *Triceratia* and become *Actinoptychus Amblyoceros* (Ehr.) A. S., or, as appears to be necessary, *Schuettia Amblyoceros* (Ehr.) De Toni. It is probable that *T. obtusum* Ehr. as figured in Mik., Pl. 18, fig. 48, is the form under consideration, as there is apparently no other in the deposit, except possibly *T. interpunctatum,* to which it may be made to apply. By priority, therefore, the name would become *Biddulphia obtusa* (Ehr.), but on account of the uncertainty it may be as well to retain Ralfs' name.

58. Biddulphia Antillarum (Cleve).

Triceratium Antillarum Cleve, Diat. W. Ind., 16, Pl. 5, fig. 29; Schmidt, Pl. 99, fig. 14.
? *Triceratium punctatum* Br. formæ *hexagona* and *pentagona* Grun.; Schmidt, Pl, 81, figs. 6, 7.
Amphipentas Antillarum (Cleve) De Toni.
? *B.* (*Amphipentas*) *punctata* V. H., Diat., fig. 206.

Valve polygonal, with produced angles and concave sides. Surface slightly elevated at the centre, with puncta about 4 in .01 mm., rounded, radiating and extending to the ends of the angles, which appear like processes. L. of v. .115 mm. Very near certain forms of *B. Reticulum* (Ehr.), from which it apparently differs in the radiation of the puncta and in the form of the angles.

Campeachy Bay (Schmidt). Fossil at Redondo Beach, Cal., in the hexagonal form, but very rare.

59. Biddulphia interpunctata (Grun.).

Triceratium interpunctatum Grun., Schmidt, Pl. 76, fig. 7. According to De Toni (947), near *T. elegans* Grev., which in turn is said by Grev. to be *T. obtusum* Ehr., but I think the form is quite distinct.

Valve triangular, sides straight, and angles rounded. Surface flat, having rounded puncta nearly equal, about 3 in .01 mm., with here and there at intervals much smaller puncta.

L. of s. .075 mm. to .115 mm.

A form apparently quite constant. Near *B. Americana* Ralfs, from which it may be distinguished not only by the interpunctation, but also by the large, round and scattered puncta. Under low powers its color is blue.

Fossil in the Miocene deposits of the Eastern States.

60. Biddulphia hebetata (Grun.).

Triceratium irregulare var. *hebetata* Grun., V. H. Syn., Pl. 111, fig. 10.
Triceratium impar A. S., Schmidt, Pl. 151, figs. 31–34.

It is quite difficult to separate *Triceratium impar* A. S. from certain forms of *B. Americana* and from the present form, which is quite common in the Petersburg deposit. The peculiarity of the angles, however, appears to be sufficient to separate it from *T. irregulare* Grev.

Valve triangular, with somewhat unequal sides and unequally convex margins. Angles rounded, one of them having puncta about 9 in .01 mm., while in the other two the puncta are about 5 in .01 mm. Surface flat, with subquadrate reticulations about

4 in .01 mm., radiating from the centre toward the margin, where they are about 5 in .01 mm.

L. of s. .072 mm.

Fossil in the Miocene deposits of Petersburg and Richmond, Va.

61. Biddulphia heteropora (Grun.).

Triceratium (*Biddulphia*) *heteroporum* Grun., V. H. Syn., Pl. 112, fig. 2.

Valve triangular, with nearly straight sides and slightly unequal and somewhat obtuse angles. Surface slightly convex, with rounded puncta which are scattered, except at the angles where they are crowded, and at the margins where they are arranged in short parallel rows, about 5 in .01 mm. At the centre a small circle of very distinct puncta is seen. L. of s. .125 mm.

Fossil at Santa Monica (V. H.), Redondo Beach, Cal.

62. Biddulphia tessellata (Grev.).

Triceratium tessellatum Grev., T. M. S. (1861), 71, Pl. 8, fig. 14.
Triceratium robustum Grev., T. M. S. (1861), 71, Pl. 8, fig. 15.
Triceratium amoenum Grev., l. c. 75, Pl. 9, fig. 7.
Triceratium secernendum A. S., Schmidt, Pl. 76, fig. 34.
? *Triceratium Fischeri* A. S., Schmidt, Pl. 76, fig. 34.

Valve triangular, with straight or slightly concave sides and rounded angles. Surface usually somewhat convex at the centre, with rounded, elliptical, hexagonal or subquadrate reticulations about 3 in .01 mm., but smaller at the centre, arranged in more or less concentric rows and much smaller at the extremities of the angles which appear hyaline under low magnification, where they are from 8 to 15 in .01 mm. Small puncta occasionally occur scattered among the larger.

L. of s. .049 mm. to .099 mm. Quite variable in size and the coarseness of markings.

Fossil in the Miocene deposits of the Eastern States.

As remarked by Cleve, the group to which the present species belongs is "extremely difficult to exactly determine." The form known as *T. tessellatum* is well described by Greville, but in the case of *robustum* and *amœnum* no sufficiently accurate and distinct differences are noted. *T. robustum* is described as having hyaline spaces at the extremities of the angles, but a careful examination will disclose a fine and indistinct punctation extending to the apices. *T. amœnum* is merely a small form, while *T. secernendum* differs from the type only in being somewhat irregular in outline and in having more rounded angles. Familiarity with the Nottingham deposit will show so many intermediate variations that the number of species might be indefinitely increased, if the distinctions in the above forms are assumed to be specific. Many forms are with difficulty distinguished from *B. Reticulum* E. The variations are well shown also in material from Weymouth, N. J., artesian well.

63. Biddulphia Reticulum (Ehr.).

Triceratium Reticulum Ehr., Berl. Akad. (1844), 88; Mik., Pl. 18, fig. 50, Pl. 33, 16, fig. 13; Schmidt, Pl. 76, fig. 4.
Triceratium sculptum Shadb., T. M. S. (1854), 15; Pl. 1, fig. 4; Schmidt, Pl. 76, figs. 9, 10, 11, 12, 31.
Triceratium obtusum Br. (not Ehr.).
Triceratium punctatum Br. (not Wall.), Schmidt, Pl. 76, figs. 19, 20.
Triceratium Browneanum Grev.
Biddulphia sculpta (Shadb.) V. H.

Valve triangular or polygonal, with either straight or concave sides. Angles rounded, sometimes produced. Surface slightly elevated at the centre and at the angles, with puncta about 4 in .01 mm., angular, irregular and unequal, mostly larger at the centre. Three or four spines are occasionally noticed about halfway between centre and sides. Groups of puncta frequently occur arranged in three or four small circles. Frustules in zonal view but slightly developed. L. of s. .059 mm.

Generally distributed along the coast, especially southward. Fossil in the Miocene and later deposits of the Eastern States.

An examination of many specimens from various localities leads me to the conclusion that if we take the form usually called *Triceratium punctatum* Br. as the type, the forms named *sculptum* Shadb., *tessellatum* Grev., *robustum* Grev. and several others may be included as variations of one species. In order, however, to avoid confusion and because of the difference in the arrangement of puncta between *tessellatum* and *robustum* on the one hand and *Reticulum* and like forms on the other, I consider them for the present as distinct. The puncta in all the forms above-mentioned are usually more or less irregular, the centre in large specimens is more likely to show the slight depression within the central elevation than in smaller forms, and the sides and angles vary according to the ordinary laws of plant nutrition. Shadbolt bases *sculptum* upon the presence of three "pseudo-nodules," but, as has been noticed by others, these do not always appear in specimens otherwise similar. A specimen in my collection from a fossil deposit at Absecon, N. J., in which four "pseudo-nodules" are plainly visible, shows the unstable character of this distinction. Two to four spurs may be seen on recent specimens from Yucatan and west coast of Florida which show at the same time the markings of *T. sculptum*. A specimen from a fossil deposit at Newbern, N. C., which somewhat approaches *robustum* shows four very small spines at about one-half the length of radius (see remarks of Schmidt about figs. 4 and 26, Pl. 76).

64. Biddulphia inelegans (Grev.).

> *Triceratium inelegans* Grev., T. M. S. (1866), 8, Pl. 2, fig. 21; Schmidt, Pl. 81, fig. 16 (not *T. obtusum* Ehr., as suggested by several authors, as the angles are not the same).
> *Triceratium Jucatense* Grun., Schmidt, Pl. 76, fig. 13.

Valves triangular, with straight, concave or convex sides which are frequently unequal. Angles obtuse. Surface with rounded, irregular and scattered puncta, about 2 or 3 in .01 mm. At the angles, which are sometimes slightly elevated, the puncta are about 7 or 8 in .01 mm. L. of s. .089 mm. to .118 mm.

Var. *areopora* Grun. has straight sides and scattered puncta.

Var. *Jucatensis* Grun. has straight sides and larger puncta.

Var. *micropora* Grun. has usually smaller and more crowded puncta.

Campeachy Bay. Fossil at Santa Monica and Redondo Beach, Cal.

65. Biddulphia parvula (Jan. and Rab.).

> *Amphitetras parvula* Jan. and Rab., Diat. Honduras, 4, Pl. 1, fig. 4 (not *A. parvula* Grev.).
> *Triceratium zonatulatum* Grev., T. M. S. (1865), 102, Pl. 9, fig. 17; Schmidt, Pl. 77, figs. 33-37, Pl. 94, fig. 9

Valve triangular or quadrangular, with deeply concave sides, producing, in the latter form, a cruciform outline with rounded angles. Surface of central part hyaline, excepting a few indistinct puncta, but at the angles the puncta are in parallel rows about 8 in .01 mm. W. of v. .059 mm.

Honduras. Rare. The triangular form not yet noticed in North America.

66. Biddulphia semicircularis (Br.).

Triceratium semicirculare Br., M. M. J. (1853), 252, Pl. 4, fig. 21; V. H. Syn., Pl. 126, fig. 20.
Triceratium obtusum Ehr. (in part), Mik., Pl. 18, fig. 49.
Euodia Brigtwellii Ralfs, Prit., 852.

Valve lunate, appearing as if divided half-way between the centre and the obtuse ends by two very faint costate lines. Surface elevated at the centre and at the ends, with rounded puncta, about 3 in .01 mm., concentric and radiating from a hyaline centre, smaller at the ends. L. of v. averages .099 mm.

Fossil in the Miocene deposits of the Eastern States.

Biddulphia semicircularis Asburyana Boyer, Proc. Acad. Nat. Sci. Phila. (1898), 469, Pl. 24, fig. 3.

Valve arcuate with the ends produced and elevated into processes. Surface not divided by costate lines, convex, with rounded puncta, about 6 in .01 mm. near the hyaline excentric space, increasing in size to about 1½ in .01 mm. at the margin. L. of v. .181.

Not uncommon in deposit (Miocene) at Asbury Park, N. J.

67. Biddulphia Testudo (Brun.).

Biddulphia ? ? K. and S., Bull. Torr. Cl. (1889), 208, Pl. 93, fig. 4.
Tabulina Testudo Brun., Diat. Jap., 59. Pl. 6, fig. 8; Schütt, 82, fig. 131. Referred by De Toni to *Cheloniodiscus*, which, however, I think it does not resemble. It appears to be a true *Biddulphia*.

Valve suborbicular or oblong-elliptical, somewhat flattened, but with four large process-like, slight elevations, two of which are near each end. Surface traversed by an indefinite number of wide, hyaline, curved lines. Two of the lines are more or less transverse to the major axis, while the others appear to radiate indefinitely from a central space and anastomose. Surface with unequal and scattered puncta, about 8 in .01 mm. L. of v. .066 mm. to .089 mm.

Frustule in zonal view quadrangular, the connective zone having transverse rows of puncta more distinct than those on the valve.

Fossil in the Miocene deposits of Atlantic City and Weymouth, N. J.

68. Biddulphia Shulzei Boyer.

Biddulphia Shulzei Boyer, Proc. Acad. Nat. Sci. Phila. (1898), 470, Pl. 24, figs. 7, 8.

Valve elliptical, slightly elevated toward the centre, with a large, rounded, process-like elevation at each end. Surface with rounded, oblong puncta averaging 5 in .01 mm., but for the most part scattering, leaving numerous hyaline spaces. Owing to the irregularity in the distribution of the puncta the circumference of the valve appears to show a scalloped border. L. of v. .115 mm.

Distinguished from *B. Testudo* in having but two processes and in being without the hyaline lines which cross the valve of the latter. A variety with three processes also occurs.

Fossil at Weymouth, N. J.

Doubtful Species.

Triceratium indentatum K. and S., *Torr. Bull.* (1889), 210, Pl. 92, fig. 4; Wolle, Pl. 78, fig. 7; De Toni, 942. From photographs sent me by Dr. Ward, of Poughkeepsie, and Mr. Kain, the following description may be given: Valve triangular, sides convex. Angles not elevated, bidentate. Surface flat, reticulate, the reticulations subquadrate or hexagonal, 2 to 4 in .01 mm., radiating from the centre where they are larger. L. of s. about .08 mm. This form may, possibly, be classed among the *Pseudo-Coscinodisci*, unless it should prove to be abnormal. I have not seen any specimens, but the photographs give the general appearance of a small form of *B. Americana* (Ralfs) with the angles notched at the apices. The absence of processes as well as angles resembling the ordinary types precludes its admission among the *Biddulphiœ* until it has been further examined. Fossil in the artesian well, Atlantic City, N. J.

Triceratium (Biddulphia) obliquum Grun., *V. H. Syn.*, Pl. 110, fig. 11; Wolle, Pl. 106, fig. 10. Santa Monica, Cal.

Triceratium Pileolus E., *Berl. Akad.* (1844), 205; *Mik.*, Pl. 35*A.*, 21, fig. 17; *K. S. A.*, 140; Weisse, 242, Pl. 1, fig. 20; *Prit.*, 856; Wolle, Pl. 108, fig. 1. This form is said by Brightwell to be allied to *T. brachiolatum* Br. (*M. M. J.* (1853), 248, and (1856) 272), which by Ralfs is said to equal *T. Pileus* E. Ralfs also gives it as equivalent to *T. obtusum* Br. (not E.) (see under *B. Reticulum* (E.), of which it may be a variation). As *T. obtusum* Br. is the only one of the above forms said to be American, it may be unnecessary to refer to the synonymy further.

Triceratium subcornutum Grun., Schmidt's *Atlas*, Pl. 99, fig. 15–18. Campeachy Bay. Near *T. elegans* Grev.?

Triceratium tripartitum Grun., *V. H. Syn.*, Pl. 110, fig. 8; Wolle, Pl. 100, fig. 5; De Toni, 945. Campeachy Bay.

Triceratium uncinatum A. S., *Atlas*, Pl. 94, fig. 4; Wolle, Pl. 102, fig. 12. Pacific coast of Central America.

Species Known Only by Name.

Biddulphia gigas E., *Berl. Akad.* (1844), 265; *Mik.*, Pl. 33, 12, fig. 11; *Prit.*, 849; Wolle, Pl. 103, fig. 11. Ralfs (in *Prit.*) gives the following description: "Large, very turgid at the centre, rough, without distinct granules, laterally five-jointed, having a large, oblong (pseudo-) opening at each attenuated apex." Apparently the above applies to large forms of *B. tridens* (E.) with the processes broken off. The habitat attributed by Ralfs to Ehrenberg is "Bermuda" (Nottingham), but Ehrenberg in *Mik.*, Pl. 33, 12, fig. 11, gives the Columbia river as the locality. From the uncertainty as to description, figure and locality the name may be dropped without loss.

The figure given by Wolle, Pl. 103, fig. 12, is, as he states, a *Melosira*. See Bailey, *Sil. Jour.*, 1845, 322, under *Gallionella*.

Biddulphia perpusilla "Bail. Coll.," *Habirshaw Cat.*, De Toni, 878.

Triceratium aculeatum E. (not Grev.) E., *Mik.*, supplement, 16; De Toni, 972; Wolle, Pl. 25, fig. 21. There is no description given of this form so far as I can discover. Wolle has made the mistake of taking Greville's description of a form from Barbados (*Triceratium aculeatum* Grev., *T. M. S.* (1861), 45) for Ehrenberg's form, and has constructed a "figure suggested by description"! Ehrenberg's form is said to be found in the rice fields of Georgia.

Triceratium interruptum "Bail. Coll.," *Habirshaw Cat.*

Triceratium Parma Bail. Prof. H. L. Smith states (*The Lens*, I, p. 232) that Bailey's "*Triceratium Parma* is only a triangular form" of *Stictodiscus Californicus*.

"*Triceratium regina* Heib." of Wolle, Pl. 105, fig. 17, is evidently a typographical error and should be *Trinacria regina* Heib., but Wolle's figure does not correspond to Schmidt's, from which it is said to be taken, and is not the figure of a *Trinacria*.

Species Excluded.

Amphitetras cruciata Jan. and Rab., *Diat. Hond.*, 4, Pl. 1, fig. 5; De Toni, 905. This form is the same as *Amphitetras crucifera* Kitton, *Science Goss.* (1867), 271, fig. 285; Ralfs in *Prit.*, 858; De Toni, 908, and is also equal to *Triceratium cruciatum* Leud.-Fort., "Ceylon," 59. It is a variety of *Rhaphoneis*, and is given in *V. H. Syn.*, Pl. 116, fig. 16, as *Rhaphoneis amphiceros tetragona* Grun., and by Cleve, *Vega*, pp. 449, 507, Pl. 37, fig. 52, *b* and *c*, as *Rhaphoneis amphiceros cruciata*. Habitat, Honduras.

Amphitetras crucifera Kitton. See under *Amphitetras cruciata.*

Amphitetras parallela E.; *Mik.*, Pl. 19, fig. 20; Kütz., *S. A.*, 134.

Triceratium parallelum (E.) Grev.; *T. M. S.* (1865), 104, Pl. 9, figs. 22, 23; Schmidt, Pl. 75, figs. 3, 4, 5, 11, 12, 13, Pl. 76, figs. 14, 15, 16, 17, 18, 30; var. *Coloniensis* Grun., Pl. 81, fig. 1; var. *Balearica* Grun., Pl. 81, fig. 2; Grun., *Alg. Nov.*, 24, 102; *V. H. Syn.*, Pl. 111, figs. 1–6; Wolle, Pl. 100, figs. 11, 12, 15; *Triceratium obtusum* (E.) Cleve, *Diat. W. Ind.*, 16; *Triceratium Gruendleri* A. S., Pl. 75, fig. 10 (?); *Nothoceratium ? parallelum* (Grev.) De Toni, 915.

The triangular forms of *Triceratium parallelum* (E.) Grev. and the vars. *Coloniensis* and *Balearica* are abundant in Campeachy Bay. As remarked by Van Heurck, *T. obtusum* E. and *T. parallelum* (E.) Grev. are the same in part. Ehrenberg's form from Richmond is possibly equivalent to Ralfs' *T. Americanum* (*q. v.*), and approaches that from Campeachy Bay, but it is not exactly like Cleve's form in the markings at the centre. Both these forms and *Triceratium Harrisonianum* Norm. are true *Stictodisci*, having the definite arrangement of puncta and the more or less faint parallel or serpentine lines extending inwards from the perimeter. Quite a large number of diatoms figured by Schmidt and by Truan and Witt, among them the beautiful *Stictodiscus adspersus* (A. S.) T. and W., are found at Campeachy Bay and are easily mistaken for Biddulphoid forms, the absence of granules at the centre, usually characteristic of *Stictodiscus*, not being noticeable in small specimens.

Biddulphia bipons E., *Berl. Akad.* (1844), 273 = *Hemiaulus* (Habirshaw).

Biddulphia? lunata E., *Berl. Akad.* (1844), 77; *Mik.*, Pl. 18, fig. 53; *Prit.*, 849 = *Eunotogramma amphioxys* E., *Berl. Akad.* (1855), 302.

Biddulphia membranacea Cleve is not included among North American forms.

Biddulphia Weissflogii Grun. in K. and S., *Bull. Torr. Cl.* (1889), 208, as stated by Mr. Kain later, is *Biddulphia Baileyi* Wm. Sm. = *Biddulphia Mobiliensis* (Bail.) Grun.

Biddulphia Woolmanii K. and S., *T. B. C.* (1889), 74, Pl. 89, fig. 3; Wolle, Pl. 98, fig. 4; De Toni, 872. This form is identical with *Salacia Boryana* Pant., a specimen of which I have from Borostelek, Hungary. Van Heurck (*Diat.*, 359) considers *Salacia* or *Castracania* (new genus created by De Toni for this species, p. 750) as equivalent to *Tetracyclus*, and states that it presents the closest affinity to *T. Rhombus*. There is no doubt, I think, that it is a *Tetracyclus*, and I had considered it as probably identical with *T. ellipticus* (E.) Grun., having found it in a fossil deposit from Oregon where it was very abundant. Ehrenberg's material was from the "Columbia river," and, possibly, from the same source (John Day Valley). There is no difference between the forms from Oregon and those from Atlantic City, except that in the latter they are frequently corroded. See Schütt, 102, fig. 180, where it is given as *Tetracyclus* (*Castracania*) *Boryanus* (Pant.) De Toni.

Nothoceratium? parallelum (Grev.) De Toni. See under *Amphitetras parallela* E.

Triceratium Amblyoceros E. = *Actinoptychus*. See under *Biddulphia Americana*.

Triceratium Brightwelli West = *Ditylum*.

Triceratium cinnamomeum Grev., *M. M. J.* (1863), 232; Wolle, Pl. 75, fig. 11, Pl. 105, fig. 18 = *Cestodiscus cinnamomeus* (Grev.) Grun.

Triceratium crenatum Kitton = *Ditylum*.

Triceratium cruciatum Leud.-Fort. See under *Amphitetras cruciata*.

Triceratium Ehrenbergii Grun. = *Ditylum*.

Triceratium Gruendleri A. S. See under *Amphitetras parallela*.

Triceratium Harrisonianum Norm. and Grev., *T. M. S.* (1861), 76, Pl. 9, fig. 9; Schmidt, Pl. 75, figs. 14–16, Pl. 81, figs. 8, 9, 17, Pl. 150, fig. 19. A species of *Stictodiscus*. Habitat, Campeachy Bay. The var. *solida* of Walker and Chase (L. N. and R. Diat.), Pl. 3, fig. 12, is also found. See under *Amphitetras parallela.*

Triceratium heterostictum A. S. = *Cestodiscus cinnamomeus* (Grev.) Grun. var. *minor* Grun.; Schmidt, Pl. 151, fig. 28; *V. H. Syn.*, Pl. 126, fig. 2.

Triceratium Marylandicum Br. = *Actinoptychus.*

Triceratium obtusum (E.) Cleve. See under *Amphitetras parallela.*

Triceratium parallelum (E.) Grev. See under *Amphitetras parallela.*

Triceratium pileatum Grun. = *Pseudo-Coscinodiscus*, *V. H. Syn.*, Pl. 112, fig. 3.

Triceratium receptum A. S. (see under *T. Shadboltii*); Schmidt, *Atlas*, Pl. 81, fig. 10. Santa Monica, Cal. Apparently near the triangular forms of *Biddulphia lævis* or *convexiuscula.*

Triceratium Shadboltii L. W. Bailey, *B. J. N. H.* (1862), 342, Pl. 8, figs. 60, 61. Not North American. Habitat, San Antonio Bay, Para river, Brazil. From the figures it would appear to be a small form of *Triceratium spinosum* Bail. Schmidt's comparison of *Triceratium receptum* A. S. (*Atlas*, Pl. 81, fig. 10) to this form is evidently a mistake.

Triceratium striolatum Wm. Sm. (not E.) = *Ditylum.*

Triceratium undulatum E. = *Ditylum.*

PORPEIA Bail. (1861).

Valve oblong, tumid in the middle, more or less constricted near the rounded ends, and divided by two transverse septa which extend inward, curving and becoming parallel to the surface.

Analysis of Species.

Septa curved, ...	1. *quadriceps.*
Septa parallel to edges of valve, ...	2. *quadrata.*

1. Porpeia quadriceps Bail. (in lit.).

Porpeia quadriceps Bail., Prit., 850, Pl. 6, fig. 6. Var. *intermedia* Grun., V. H. Syn., Pl. 95 *bis*, fig. 14; Schmidt, Pl. 142, figs. 46–52. *Biddulphia clavulata* Ehr., Berl. Akad. (1861), 94?

Valve rounded at both ends, which are constricted into lobes and inflated at the middle. Ends of valve more or less elevated.

From the junction of each process with the valve a septum extends downward curving more or less toward the centre. Surface of valve usually flattened and covered with granules, which are more crowded on the processes, about 6 in .01 mm. Zonal view quadrangular, the connective zone having puncta in parallel rows. L. of v. averages .029 mm.

Campeachy Bay; Gulf of Mexico.

2. Porpeia quadrata Grev.

Porpeia quadrata Grev., T. M. S. (1865), 53, Pl. 6, fig. 20; Schmidt, Pl. 142, fig. 38 and figs. 53-56 (fig. as *quadriceps*).

Valve as in *quadriceps*, except that the processes are but slightly elevated and the septa extend inward in a direction more or less parallel to the edge of the valve as seen in zonal view. L. of v. .082 mm. Connected with the preceding by intermediate forms. The variations in the curves of the septa are determined by the length of the valve.

Fossil at Santa Monica, Cal.

TERPSINOË Ehr. (1843).

Valve elliptical or triangular, more or less constricted by septa which are prominent and in zonal view appear either straight or curved at the ends. Surface reticulated or punctate, sometimes indistinctly so. Closely allied to *Anaulus*, from which it is chiefly distinguished by the character of the septa.

Analysis of Species.

Valves elliptical, reticulate or coarsely punctate:

Septa curved:

Surface not reticulate, ... 1. *Musica.*

Surface reticulate,. . . . . 2. *intermedia.*

Septa not curved, ... 3. *Brebissonii.*

Valves elliptical or triangular, indistinctly punctate:

Puncta radiating from hyaline centre, . . . 4. *Americana.*

Puncta scattered except at angles and centre, 5. *Novæ-Cæsareæ.*

1. Terpsinoë Musica Ehr.

Terpsinoë Musica Ehr., Amer., Pl. 3, 4, fig. 1; 3, 7, fig. 30; Mik., Pl. 34, 6, A. 8; Schmidt, Pl. 199, figs. 9-13, Pl. 200, figs. 7, 8.
Terpsinoë magna Bail., L. W. Bail., B. J. N. H., 340, figs. 46, 50-54.
Terpsinoë tetragramma Bail., *l. c.*
Terpsinoë minima Bail., *l. c.*

Valve elliptical, with undulating sides and lobed at the ends, divided by septa into three or more parts. Surface with coarse puncta, about 8 in .01 mm., not radiating, much finer at the ends. On the connective zone the puncta are about 12 in .01 mm. An irregular nodular centre is usually visible. Frustule in zonal view quadrangular, the septa with their inner margins curved and thickened on the edges, presenting the appearance of musical notes.

Variable in size and in the divisions of the valves. L. of v. averages .165 mm.

Marine and fresh water. Delaware river mud (Lewis); St. Mary's river, Ga. (Lewis). More common southward.

2. Terpsinoë intermedia Grun.

> *Terpsinoë intermedia* Grun., Diat. Franz Jos. Land, 59 ; Schmidt, Pl. 199, figs. 1–8 ; Pl. 200, figs. 1–6 ; Pl. 198, fig. 65.

Valve elliptical with undulating sides, and divided by septa into several divisions. Surface punctate and reticulated, sometimes indistinctly so, the reticulations irregular and unequal, about 2 or 3 in .01 mm. Septa usually not thickened as in *Musica*, but bent near the edge. The nodular centre is, in most specimens, quite pronounced. L. of v. .174 mm.

Mobile (Schmidt). Fossil at Nottingham (Brun), Atlantic City (K. and S.), Asbury Park and Longport, N. J.

Terpsinoë intermedia latecavata (Brun) differs from the type in outline, which is rhombic-elliptical with produced ends. Brun remarks that this form belongs to *Terpsinoë* as much as to *Anaulus* and is near *T. intermedia* Grun. See on *Anaulus* (*Terpsinoë*) *latecavatus* Brun, *Diat. Jap.*, 16, Pl. 1, fig. 13.

Fossil at Nottingham (Brun).

3. Terpsinoë Brebissonii (Kütz.) V. H.

> *Terpsinoë* (*Pleurodesmium*) *Brebissonii* (Kütz.) V. H., Diat., 453.
> *Pleurodesmium Brebissonii* Kütz., Bot. Zeit. (1846), 248 ; Schmidt, Pl. 200, figs. 15–19.

Valve elliptical with undulating sides and slightly lobed at the ends. Surface divided by septa into five compartments, with puncta averaging 6 in .01 mm. L. of v. .066 mm.

Frustule in zonal view quadrangular, with septa capitate but not appearing curved. Connective zone with fine puncta, about 15 in .01 mm. The frustules are said by De Brébisson to be connected by "threads," and by Van Heurck by "short processes in the form of feet," which are best seen in specimens mounted *in* *situ* and appear to belong to the membrane enveloping the frustules.

Cedar Keys, Fla., and southward

4. Terpsinoë Americana (Bail.) Ralfs.

Tetragramma Americana Bail., N. Sp., 7, fig. 1.
Terpsinoë Americana (Bail.) Ralfs, Prit., 859; Schmidt, Pl. 200, figs. 9–13.

Valve with undulating outline, lobed at each end, and lobed or inflated at each side; divided by septa into three or more parts. Surface with coarse but rather indistinct puncta, about 6 in .01 mm., which radiate interruptedly from a hyaline centre. Frustule in zonal view quadrangular with septa extending about halfway into the valve. L. of v. .059 mm.

Marine and fresh water. Hudson river; Rockaway, L. I.; Charleston; St. Augustine; Tampa Bay (Bail.). Fossil at Atlantic City and Harvey Cedars, N. J.

5. Terpsinoë Novæ-Cæsareæ Boyer.

Hydrosera (Terpsinoë ?) Novæ-Cæsareæ Boyer, Torr. Bull. (1895), 263; Lewis Woolman, Ann. Rep. Geol. Sur. N. J. (1894), Pl. 6, fig. 2; Le Diatomiste, 2, 207.

Valve triangular, sides concave. Angles broad at the base, equally three-lobed. Surface flat, divided by straight septa separating the angles from the central part, which is for the most part hyaline, except at the centre, where a few puncta are seen. Angles with faint, scattered puncta, about 7 in .01 mm. Connective zone with faint puncta. W. of v. averages .062 mm. Fossil in artesian well, Wildwood, N. J.; Cold Spring, L. I. (Reis)?

HYDROSERA Wallich (1858).

Valves quadrangular in zonal view and elliptical or triangular in valve view. The angles are separated from the central part by septa which extend inward but a short distance. There is usually present on one side of each valve an indistinct mark. Surface of valves granular or cellular.

Hydrosera triquetra Wall.

Hydrosera triquetra Wall., M. M. J. (1858), 251, Pl. 13, figs. 1–12; Schmidt, Pl. 78, figs. 36–38; Deby, Jour. de Micrographie (1891), Pl. 1, fig. 1.
Not *Triceratium Javanicum* Cleve.

Cleve (*N. and L. K. D.*, 24) considers this form possibly a variety of *Hydrosera triquetra* Wall. Both Deby and De Toni consider the two equivalent. A slide in my collection of *T. Javanicum* Cleve, mounted by Brun, shows the valve with unequal granular markings, more closely resembling those of *H. Whampoense* than the markings of *H. triquetra.*

Valve triangular or elliptical, sides slightly convex, the angles constricted by strong septa which separate them from the central part. Surface with angular reticulations, about 6 in .01 mm. at centre and increasing outward to about 3 in .01 mm., the extremities of the angles appearing hyaline. Inner surface or secondary layer of valve punctate, somewhat as in *Biddulphia Favus,* but the puncta are coarser. Near one of the sides is frequently seen below the surface of the valve a line with two or three granules, which Mr. Deby well remarks are "often illusory." The line appears to be a projection of a siliceous plate from the cell wall and is more easily seen if the valve is examined from the under side. Pritchard's figures (*Inf.*, Pl. 6, figs. 8, 13) exaggerate the "*stigmata.*" Zonal view quadrangular, the septa entering the valve obliquely. Connective zone appearing hyaline. I have not been able to find in the fossil forms the minute spines said to occur at the extremities of the angles. L. of s. .099 mm. to .132 mm.

Fossil at Atlantic City, N. J., in the triangular form only. Carpentaria Bay (Schmidt).

ANAULUS E. (1844), Em. V. H. (1881).

Valves more or less elliptical or lunate, divided into three or more parts by septa which usually constrict the margins. Surface without elevation, with puncta usually radiate from an occasionally nodular centre or arranged in transverse lines.

Analysis of Species.

Valves elliptical:
  Without central nodule, ... 1. *Mediterraneus.*
  With central nodule:
    Not beaked at extremities, ... 2. *birostratus.*
    Beaked at the extremities, ... 3. *acutus.*
Valves lunate (*Eunotogramma*):
  Puncta somewhat scattered, ... 4. *lævis.*
  Puncta in transverse rows, ... 5. *debilis.*

1. **Anaulus Mediterraneus** Grun.

Anaulus Mediterraneus Grun., V. H. Syn., Pl. 102, fig. 8–11.

Valve elliptical, rounded at the ends, divided by two septa into three parts. Surface convex with scattered puncta, 5 or 6 in .01 mm. No central nodule visible. L. of v. .066 mm.

Fossil at Atlantic City, Asbury Park and Longport, N. J. Occasional specimens from Weymouth, N. J., show but one septum.

Anaulus Mediterraneus intermedius Grun.

Anaulus Mediterraneus var. *intermedia* Grun., V. H. Syn., Pl. 102, fig. 9.

Valve constricted at the centre and at the ends; otherwise as in *A. Mediterraneus*.

Fossil in the Miocene deposits of California and the Eastern States.

There are several intermediate variations found in the Nottingham, Longport and other deposits, which lead to the conclusion that the above forms might be united under one specific name.

2. **Anaulus birostratus** Grun.

Anaulus birostratus Grun., V. H. Syn., Pl. 22 *bis*, fig. 15; Pl. 103, figs. 1–3.
Biddulphia birostrata Grun., Wien Verhandl. (1863), 158, Pl. 13, fig. 23.

Valve elliptical-lanceolate, usually constricted near the ends; angles obtuse. Surface divided by septa into three parts, the central one being square in outline, with scattered puncta, about 4 in .01 mm., more evident near the centre, at which a nodule is usually quite apparent. L. of v. .105 mm.

Fossil in the Miocene deposits of California and the Eastern States. Found also living on the shores of Peru, Virgin Islands, West Indies, etc., and may, therefore, be looked for northward.

3. **Anaulus acutus** Brun.

Anaulus acutus Brun., Le Diatomiste, 2, 231, Pl. 20, figs. 15–18.

Valve more or less constricted at the middle with the ends produced. Near *A. birostratus*, from which it differs, according to Brun, in having its valves, seen in zonal view, "joined by their extremities in the form of beaks." Puncta scattered, 5 or 6 in .01 mm. L. of v. .105 mm.

Fossil at Santa Crux (Brun); Wildwood, N. J. (Brun); Redondo Beach, Cal.

4. **Anaulus lævis** (Grun.) V. H.

Eunotogramma læve Grun., V. H. Syn., Pl. 126, figs. 6, 7, 9, 15; Schütt, fig. 171, *A*, *B*.

Valve lunate, with obtuse ends; and with or without slight constrictions at the prominent septa, which usually number from four to six. Surface marked with rather indistinct puncta, somewhat scattered, about 8 in .01 mm. Zonal view sharply quadrangular, the connective zone having transverse but somewhat distant rows of fine puncta. L. of v. .046 mm.

Coast of North Carolina and Florida; stomachs of fish, coast of South Carolina. Not common. Fossil at Buckshuten, N. J.; Atlantic City artesian well, N. J.

5. **Anaulus debilis** (Grun.) V. H.

Anaulus debilis (Grun.), V. H. Syn., 202.
Eunotogramma debile Grun., V. H. Syn., Pl. 126, figs. 17, 18, 19.

Valve lunate with margins entire. Transverse septa more numerous than in *A. lævis*. Surface with puncta in transverse rows, about 15 in .01 mm. L. of v. .049 mm.

Very near *A. lævis*, with intermediate forms.

West river, Conn.; Campeachy Bay (V. H.).

Species Excluded.

Anaulus Campylodiscus E., *Prit.*, 859; *Euodia Frauenfeldii* Grun., *Wien Verhandl.* (1863), 158, Pl. 14, fig. 19; *Eunotogramma Frauenfeldii* Grun., *V. H. Syn.*, Pl. 126, fig. 14; De Toni, 892. Habirshaw refers this to Grunow's form, apparently because Grunow says (*l. c.*) that the latter appears to bear some resemblance to the quite insufficiently described *Anaulus Campylodiscus*. The reference is probably incorrect. Ehrenberg's locality is given as "Bermuda" (Nottingham), and his form may possibly be *Biddulphia semicircularis* (Br.).

Eunotogramma amphioxys E., *Berl. Akad.* (1855), 302; De Toni, 892. This form is given as equivalent to *Biddulphia? lunata* E., *Berl. Akad.* (1844), 77; *Mik.*, Pl. 18, fig. 53; Kütz., *S. A.*, 138; *Prit.*, 849. It is described in *Prit.* as "three-lobed, smooth, slightly curved, lunate, with subacute horns." The form is unknown to me.

HUTTONIA Gr. and St. (1887).

The generic diagnoses not yet having been made and the genus ncluding species unlike the only American form thus far discovered, it is considered unnecessary to do more than give specific characteristics. De Toni remarks that the "genus is scarcely to be preserved" and that "perhaps it should be united with *Triceratium* or with *Odontella*." The processes appear like those of *Cerataulus*, while the outline and septa partake of the characteristics of *Anaulus Mediterraneus*.

Huttonia Reichardtii Grun.

Huttonia Reichardtii Grun., Just's Jahresb. (1887), 279; Schmidt, Pl. 116, fig. 4.

Cerataulus (?) *Reichardtii* Grun., Wien Verhand. (1863), 158, Pl. 13, fig. 22.

Valve elliptical, divided by two somewhat irregular, transverse, imperfect septa. Surface not elevated, punctate, the puncta about 9 in .01 mm., in irregular, somewhat oblique rows. Near each end, on opposite sides, an indefinite, truncate process extends obliquely outward. Zonal view quadrangular. L. of v. .049 mm. In a specimen from Wildwood, N. J., one of the processes is obsolete.

Fossil in the Miocene deposits of Virginia (Grun.); Atlantic City (K. and S.); Weymouth, N. J.; Wildwood, N. J. Rare.

HEMIAULUS Ehr. (1844) Em. H. L. Smith.

Valves elliptical or triangular, with the ends or angles usually extended into robust processes which are frequently mucronate. Surface usually more or less depressed at the centre, but occasionally divided by costæ into rounded elevations, with puncta usually coarse and prominent. Valves of same frustule not always equal.

Analysis of Species.

Valves triangular, ... 1. *Solenoceros.*
Valves elliptical:
  Processes short, ... 2. *bipons.*
  Processes long:
    Valves costate:
      Surface divided into elevations, ... 3. *polymorphus.*
      Surface not so divided, ... 4 *polycistinorum.*
    Valves not costate:
      With minute spine near end of process, . . . 5. *Kittonii.*
      With spine on end of truncate process, . . . 6. *Monicæ.*
      Without spines, ... 7. *Californicus.*

1. Hemiaulus Solenoceros (Ehr.)

Triceratium Solenoceros Ehr., Berl. Akad. (1844), 273 ; Schmidt, Pl. 77, fig. 21 ; Pl. 96, fig. 11 ; Pl. 97, figs. 6, 7.
Triceratium ligulatum Grev., T. M. S. (1864), 91, Pl. 13, fig. 9.
Triceratium Kittonianum Grev., T. M. S. (1865), 8.

Valve triangular, with deeply concave sides and angles produced into slender arms, from the extremities of which extend at right angles truncated, "hammer-like" processes which are usually less than .01 mm. in height. Surface elevated at the nodular centre, from which puncta about 5 in .01 mm., although somewhat larger toward the extremities, radiate along the produced angles in three or four nearly parallel rows. W. of v. .132 mm.

Fossil in the Miocene deposits of the Eastern States.

Greville, in his description of *Triceratium Kittonianum*, lays stress on the presence of the pseudo-nodule which, he says, "like a hammer," projects above and below the connective zone, and also upon the hexagonal reticulations as distinguishing his species from *Triceratium Solenoceros* Ehr. An examination of numerous specimens from the Nottingham deposit shows that the reticulation is more or less hexagonal in all and that there is considerable variation in the amount of elevation of the processes, as is mentioned by Heiberg in his description of *Trinacria Regina*, due occasionally to their being broken off, but quite often to their imperfect development, it being somewhat difficult to find valves in which all three processes are of exactly the same height. While I have not seen the curved spines characteristic of *Trinacria* at the apices of the processes, yet the roughened edges occasionally appear to indicate the possibility of their having been originally present, and the close resemblance of the American forms to those described by Heiberg under *Trinacria* leave no doubt, I think, of their generic character.

Trinacria is united to *Hemiaulus* in accordance with the views of Van Heurck, Brun and others, the difference being chiefly that of outline. *Trinacria excavata* Heib., which is given by some authors as equivalent to this form, differs from it in having much larger marginal reticulations. The *Habirshaw Catalogue* gives *Trinacria Regina* Heib. as a synonym, but I think this is also distinct. The three forms are, however, closely allied.

2. Hemiaulus bipons (Ehr.?) Grun.

Zygoceros bipons Ehr., Berl. Akad. (1844), 273.
Hemiaulus bipons (Ehr.?) Grun., Fr. Jos. L., 13; V. H. Syn., Pl. 103, figs. 6–9.

Valve elliptical-lanceolate, acute at the ends, divided into three nearly equal parts by two robust transverse costæ. In zonal view the surface is depressed at the centre, the sharply defined edges of valve extending into a double keel along the short processes, each of which bears a short, stout, incurved spine. Puncta rounded, 3 in .01 mm. L. of v. .075 mm.

Fossil in the Miocene deposits of the Eastern States, especially at Nottingham and Richmond.

3. Hemiaulus polymorphus Virginicus Grun.[6]

Hemiaulus polymorphus Virginicus Grun., Fr. Jos. L., 14, Pl. *B*, fig. 46; Schmidt, Pl. 143, fig. 31.

Valve elliptical-lanceolate, with the margin apparently but not really constricted by the transverse costæ which, variable in number, divide the surface into rounded elevations, of which the central is usually the largest and more elevated. Processes robust, seldom more than half the length of valve, each with a strong inwardly curved spine .01 mm. in length. Puncta 6 or 7 in .01 mm., not in regular rows. L. of v. averages .048 mm.

Fossil at Richmond, Va.

4. Hemiaulus polycistinorum Ehr.

Hemiaulus polycistinorum Ehr., Mik., Pl. 36, fig. 43, *a–d*; Schmidt, Pl. 143, figs. 23–29.

Valve elliptical-lanceolate, acute at the ends, divided by two or more costæ which are usually but slightly depressed. Surface either depressed toward the centre or flat. Processes usually long and robust, terminated by a short, stout, incurved spine. Puncta rounded, pearly and prominent, especially on the processes, where they are about 3 in .01 mm. L. of v. averages .033 mm.

Nottingham ("Stratford Cliffs," Ehr.).

5. Hemiaulus Kittonii Grun.

Hemiaulus Kittonii Grun., V. H. Syn., Pl. 106, figs. 6–9; Schmidt, Pl. 142, figs. 2–8, 11.
Hemiaulus sp. Kitton., J. Q. C. (1870), Pl. 14, fig. 2.

Valve elliptical, without costæ. Surface slightly raised at centre,

[6] Schmidt states (*Atlas*, Pl. 143) that, according to Witt's opinion, *Hemiaulus polymorphus* Grun. is identical with *Hemiaulus Proteus* Heib., and that the latter name has the right of priority. The variety *Virginicus* Grun. and other forms known as *H. polymorphus* differ from *H. Proteus* in not having the margins constricted at the middle.

with puncta in irregular rows on the valve, but parallel on processes, about 10 in .01 mm. Processes slender, .049 mm. in length, incurved, terminated by a fine straight mucronate spine, at the base of which, on the outer edge of each process, a minute spine projects. L. of v. .019 mm.

Vera Cruz. Rare.

6. **Hemiaulus Monicæ** Grun.

Hemiaulus Monicæ Grun., Fr. Jos. L., 10.

Valve elliptical. Processes robust, short and truncate, tipped with a minute spine. Surface slightly elevated at the centre, with puncta somewhat irregular, 4 in .01 mm., but becoming smaller toward the ends of the processes, where they are about 7 in .01 mm. L. of v. .022 mm.

Near *H. symmetricus* Grev. (*T. M. S.*, 1865, 53, Pl. 6, fig. 22), from which it differs in having the puncta less regularly disposed.

Fossil at Santa Monica, Cal.; Richmond (De Toni).

7. **Hemiaulus Californicus** Ehr.?

Hemiaulus Californicus Ehr., Mik., Pl. 33, 13, fig. 15.

Valve elliptical with robust processes. Costæ wanting, but in zonal view a slight depression is seen where the processes join the surface. Puncta more or less hexagonal, about 4 in .01 mm., in longitudinal rows. L. of v. .019 mm.

Fossil in California (Ehr.); Richmond, Va.

It is with some hesitation that the above description of specimens in my collection is attributed to *H. Californicus*, as Ehrenberg's figure is not sufficiently clear, but it is evident, I think, that the figure is intended to represent a small form having slight depressions at the junction of processes with the surface, and with puncta in longitudinal rows. The only other species, probably, to which the American forms can be referred is *affinis* Grun., which, however, may be identical with *Californicus*.

PLOIARIA Pant. (1889).

Valves elliptical-lanceolate, elevated at the centre, which is separated from the ends by depressions which appear like costæ. Puncta coarse. In general the valves resemble those of *Hemiaulus*, but are without processes. Includes but one species.

Ploiaria petasiformis Pant.

Hemiaulus ? petasiformis Pant., Foss. Bacill. Ung., I, 48, Pl. 29, fig. 295.
Ploiaria petasiformis Pant., *l. c.* 2, Pl. 28, figs. 403, 405.

Valve elliptical-lanceolate or elliptical-rhomboidal, acute at the ends, divided transversely by two lines, apparently costæ, into three parts, the two outer being flattened or slightly concave, while the central part is convex. Surface with puncta about 6 in .01 mm., more or less radiating from an apparent nodule which is usually excentric. In zonal view the valves appear petasiform and are slightly unequal. L. of v. .059 mm. to .082 mm.

Fossil at Nottingham and Atlantic City. Not common. Sometimes mistaken for *Hemiaulus bipons* Ehr.

GRAYA Grove and Brun. (1892).

Valve elliptical, appearing hyaline under low magnification. Surface undulating, with fine puncta chiefly along the longitudinal axis and radiating from a nodular centre. Represented by one species which is closely related to *Eucampia.*

Graya Argonauta Grove and Brun.

Grayia Argonauta Grove and Brun., Schmidt, Pl. 192, fig. 11.
Graya Argonauta Brun. and Grove, V. H. Diat., 458, fig. 187.

Valve elliptical or elliptical-lanceolate, with rounded ends. Surface convex, elevated at the centre and ends, but usually appearing beveled at the middle of the sides; subtly punctate near the margin, the puncta becoming more prominent along the longitudinal axis, where they are about 7 in .01 mm., radiating unequally from a nodular centre. Zonal view quadrangular. The connective zone appears to increase by the addition of successive plates which overlap each other. L. of v. .099 mm. to .181 mm.

Av. l. of frustule .099 mm.

Fossil in the elliptical form at Nottingham and in the elliptical-lanceolate form at Redondo Beach, Cal.

EUCAMPIA Ehr. (1839.)

Valves elliptical with undulating surface. In zonal view the frustules appear more or less cuneiform and are joined together in spiral chains. They are imperfectly siliceous, notably so in the connective zones which are annulate.

Eucampia Zodiacus Ehr.

Eucampia Zodiacus Ehr., Kreideth, Berl. Akad. (1839), 71, Pl. 4, fig. 8 ; Wm. Sm., Brit. Diat., 2, 25, Pl. 35, fig. 299 ; Pl. 60, fig. 299 ; V. H. Syn., Pl. 95, figs. 17, 18 ; 95 *bis*, figs. 1, 2.
Eucampia? Virginica Grun., V. H. Syn., Pl. 95, *bis*, fig. 6.
Eucampia Britannica Wm. Sm., Brit. Diat., 2, 25, Pl. 61, fig. 378.

Valve elliptical with rounded ends. Surface with slight elevations at the nodular centre and at the ends, the puncta, about 7 in .01 mm., radiating from the centre to the sides where they are about 10 in .01 mm. Ends of valves hyaline. Zonal view cuneiform, the connective zone annulate and very indistinctly punctate.

L. of v. .115 mm.

Newport, R. I. (Lewis). Fossil in the Miocene deposits of the Eastern States. Rare.

I have not seen the connective zone of the fossil form known as *Eucampia Virginica*, but as the valves correspond exactly with those of *E. Zodiacus*, the two are doubtless identical.

The distinction made by William Smith between the two forms, *E. Zodiacus* and *E. Britannica*, is not specific, as spiral filaments may be seen in which some frustules have their sides "excavated," while others, in the same filament, have merely undulating surfaces without any "foramina between the joints."

Lithodesmium, a genus included by Van Heurck, De Toni and others among the Biddulphoid forms, is here omitted as it appears to have scarcely any of their characteristics. Its frustules are united by a reticulated siliceous membrane, and in other respects it appears to be more closely allied to *Ditylum*.

Index.

Synonyms are in Italics.

DECEMBER 4.

Mr. CHARLES MORRIS in the Chair.

Eighteen persons present.

DECEMBER 11.

The President, SAMUEL G. DIXON, M.D., in the Chair.

Fourteen persons present.

A paper entitled "A New Weasel from Western Pennsylvania," by Samuel N. Rhoads, was presented for publication.

DECEMBER 18.

Mr. CHARLES MORRIS in the Chair.

Twenty-nine persons present.

A paper entitled "Crustacea from the Cretaceous Formation of New Jersey," by Henry A. Pilsbry, was presented for publication.

DECEMBER 27.

Christmas Day falling on Tuesday, under the revised code of By-Laws the meeting was held on the succeeding Thursday.

The President, SAMUEL G. DIXON, M.D., in the Chair.

Twenty-six persons present.

Papers under the following titles were presented for publication:
"Crustacea and Pycnogonida Collected during the Princeton Arctic Expedition of 1899," by Dr. A. E. Ortmann.

"Report on the Echinoderms Collected off the West Coast of Greenland by the Princeton Arctic Expedition of 1899," by Walter M. Rankin.

"A List of Fishes from St. Croix, West Indies," by Henry W. Fowler.

The following were ordered to be published:

A NEW WEASEL FROM WESTERN PENNSYLVANIA.

BY SAMUEL N. RHOADS.

One of the most unlooked-for results of recent systematic field study of smaller mammals inhabiting the settled and populous areas of the Eastern States is the discovery of a small weasel in the regions contiguous to the city of Pittsburgh. Fortunately three specimens have been secured, each representing a phase of pelage characteristic of the seasonal moult. This weasel is allied to the minute Arctic and Canadian *Putorius rixosus* Bangs,[1] being somewhat larger than *rixosus* and less than half the size of *P. cicognani*, the smallest species hitherto recorded from the Middle States. It may be diagnosed as follows:

Putorius allegheniensis sp. nov. Allegheny Weasel.

Type, No. 6195, adult, Museum of the Academy of Natural Sciences of Philadelphia. Captured by Robert Hawkins, near Beallsville, Washington county, Pa., about the year 1885 or 1886.

Description of the Type.—In size and color it resembles *Putorius rixosus* Bangs from the Saskatchewan, B. A., but larger, darker and more thinly furred. Skull broader and flatter, with interorbital space high, tumid and constricted posteriorly. No supraorbital ridges.

Color (summer pelage).—Upper parts walnut-brown, abruptly separated from the pure white of under parts, the line of demarcation running from nasal pad along border of upper lip, through base of whiskers, just below base of ear, along median lateral line of neck to anterior base of shoulder; thence down anterior profile of foreleg to elbow, rising thence along posterior profile of leg to and along median lateral body line to flank, thence to heel and posterior thigh as on foreleg, rising and encircling anal region to lower base of tail. Tail colored like back with some scattering white hairs at tip (extreme tip apparently missing). Forefeet and

[1] *Proc. Biol. Soc. Washn.*, 1896, p. 21.

lower foreleg white; hind feet white only on toes and inside border. Whiskers mixed brown and white. The color areas occupied respectively by brown and white are almost exactly divided in equal parts. Compared with the type of *rixosus* and another summer specimen from Moose Factory, Hudson Bay, the type of *allegheniensis* is much darker and duller hued.

Measurements (of type, a well-mounted specimen, but undoubtedly stretched).—Total length, 199;[2] tail without hairs of tip, 19; hind foot, 20. Skull: Basilar length, 29; zygomatic width, 15.3; mastoid width, 14; interorbital constriction, 6; greatest mandibular length, 16.5.

Description of two other specimens.—No. 4279, Coll. of S. N. Rhoads; young adult (sex undetermined), cotype, in late winter early pelage, collected by aforesaid R. Hawkins, near Beallsville, Washington county, Pa., about the year 1885 or 1886.

Color.—Everywhere pure white except on head, where brown summer fur is appearing, also about 15 dark brown and blackish hairs at tip of tail.

Measurements (specimen is a mummy, preserved without skinning, having been eviscerated, poisoned and wired to a stand erect on its haunches. On this account its tail and body measurements are of real value after allowing an increase of five per cent. for shrinkage of intervertebral tissue).—Total length, 145; tail vertebræ, 22; hind foot, 20. Skull: Basilar length, 28; zygomatic width, 14.7; greatest mandibular length, 15.8.

No. $\frac{517}{2}$, adult female, Coll. of the Carnegie Museum, collected by William Seager, near Leetsdale, Allegheny county, Pa., April 25, 1898. This interesting specimen is in the shape of a cabinet skin, with anterior half of skull attached to lips and without sex mark or measurements on label. I have determined its sex by the series of teats, evidently those of a female having nursed young the previous season. The skull and teeth indicate full maturity. The pelage is changing from winter to summer garb, this change appearing to have but recently begun.

Color.—White, except an irregular mottled stripe of brown, well defined on head between nose, eyes and ears, narrowing along neck and back with wider areas at shoulders and hips and disappearing on hind rump. Tail white with about 20 brown-black

[2] All measurements in millimeters.

hairs at tip almost concealed by surrounding white hairs. A faint mottling of brown is appearing on all four legs and the upper hind feet.

Measurements (skin stretched).—Total length, 175; tail, 22; hind foot, 20.

The two Beallsville specimens were kindly loaned to me October 27, 1899, by Mr. Jacob Nease, of Washington, Pa., in response to a circular, widely distributed in the State, requesting information concerning certain rare mammals. The size of these tiny weasels, so different from anything to be expected from that region, raised the question of their being a genuine Pennsylvania product, and I wrote Mr. Nease for particulars. In answer, Mr. James S. Nease, who conducted the entire correspondence on the subject for his father, Jacob Nease, to whom the specimens belonged, sent me the following letter:

"Beallsville, Pa., 11–6–1899.

"Mr. Jas. S. Nease,
"Washington, Pa.

"*Dear Sir*:—In reply to your letter of 2d inst., I have consulted father in regard to the weasels which he sent your father to have stuffed. They were caught under dead-falls set for skunks, and of course were wild as any weasel. Father remembers well of catching them and sending them up, and got one or two he did not send, but has not seen any since then, some ten or fifteen years ago, if memory serves him right. They were caught when the bounty was on hawks and owls.[3] Very truly,

"J. W. Hawkins."

While there seemed to be no question as to the statements of the gentlemen above mentioned, the publication of them was deferred nearly a year, when I was unexpectedly confronted with the specimen in the collection of the Carnegie Museum. As it had been taken along the Ohio river, only a few miles below Pittsburgh, by a resident collector regularly employed by the Museum, it was accepted as conclusive evidence that these weasels are indigenous and living in those parts.

[3] This bounty act was passed in May, 1885, and repealed about eighteen months later.

Regarding the affinity of *allegheniensis* with *rixosus*, it may be stated that the nearest localities from which the latter has been recorded are Moose Factory, Ontario and Pembina, Minnesota, the latter being the specimen mentioned by Prof. Baird under "*Putorius pusillus* Dekay" in the Pacific R. R. Reports. It will be seen that there is an immense stretch of territory between these places and Pittsburgh, besides the great difference in the faunal position of the localities. That the habitat of these weasels shall prove to be continuous through the Appalachian system from Ontario southward is not impossible, but that specimens from the intermediate country have as yet escaped notice is indeed strange. The facts now known to us as to the differences between *rixosus* and its southern ally in size, cranial proportions and color are sufficient to indicate specific values. It is singular that all the known specimens of *rixosus* and *allegheniensis* appear to be females, though in every case the sex has not been absolutely determined. If any of them are males the great difference in size between the sexes, so notorious in all other species, is not apparent among the least weasels. Mr. Bangs, in his monograph of these mammals, gives us a special character of *rixosus:* "Tail not tipped with black"—but I find that his type of that species has several distinctly blackish hairs among the brown ones at the tail tip, so also has the specimen examined from Moose Factory. I am indebted to the Messrs. Nease for consenting to part with the type, on condition that it be preserved in the Academy of Natural Sciences of Philadelphia, as well as for their coöperation in this investigation. Mr. Outram Bangs generously loaned me the two specimens of *rixosus* mentioned above, one of them belonging to the Museum of Comparative Zoölogy of Cambridge, Mass.

NOTES ON CHIROPTERA.

BY JAMES A. G. REHN.

In the collection of Brazilian mammals made by Mr. H. H. Smith on the Naturalists' Exploring Expedition to southern Brazil (1882–1883), and bequeathed to the Academy by the late Prof. E. D. Cope, are some bats which are of great interest. Several specimens of the same group from different sources were included in the bequest, and together they form a number of interesting subjects for close examination, the results of which seem to warrant publication.

Eptesicus arge (Cope).

Vesperus arge Cope, American Naturalist, XXIII, p. 131, February, 1889.

Type No. 4899. Coll. Acad. Nat. Sci. Phila.

Sao Joao, Brazil. Collected by H. H. Smith.

The type of this species is in a fair state of preservation, and a comparison with the figures and descriptions of other South American forms, like *hilarii*, *dorianus* and *montanus*, has convinced me that it should be considered a very distinct species. The form of the ear and the tragus, besides the extent of the antibranchial membrane, are distinctive. The dental characters I cannot compare satisfactorily, as few of the allied species have the teeth figured or well described.

The placing of this in the genus *Eptesicus* is in accordance with Lajos.[1]

Measurements:

	MM.
Forearm,	42.2
Tibia,	15.5
Ear,	15
Width of ear (flattened),	9.5
Skull: Total length,	17
Basilar length,	14.6
Greatest zygomatic breadth,	11.1

[1] *Magyarország Denevéreinek Monographiája* (*Monographia Chiropterorum Hungariæ*), pp. 206–208.

Measurements:

		MM.
Skull :	Depth of brain-case,	6
	Depth at first premolar,	3
	Length of palate,	6.9
	Width of palate (including molars),	7

Uroderma bilobatum Peters.

Uroderma bilobatum Cope, American Naturalist, XXIII, p. 130, February, 1889.

Two specimens, Nos. 4883 and 4884. Sao Joao, Brazil. Collected by H. H. Smith. The genera *Uroderma* and *Dermanura* were separated from *Artibeus* on the number of molars present. Dobson[2] states regarding this: "The species of *Artibeus* have been divided into three subgenera according to the presence or absence of the minute last upper or lower molars; but as I find that the presence of these small last molars, certainly of the last upper molars, is variable even in the same species, it is evident that this character can scarcely be considered of much importance." On examining specimens of *planirostris* from southern Brazil, I find that in one specimen the last upper molar is present on one side and absent on the other, and in another both last upper molars are missing. While the last upper molars may always be present in young specimens of *planirostris*, the fact that they are sometimes absent in the adult forces itself upon us. An examination of a large series of bats of these three genera would probably show that the presence or absence of the last molars is of secondary consequence.

Peters[3] founded the genus *Uroderma* on what he supposed was the *Phyllostoma personatum* of Wagner, but later he concluded the description of that species was too indefinite to be determined, the description being equally applicable to specimens of either *Vampyrops lineatus* or *Chiroderma villosum*. The name *Uroderma bilobatum* was applied to the new species,[4] and accordingly the type of the genus *Uroderma* is *Phyllostoma personatum* Peters (nec Wagner) = *Uroderma bilobatum* Peters. The species *Phyllostoma planirostre* Spix was considered by Peters to be the same as *Artibeus perspicillatus*, but Dobson placed *planirostris* and *bilobatum* in

[2] *Catal. Chirop.*, p. 514.
[3] *Monatsber. K. Akad. Wissensch.* Berlin, 1865, p. 588.
[4] *Monatsber. K. Akad. Wissensch.* Berlin, 1866, p. 394.

the same subgenus solely on the number of molars, while the cranial characters of the latter seem to have never been examined.

Prof. Cope did not remove the skulls of the two specimens in the collection and the only reference to the skull of this species I can find is that of Thomas,[5] who simply makes the following comparison in describing *Artibeus glaucus:* " Skull . . . . almost as elongated as that of *A. bilobatus*, and sharing with that species in the less abrupt rise of the brain-case above the level of the muzzle; but while in *A. bilobatus* it is the muzzle that is raised, in *A. glaucus* it is the brain-case which is depressed, so that there is no really close resemblance between the two."

A study of specimens of both *bilobatum* and *planirostris* shows that the latter should be removed generically from the former, and a comparison with *perspicillatus* gives no good reason for separating it from *Artibeus*, the simple presence or absence of the last upper molar being of too uncertain value.

A table of the characters of the two genera (disregarding the number of molars entirely) would be as follows:

Genus **URODERMA** Peters.

Type—*Phyllostoma personatum* Peters (nec Wagner) = *Uroderma bilobatum* Peters.

Skull elongate, weasel-like, the anterior portion little lower than the brain-case, the height (from centre of base of second premolar) being decidedly greater than the width of the postorbital constriction. Horseshoe laterally with two rounded lobes. Species medium-sized.

Genus **ARTIBEUS** Leach.

Type—*Artibeus jamaicensis* Leach = *Vespertilio perspicillatus* Linnæus.

Skull thick and massive, the anterior portion depressed, the height being less than the width of the postorbital constriction. Horseshoe without lateral lobes.

Species large (except *A. glaucus* Thomas).

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[5] *Proc. Zool. Soc.* London, 1893, p. 336.

Comparative Cranial Measurements:

	Artibeus perspicillatus, No. 5705, Jamaica.	*Artibeus planirostris*, No. 4875, Chapada.	*Uroderma bilobatum*, No. 4883, Sao Joao.
Total length, ...	28	30	24
Basilar length, ...	22.75	24	21
Greatest zygomatic width, . . .	17.1	19	*circa* 12.6
Length of palate (from anterior face of incisors), ...	13.6	16	13
Breadth of palate and teeth at first molar,.	12.5	13.25	9.5
Depth of brain-case, ...	11	12.1	9.1
Depth at second premolar, . . .	5	7	7
Width of postorbital constriction, .	7.2	7.5	6.1

Artibeus eva (Cope).

Dermanura eva Cope, American Naturalist, XXIII, p. 130, February, 1889.

Types—Nos. 5783 and 5784. St. Martins, West Indies. Collected by Dr. R. E. Van Rijgersma. A study of the types of this species proves that Prof. Cope gave them a rather superficial examination when he placed them in the genus *Dermanura*, his record of the molars present being incorrect. The skull of No. 5,783, which I have removed, shows that the specimen evidently possessed six lower molars, as is generally considered to be the case with *Artibeus*, one being in position and the alveolus of the other being unabsorbed.

I can add little to the original description, the only point which seems to have escaped attention being the shallow emargination of the interfemoral membrane, which is of much greater expanse than either *perspicillatus* or *planirostris*. The form of the nose-leaf has induced me to place this species in *Artibeus*, the species of which all seem to possess a nose-leaf which is little higher than broad, while that of *Dermanura* is twice as high as broad.

Measurements:

Specimen No. 5784:

Total length, ...	73.25	mm.
Forearm, ...	62	"
Tibia, ...	24	"
Foot, ...	14	"
Ear, ...	19	"
Width of ear (flattened), ...	12	"

Measurements:

Skull of specimen No. 5783:

Total length,	27.6	mm.
Basilar length,	22.5	"
Greatest zygomatic breadth,	17	"
Depth of brain-case,	10.4	"
Depth of second premolar,	6	"
Length of palate,	13.5	"
Breadth of palate (including molars),	12.5	"

Sphæronycteris toxophyllum Peters. Sitzungberichte der K. P. Akademie der Wissenschaften, Berlin, 1882, pp. 988-990, taf. XVI.

The discovery of an alcoholic specimen of this very remarkable bat among the material received from Prof. Cope is of interest. It was collected at Pebas, Peru, by John Hauxwell, and was not identified by Cope. The specimen agrees perfectly with Peters' description and plate, and forms a link in the chain of distribution. The type came from an unknown locality, and the only other specimen of which we have information is one collected at Merida, Venezuela.[6]

[6] Thomas, *Ann. and Mag. Nat. Hist.* (7), II, p. 318.

The following annual reports were read and referred to the Publication Committee:

REPORT OF THE RECORDING SECRETARY

The average attendance at the meetings during the past year amounts to 21. A quorum was lacking three times during the heat of midsummer, while the largest number present at any session was 112. Verbal communications have been made at nearly all the meetings, but comparatively few have been reported for publication, many of those dealing with original observations being embodied in the formal papers presented by title and printed as part of the *Proceedings* when reported on favorably by the Publication Committee.

Among those who have thus added to the interest of the meetings are Messrs. George and William S. Vaux, Jr., Johnson, Woolman, Pilsbry, Stone, Calvert, Sharp, Saunders, Chapman, T. H. Montgomery, Rand, Willcox, Goldsmith, Holt, Skinner, Harshberger, U. C. Smith, Keeley, C. Morris, Balch, Dixon, A. E. Brown, Carter, Hamilton, Holman, J. C. Morris, McElwee, Meyer, Lyman, A. Miller, Seiss, Palmer and Mesdames Bladen and Burgin.

One hundred and eleven pages of the *Proceedings* for 1899, with five plates, and five hundred and ninety-six pages of the volume for 1900, with twenty-three plates, have been issued, together with the third number of the eleventh volume of the quarto *Journal*, the latter consisting of one hundred and thirty pages and two plates.

For all but the plates and twenty-three pages of this part of the *Journal* we are indebted to the liberality of Mr. Clarence B. Moore, whose contributions in continuation of his papers on Southern mound burials are profusely illustrated by figures in the text.

Fifty papers have been presented for publication, as follows: Henry A. Pilsbry 14, Witmer Stone 2, J. Percy Moore 2, Thomas Meehan 2, Henry W. Fowler 2, R. W. Shufeldt 2, H. A. Pilsbry and E. G. Vanatta 1, Edward G. Vanatta 1, William and George Vaux, Jr., 1, Charles T. Simpson 1, C. F. Saunders 1, Vernon L. Kellogg and Shinkai I. Kuwana 1, William Healy Dall 1, T. D. A. Cockerell 1, T. D. A. Cockerell and Wilmatte Porter 1, Charles S. Boyer 1, Annie Bell Sargent 1, Charles Morris 1, Nathan Banks 1, T. Wayland Vaughan 1, Frank C. Baker 1, Charlotta J. Maury 1, Alexander McElwee 1, Henry C. Chapman 1, Arthur M. Edwards 1, Ida A. Keller 1, T. Chalkley Palmer and Frank J. Keeley 1, Clarence B. Moore 1, H. von Ihering 1, John W. Harshberger 1, Arthur Erwin Brown 1, Charles E. Hall 1. Forty-one of these have been accepted for publication in the *Proceedings* and have been issued or are now in press; two constitute the last number of the *Journal*, two were reported on adversely, two were withdrawn by the authors, one was transferred to another journal at the request of the author, one is held for publication next year, and one has not yet been reported on.

The Entomological Section (American Entomological Society) has published three hundred and thirty-six pages and seven plates of the *Transactions* and three hundred and thirty-nine pages and seventeen plates of the *Entomological News*.

The Conchological Section has issued five numbers of the *Manual of Conchology*, embracing three hundred and thirty-five pages and ninety plates.

The Academy's publications, therefore, since the last annual report have consisted of 1847 pages and 144 plates, a very important increase over the 1416 pages and 81 plates of the preceding year.

Perhaps the most important advance in the work of the publication office has been the distribution of the *Proceedings* to all members in good standing. It had long been the desire of the Council to thus bring those interested in the society into closer relation with its current work, but the annual income had not been such as to warrant the increased expenditure. The distribution has been made possible by the settlement of the estate of the late Dr. Robert H. Lamborn, resulting in an important addition to the Academy's resources. It is believed that such extended distribution of the Academy's published work is in harmony with the desire of our generous benefactor to provide for the encouragement of scientific research and to enlarge the sphere of the society's usefulness.

The statistics of distribution are now as follows:

Proceedings,	delivered to members, ...	547
"	exchanged for other publications, ...	561
"	sent to subscribers, ...	48
		1,156

Journal,	exchanges, ...	69
"	subscriptions, ...	34
		103

To provide for the additional distribution of the *Proceedings,* the printed edition has been increased from 1,000 to 1,500 copies.

The plates damaged by the flood of 1898 have been reprinted as far as was necessary to provide for a supply of back volumes to exchanges and purchasers.

Eighteen members and two correspondents have been elected. Resignations have been accepted from Gavin W. Hart, William L. Whitaker, George W. Warren, John B. Deaver and Mrs. Susannah M. Gaskill. The deaths of fourteen members have been announced, and seven have been dropped from the roll for non-payment of annual contributions.

The Hayden Memorial Geological Trust has been modified by agreement with the founder so as to provide for the award every third year of a gold medal instead of a bronze medal and the interest arising from the fund annually.

Vacancies in the Publication Committee and in the Council, caused by the death of Charles E. Smith, have been filled by the election of Philip P. Calvert, Ph.D., to the former, and of Mr. Charles Roberts to the latter. The death of Mr. Smith was severely felt by his associates on the Publication Committee, his work as an accurate proof-reader having been recognized as of importance during several years of devoted service.

The resignation of the Rev. Henry C. McCook, D.D., from the office of Vice-President was tendered before the annual nominations were made, and was accepted with regret. By direction of the Academy, a minute of appreciation of his services to science and to the society has been placed upon the records.

The use of the lecture hall of the Academy was granted the Pennsylvania Audubon Society for its meeting of January 6. The meetings of the Pennsylvania Mycological Society, Students' Mineralogical Club, Students' Entomological Association, Delaware Valley Ornithological Club, the Philadelphia Botanical Club and Philadelphia Moss Chapter have also been held on the premises.

EDW. J. NOLAN,

Recording Secretary.

REPORT OF THE CORRESPONDING SECRETARY.

During the past year there have been received from seventy-four societies, museums, libraries, etc., one hundred and thirty-two acknowledgements of the receipt of the publications of the Academy, and from thirty-one societies, libraries, etc., forty-one notices of transmission of their publications.

Eleven applications for exchange of publications and for supplies of deficiencies, together with seven circulars and invitations to the Academy to participate in congresses, etc., and four announcements of the deaths of scientific men, have also been received and when necessary answered.

Two correspondents have been elected during the year and the deaths of seven have been recorded.

Seven hundred and fifty-five acknowledgments of gifts to the library and eleven diplomas to correspondents have been forwarded.

Respectfully submitted,

BENJ. SHARP,

Corresponding Secretary.

REPORT OF THE LIBRARIAN.

The accessions to the library catalogued and placed since the last annual report amount to 5,441, an increase of 567 over the growth of last year. There were 4,427 pamphlets and parts of periodicals, 752 volumes, 261 maps and one photograph.

They have been received from the following sources:

Societies	2,183
I. V. Williamson Fund	1,263
Editors	811
U. S. Department of Interior	278
Authors	169
General Fund	154
U.S. Department of Agriculture	134
Estate of Charles E. Smith	79
Meigs Fund	59
Wilson Fund	44
Thomas Meehan	41
Dr. H. C. Chapman	19
U.S. Department of State	16
Ministère des Travaux Publics, France	14
Comité Géologique Russe	12
Victoria Department of Mines	10
Pennsylvania State Library	11
Geological and Natural History Survey of Minnesota	11
Wisconsin Geological Survey	11
Geological Survey of India	7
Department of Agriculture, Cape of Good Hope	7

Dr. E. J. Nolan	6
Dr. H. A. Pilsbry	6
Dr. W. W. Keen, Jr.	5
Bernice Pauahi Bishop Museum	5
California State Mining Bureau	5
Commission Géologique de Finlande	5
British Museum	4
Library of Congress	4
Geological Survey of Louisiana	4
Geological Survey of Alabama	4
Indian Museum	3
Congreso Cientifico Latino-Americano	3
Geological and Natural History Survey of Canada	3
Conchologcal Section of the Academy	3
Department of Mines, New South Wales	3
Philadelphia Commercial Museums	2
Geological Survey of New Jersey	2
Zoölogical Museum, Copenhagen	2
Kew Gardens	2

Department of Mines, Nova Scotia,	2
Comision Geologica de Mexico,	2
U. S. War Department,	2
U. S. Commission of Fish and Fisheries,	2
Joseph Willcox,	2
U. S. Treasury Department,	1
U. S. Coast and Geodetic Survey,	1
Walter Faxon,	1
William J. Fox,	1
Maryland Geological Survey,	1
Maryland State Weather Service,	1
Government of India,	1
Massachusetts Commissioners of Inland Fisheries and Game,	1
Miss L. H. Baird,	1
Henry A. Ward,	1
Illinois State Bureau of Labor Statistics,	1
Council of the Fridtjof Nansen Fund for the Advancement of Science,	1
Institut Solaire Internationale, Montevideo,	1
U. S. Civil Service Commission,	1
Norwegian Government,	1
Department of Geology and Natural History, Indiana,	1
N. C. Geological Survey,	1
W. E. Meehan,	1
Heirs of H. Schaafhausen,	1
Dr. Fritz Sano,	1
University Geological Survey, Kansas,	1
William Beer,	1
Geological Survey of Missouri,	1
Adams Memorial Committee,	1
Iowa Geological Survey,	1
Estate of Robert H. Lamborn,	1

They were distributed to the several departments of the library as follows:

Journals,	4,085
Geology,	485
Botany,	261
General Natural History,	133
Agriculture,	100
Entomology,	52
Conchology,	38
Anatomy and Physiology,	37
Voyages and Travels,	34
Miscellaneous,	31
Anthropology,	29
Ornithology,	23
Physical Science,	21
Mineralogy,	21
Mammalogy,	20
Medicine,	18
Helminthology,	11
Ichthyology,	11
Bibliography,	9
Encyclopædias,	6
Herpetology,	6
Chemistry,	5
Geography,	5

In addition to the above, 104 duplicate volumes and 112 pamphlets were received from the estate of the late Charles E. Smith.

Eight hundred and eighty-six volumes have been bound during the year, and three hundred and thirty-five are in the hands of the binders. This gratifying increase in this department of library work over the accomplishment of recent years is the result of the much larger appropriation than usual which the Council was able to grant. It is estimated that nearly five thousand volumes, mainly in the department of journals and periodicals, are still unbound, although many of the most pressingly urgent needs have been provided for during the past year.

A desirable addition to the space devoted to the arrangement of journals and periodicals has been secured by erecting cases on the entresol floor of the former staircase to the Museum, rendered available by the present exclusive use of the door on Nineteenth street as the public entrance to that department of the Academy. This section of the library is so rapidly growing that the need of additional accommodation is still urgently needed for the convenient use of the books.

About twenty books and pamphlets not related to the objects of the Academy were transferred to the Free Library in addition to those noted in my last report.

The Warner Library, consisting, for the most part, of books on mathematics, received in 1892, has been rearranged, works on general science being placed in their appropriate departments of the main library and the catalogue incorporated with that of the Academy. Nearly one thousand pamphlets belonging to the collection are now in the hands of the binders.

In association with the work of preparing volumes for binding constant effort is made to secure a supply of deficiencies as gifts or from booksellers' catalogues. Much remains to be done in this direction.

It gives me much pleasure to assure you of the efficiency of my assistant, William J. Fox.

EDW. J NOLAN,
Librarian.

REPORT OF THE CURATORS.

The collections under care of the Curators have been kept in the excellent state of preservation reported last year, while much has been accomplished toward their better display, arrangement and cataloguing. During the year two large plate-glass cases have been provided, one for large mammals and one for the new ornithological floor which it is proposed to open during the coming year. There have also been erected two handsome wall cases in the Archæological department for the reception of the Lamborn Collection of Mexican Antiquities, and two others for a series of human crania.

For storage purposes a room in the basement has been fitted up with fifty-two closet cases in which geological study collections will be arranged. The specimens will thus be more accessible, and the cases on the upper floor now occupied by them will be available for more perishable material. Ten moth-proof tin cases for the accommodation of the rapidly increasing study collection of birds were also secured.

In addition to these improvements, the entire library hall has been painted during the summer. Necessary improvements have also been made to the roofs and the heating plant, and sunshades provided for several windows as a protection to the specimens.

The principal rearrangement in the Museum during the year has been on the floor devoted to mammals. The new case provided for the large mounted specimens rendered the old cases available for osteological material, much of which had previously been without protection. This not only insures the better preservation of the specimens, but facilitates their systematic arrangement. With the same object all the skeletons of Cetacea have now been placed together at the east end of the floor protected by a railing, and some of them articulated and remounted. The entire series of mammals exhibited in the new cases has also been relabeled with buff cardboard, which will not discolor on exposure to the light, while nearly all of the study series of mammalian skeletons has been labeled with permanent tags.

In addition to the above work, the assistant to the Curators has devoted a large part of the year to the arrangement of the alcoholic Batrachians and Reptiles. The entire series of some thirty-five hundred jars has been cleansed and systematically arranged in accordance with the British Museum Catalogue, and many specimens misplaced when the collection was transferred have now been located and properly classified. The entire Cope collection of Ophidia and Tailed Batrachia, excepting some of the largest specimens, was catalogued; many unnamed specimens were identified and systematically arranged. The shelves have been numbered and labeled, so that any specimen can be readily found.

The alcoholic mammals were at the same time systematically examined and relabeled by Mr. J. A. G. Rehn, Jessup Fund student, and the additions from the collections of the late Prof. Edward D. Cope and Dr. Harrison Allen properly arranged. Mr. Henry W. Fowler has completed the rearrangement of the alcoholic fishes.

In the Botanical department, the services of Mr. Stewardson Brown were secured in the spring as an assistant to the Curators and the work of mounting the herbarium has been pushed rapidly toward completion. Much work has been done in this department by Vice-President, Thomas Meehan.

Mr. Clarence B. Moore has added many valuable specimens to his collection in the department of Archæology, which is now one of the most valuable in our museum, and Mr. Theodore D. Rand has spent much time in the care and arrangement of the William S. Vaux Collection of minerals.

By the liberality of Rev. Dr. Leander T. Chamberlain, the Isaac Lea Collection of Eocene and Oligocene fossils has been extended by a large series from the Chipola (Florida) bed, collected by Mr. C. W. Johnson; a fine series from the Ballast Point Silex beds, and less important collections from other American localities. Substantial additions have also been made to the series from the Oligocene and Eocene of Europe. In all, fifteen hundred and thirty-two trays of fossils have been added to the collection during the year, the total number of accessions catalogued now reaching sixty-six hundred and eighty-two entries, with some material still to be determined. Two new cases have been provided for the accommodation of this material. The continued interest of Dr. Chamberlain in this department of the Museum is a cause of congratulation, as it secures important advancement of American invertebrate paleontology.

The Curators, considering the duplication of collections undesirable, have transferred certain Eocene and Oligocene fossils of Jamaica and Santo Domingo and of the London and Paris basins to the Isaac Lea Collection, wherein they can be arranged and displayed.

In other departments we would acknowledge the continued assistance of Dr. Henry A. Pilsbry of the Conchological Section, Dr. Henry Skinner, Dr. Philip P. Calvert and Mr. Charles Liebeck of the Entomological Section, and Messrs. Lewis Woolman and Theodore D. Rand of the Geological Section; also the efficient aid received from the students of the Jessup Fund, Miss Harriet N. Wardle and Messrs. Fowler, Hamilton, Vanatta, Satterthwait and Rehn.

Several of the collections have benefited from critical study by specialists during the year, notably the North American Ophidia, studied by Mr. Arthur Erwin Brown, the Cetacean skeletons by Dr. F. W. True, and the Mosses by Mrs. Elizabeth G. Britton. The additions to the Museum have been many; among the most important being the Lamborn Collection of Mexican Antiquities, the Charles E. Smith Herbarium, the numerous valuable specimens received from the Zoölogical Society of Philadelphia, and the Japanese Mollusca received from Mr. Y. Hirase, of Kyoto, Japan. Of particular interest also is a life-size portrait of Linnæus, copied from the original in Holland especially for the Academy and presented by the late Charles E. Smith early in the year; some heads of Indian Buffaloes, collected and deposited by Dr. A. Donaldson Smith, and a beautiful exhibition case of Lepidoptera, the gift of Mr. Charles H. Hutchinson.

Specimens have been loaned for study during the year to Mrs. E. G. Britton, Messrs. C. R. Ball, W. B. Clarke, F. M. Chapman, F. R. Coville, W. H. Dall, M. J. Elrod, C. R. Eastman, George H. Girty, A. H. Howell, Alpheus Hyatt, W. P. Hay, R. T. Jackson, G. S. Miller, E. L. Morris, P. Ryberg, Robert Ridgway and J. K. Small.

HENRY C. CHAPMAN,

Chairman.

REPORT OF THE CURATOR OF THE WILLIAM S. VAUX COLLECTIONS.

The Curator of the William S. Vaux Collections would respectfully report tnat there have been added to the collection since the last report one hundred and fifty-eight specimens, many of them of unusual excellence, at a cost of over $1000, exhausting the funds available at present.

To provide for efficient display additional case room must very soon be supplied, as a number of excellent specimens are not exposed to view.

The catalogue of species has been completed and also a card catalogue.

The Curator desires to express his acknowledgments to Mr. George Vaux, Jr., for valuable aid in the selection and procuring of specimens, and to Miss Harriet N. Wardell for admirable work on the catalogue and assistance in arranging the collection.

Respectfully submitted,

THEO. D. RAND,

Curator.

REPORT OF THE BIOLOGICAL AND MICROSCOPICAL SECTION.

The Section held ten meetings during the year with the usual attendance. Numerous communications, illustrated by slides and specimens, were made at the regular meetings, and in addition to these others were made at the meetings in conjunction with the Academy by Messrs. Pilsbry, Woolman, Sharp, Morris, Palmer and Keeley.

The following articles were recommended for publication in the *Proceedings* of the Academy:

"The Structure of the Diatom Girdle," by T. C. Palmer and F. J. Keeley.

"Biddulphoid Forms of North American Diatomaceæ," by Charles S. Boyer.

Arrangements have been made for a joint meeting of the Biological Society of the University of Pennsylvania and the

Biological and Microscopical Section of the Academy, and for a Microscopical Exhibition.

The following officers were elected to serve during the ensuing year:

Director, ...	J. Cheston Morris, M.D.
Vice-Director, ...	T. Chalkley Palmer.
Treasurer, ...	Lewis Woolman.
Conservator, ...	F. J. Keeley.
Corresponding Secretary, . .	Silas L. Schumo.
Recorder, ...	Charles S. Boyer.

CHARLES S. BOYER,
Recorder.

REPORT OF THE CONCHOLOGICAL SECTION.

The collection of mollusks has been increased during the year by about 2,064 lots, representing over 10,000 specimens, received from sixty-six persons. The collection remains in about the same condition as last year, except that a rearrangement of the entire series of land mollusks has been begun.

The Australian and Oriental Bulimi have been examined and relabeled in the course of work upon these groups for the *Manual of Conchology.* The North American Pupidæ have also been reviewed, and the Japanese land snails of the collection have undergone revision.

As in former years, a large amount of work has been done upon North American mollusks. These studies have been instrumental in obtaining much material from naturalists in this country and abroad, who send it upon the condition that such collections be investigated.

Sixteen papers dealing with this material have been published in the current volume of the *Proceedings* of the Academy, with an equal number of minor articles in the *Nautilus* and elsewhere.

During the year the Section has issued Vol. XIII of the second series of the *Manual of Conchology.*

Mr. E. G. Vanatta has rendered valuable assistance throughout the year in all departments of the Section's activity. The thanks of the Section are also due to Mr. Charles W. Johnson, of the Museum Committee, for assistance upon many occasions.

HENRY A. PILSBRY, *Conservator.*

REPORT OF THE ENTOMOLOGICAL SECTION.

The usual monthly meetings of the Section have been held, with an average attendance of ten persons. Two members and two associates have been elected. The collections are in a good state of preservation, and their care, mounting and the incorporation of new material has been the principal work of the year. The Conservator has been aided in this work by Mr. Alfred F. Satterthwait, Jessup Fund student, and by several members of the Section. The desiderata from the 10,000 specimens of exotic Coleoptera included in the Griffith collection have been properly placed. Like disposition has been made of the collections made in Florida by H. A. Pilsbry, in Maryland by E. G. Vanatta, in Manchuria by Dr. A. D. Smith and G. Farnum, in Palestine by R. Weber, in Utah by H. Skinner, and in Pennsylvania by H. W. Wenzel. These gifts are more particularly recorded in the list of additions to the Museum last year and this.

A second case for the display of the beautifully mounted butterflies, the gift of Mr. Charles H. Hutchinson, has been filled. The large collections made by Dr. A. D. Smith in Africa have been remounted and are ready for distribution to the cabinets. A fine collection of 450 specimens of various orders from Japan, collected and presented by Dr. H. C. Wood, have also been mounted and partly distributed. A collection of 340 ants from Pennsylvania and New Jersey, presented by Mr. H. W. Wenzel, have been mounted and placed with the Hymenoptera. A small but valuable collection of butterflies and moths from Bolivia was received from Miss Prentiss Smith. They have been placed in the Martindale collection and are all new to the cabinet. The exotic Bombycidæ have been rearranged and relabeled.

Dr. Calvert has incorporated into the collection of Odonata 381 dragon-flies from Bolivia, which were purchased.

The American moths to the end of the Crambidæ have been rearranged and relabeled. They are now in good condition for study and reference. Mr. Liebeck has rearranged the American Coleoptera as far as the family Anthicidæ.

The enormous collections in the care of the Section are particularly liable to the attack of museum pests and require a care and oversight which necessitate the expenditure of much time. As improvements in cabinets and cases are secured, the use of poisons for disinfecting—or rather disinsecting—purposes will be less necessary. This year about fifty pounds of naphthaline have been placed in the collection of exotic Coleoptera alone.

The growth of the collections is very satisfactory, and their value is evidenced by the fact that many students from other museums and scientific societies find it necessary to consult them. The *Entomological News* has been continued and Volume XI, just completed, contains 339 pages and 17 plates.

At the annual meeting of the Section, held December 27, the following persons were elected to serve as officers for the year 1901:

Director,	Philip Laurent.
Vice-Director,	H. W. Wenzel.
Treasurer,	E. T. Cresson.
Conservator and Recorder,	Henry Skinner.
Secretary,	C. W. Johnson.
Publication Committee,	J. H. Ridings, C. W. Johnson.

HENRY SKINNER,
Recorder and Conservator.

REPORT OF THE BOTANICAL SECTION.

The Director of the Botanical Section has pleasure in reporting that the prospects of the botanical interests of the Academy were never better than now. So far as the growth and care of the herbarium is concerned, the report of the Conservator attached hereto details the progress made. The Redfield Memorial Fund of $20,000, which it was proposed to establish as a mark of gratitude for the life-long devotion to the interests of the Academy of our deceased fellow-member, John H. Redfield, ceased to grow when about one-fourth of the sum had been subscribed, owing to the temporary need of the Academy at that period in another direction. Though the Academy has materially aided in the care of the herbarium by detailing a special assistant to the Curators to assist in the work, the original idea of honoring our deceased friend by a $20,000 "Memorial Fund" should not be lost sight of through lapse of time.

The growth and care of the herbarium is but a small field in the realm of botany, and there is no reason why the Academy may not occupy in time a foremost place among the institutions of the world in the advancement of this amiable science, when it possesses resources commensurate with the full measure of the task.

Meetings of the Section have been held regularly, except during the three summer months. Valuable communications have been made at each meeting, some of which have been accepted as of original merit for the *Proceedings* of the Academy.

The officers elected for the year ensuing were:

Director, ...	Thomas Meehan.
Vice-Director, ...	George M. Beringer.
Recorder, ...	John W. Harshberger.
Treasurer and Conservator, .	Stewardson Brown.
Corresponding Secretary, . .	Joseph D. Crawford.
Executive Committee, . .	George M. Beringer, Thomas Meehan, Stewardson Brown, Joseph D. Crawford, Dr. Ida A. Keller.

Respectfully submitted,

THOMAS MEEHAN,
Director.

Report of the Conservator.—The mounting of the plants in the general herbarium has been finished through the Exogens, and it is expected that this entire work will be completed during the coming year. The work has been accomplished through the untiring efforts of the Director of the Section, Mr. Thomas Meehan, aided by Mr. Uselma C. Smith, with the official aid of the Conservator, who in May became a member of the working staff of the Academy by his appointment as an assistant to the Curators. He has thus been enabled to devote his entire time to the work in hand, and, with the employment of a permanent assistant in the herbarium, 14,000 sheets of specimens have been arranged during the year.

While a rapid completion of the work of mounting the herbarium would thus be indicated, there yet remains a vast accumulation of material, including the C. W. Short herbarium and several smaller collections, which, at the present rate of progress, will take several years to properly arrange.

It is also proposed, during the coming year, to rename the North American species to conform with the modern ideas of nomenclature. This in itself will be a vast work, but the Conservator has been promised liberal assistance to aid in its accomplishment.

Notwithstanding that two years ago nine new cases were provided to relieve the congested condition of the collections, the cases are again becoming overcrowded, and additional accommodation is required for the arrangement of the specimens after mounting and for the placing of the natural growth through accessions.

The Cyperaceæ, Gramineæ and Pterïdophytes are at present in the room devoted to North American plants, because of the impossibility of placing them systematically with the rest of the herbarium owing to the lack of casing.

It seems very advisable that all the general collections should be arranged together in sequence, and in order to accomplish this and relieve the overcrowded condition, as well as provide for the several special collections which are now wholly unprovided for, the Conservator recommends the erection of cases on the remaining wall space in the Botanical rooms on the library floor.

In the latter part of May the herbarium of the late Charles Eastwick Smith was received at the Academy. It contains nearly 5,000 species, about half of which were collected within the fifteen-mile radius of the City Hall, the balance being largely plants which were no doubt, with a few exceptions, received in exchange. The latter part of the collection is unusually rich in Carices and the Juncaceæ, two groups in which Mr. Smith was particularly interested. It contains a full set of Engelmann's *Herbarium Juncorum Boreali-Americanorum Normale*, as well as a partial set of the species of the "Southern Flora" collected by Drs. Chapman and B. F. Saurman. Of these plants 1,200 sheets have been mounted and the balance will be completed during the coming year. These and other accessions to the herbarium, amounting to 7,000 specimens, are recorded in the list of accessions to the Museum.

STEWARDSON BROWN,
Conservator.

REPORT OF THE MINERALOGICAL AND GEOLOGICAL SECTION.

The Director of the Mineralogical and Geological Section would respectfully report that nine meetings were held during the year with an average attendance of eight members. A number of communications were read, and no lack of interest has been manifested among the few connected with the Academy who are especially concerned with these branches of science.

In addition to the above two field meetings were held, one at Durham Furnace and vicinity and the trap outcrop at Nockamixon, the other to Camp Hill, Jarrettown and Three Tuns. These were largely attended.

The Section has suffered the loss by death of two of its members, Mr. Wilfred Harned and Dr. J. T. M. Cardeza. The latter was one of the earliest members of the Section, and took an active part in its work so long as his health permitted.

Additions to the Museum, elsewhere recorded, have not been large in number, but some of them are valuable.

The officers elected at the annual meeting were as follows:

Director, ...	Theodore D. Rand.
Vice-Director, ...	Benjamin Smith Lyman.
Conservator, ...	F. J. Keeley.
Secretary, ...	Charles Schæffer, M.D.
Treasurer, ...	Emma Walter.

Respectfully submitted,

THEODORE D. RAND,
Director.

REPORT OF THE ORNITHOLOGICAL SECTION.

While no general rearrangement of the exhibition series of birds has been possible during the past year, the erection of a large exhibition case has been completed on the bird-floor of the new Museum, which, with the two smaller cases already in position, will permit of the removal of a portion of the collection to its new quarters early in the coming year.

The Curators have also provided ten additional moth-proof storage cases for skins, and the Conservator has been enabled to rearrange the entire series of American Passerine birds, numbering some 12,000 specimens. By this means the Hoopes series has been combined with the general collection, which greatly facilitates the study of the material. Many specimens previously exposed in unsafe wooden cases have been placed beyond the reach of dust and moths.

The Old-World Passeres are, however, still occupying temporary cases, and the provision of tight cases for their accommodation cannot be too strongly urged. The receptacles as finally arranged have been labeled to facilitate reference, some 400 cards having been prepared.

During the year the exhibition collection of North American Warblers, Woodpeckers, Hawks and Owls formed by Mr. Josiah Hoopes has been entirely remounted on natural branches and placed in the Museum. It comprises 158 groups and forms one of the finest exhibits in the ornithological galleries.

A number of specimens presented by Dr. Samuel W. Woodhouse have also been remounted and placed on exhibition, while several valuable nests and eggs from the mountains of Pennsylvania have been added to the Delaware Valley Club collection.

Through the liberality of several members of the Academy a fund has been subscribed sufficient to secure for the institution a full set of the valuable Alaskan birds obtained by Mr. E. A. McIlhenny, which when added to the present series of American water birds will render it nearly complete.

The general activity in the study of ornithology at the Academy has continued during the year. The Delaware Valley Ornithological Club and Pennsylvania Audubon Society have held their meetings in the building. Many of our specimens have also been consulted by ornithologists from other institutions, notably by Mr. Robert Ridgway, who has made considerable use of the Academy's material in the preparation of his forthcoming monographs of American birds.

For assistance during the year the Conservator is indebted to Mr. J. A. G. Rehn.

At the annual meeting of the Section, held December 17, 1900, the following officers were elected:

Director,	Spencer Trotter, M.D.
Vice-Director,	George Spencer Morris.
Recorder,	Stewardson Brown.
Secretary,	William A. Shryock.
Treasurer and Conservator,	Witmer Stone.

Respectfully submitted,

WITMER STONE,

Conservator.

The election of Officers, Councilors and Members of the Committee on Accounts to serve during 1901 was held with the following result:

President,	Samuel G. Dixon, M.D.
Vice-Presidents,	Thomas Meehan,
	Arthur Erwin Brown.
Recording Secretary,	Edward J. Nolan, M.D.
Corresponding Secretary,	Benjamin Sharp, M.D.
Treasurer,	George Vaux, Jr.
Librarian,	Edward J. Nolan, M.D.
Curators,	Henry C. Chapman, M.D.,
	Arthur Erwin Brown,
	Samuel G. Dixon, M.D.,
	Henry A. Pilsbry, Sc.D.
Councilors to serve three years,	Charles Schaeffer, M.D.,
	Dr. C. Newlin Pierce,
	Theodore D. Rand,
	Philip P. Calvert, Ph.D.
Committee on Accounts,	Uselma C. Smith,
	Charles Morris,
	William L. Baily,
	Harold Wingate,
	Lewis Woolman.

COUNCIL FOR 1901.

Ex-officio.—Samuel G. Dixon, M.D., Thomas Meehan, Arthur Erwin Brown, Edward J. Nolan, M.D., Benjamin Sharp, M.D., George Vaux, Jr., Henry A. Pilsbry, Henry C. Chapman, M.D.

To serve Three Years.—Charles Schaeffer, M.D., Dr. C. Newlin Pierce, Theodore D. Rand, Philip P. Calvert, Ph.D.

To serve Two Years.—Thomas A. Robinson, Charles H. Cramp, Charles Morris, Isaac J. Wistar.

To serve One Year.—Charles Roberts, Uselma C. Smith, John Cadwalader, William Sellers.

ELECTIONS DURING 1900.

MEMBERS.

January 30.—Florence Bascom, William E. Barrows, S. Mendelson Meehan, Catharine G. Dixon, William R. Reinick.

February 27.—Harry G. Parker.

March 27.—John W. Harshberger, Ph.D., John H. Converse.

April 24.—Walter T. Taggart, M. G. Miller, M.D.

May 30.—W. H. Bower, John Thomson.

September 25.—Lowndes Taylor, Helen Taylor, Emily Hinds Thomas.

October 30.—Thomas S. Stuart, M.D.

November 27.—T. Percival Gerson, M.D.

CORRESPONDENTS.

February 27.—Henri Lacaze-Duthier, of Paris; Frederic W. True, of Washington.

ADDITIONS TO THE MUSEUM.

MAMMALS.

G. W. BELL. Three specimens of Varying Hare, *Lepus americanus virginianus*, from Pennsylvania, prepared as skins.

OTTO BEHR. Red Squirrel, *Sciurus hudsonius loquax*, Pennsylvania. Skin.

J. L. BUCK. Young Black Bear, *Ursus americanus*, prepared as skin.

H. C. CHAPMAN, M.D. *Notoryctes typhlops*, specimen in alcohol and mounted skeleton; *Semnopithecus sp.*, brain; *Cheiromys madagascariensis* in alcohol.

J. E. CLEAVELAND, M.D., through S. N. Rhoads. Varying Hare, *Lepus americanus virginianus*, Bradford county, Pa., prepared as a mount.

H. W. FOWLER. Five skins from Holmesburg, Pa., *Putorius noveboracensis*, *Scalops aquaticus*, *Didelphis virginianus* (2), *Blarina brevicauda*.

EDW. B. GLEASON, M.D. Ear bone of Whale.

ANNA HARTSHORNE. Mounted specimen of Rat, *Mus* sp., Japan.

DAVID MCCADDEN. Skull of Caribou, *Rangifer terræ-novæ*.

MRS. J. A. MARSDEN. Mummified Rat.

PURCHASED. Young Orangutan, *Simia satyrus*, in alcohol; *Macacus maurus*, prepared for mounting.

ABRAHAM REED, M.D. Mounted specimen of Gray Seal, *Holochœrus gryphus*, Tadousac Bay.

S. N. RHOADS. Mole, *Scalops aquaticus*, Audubon, N. J., prepared as skin.

P. A. SHEAFF, M.D. Preparation of Human Ear.

MRS. CHARLES SCHAEFFER. Skin of Alaskan Lynx, *Lynx canadensis mollipilosus*; skins of *Arctomys*, *Neotoma* and *Peromyscus*, from Glacier, B. C.

E. W. COLES. Double Kitten in alcohol.

Henry Warrington. Mounted Opossum, *Didelphis virginianus;* two skins and skulls of *Oryzomys palustris*, from Salem, N. J.

Zoological Society of Philadelphia. The following specimens which have been prepared as indicated: Mounted: Black Macaque, *Macacus maurus*, female; Vervet Monkey, *Cercopithecus pygerythrus;* Green Monkey, *C. callitrichus*, male; Diadem Monkey, *C. leucampyx*, male; Mona Monkey, *C. mona*, female; White-crowned Mangaby, *Cercocebus æthiops;* Wanderoo, *Macacus silenus;* Leonine Macaque, *Macacus leoninus*, male; Arabian Baboon, *Papio hamadryas;* Mongoose, *Herpestes mungo;* Prong-horned Antelope, *Antilocapra americana*, male and female; Vulpine Phalanger, *Trichosaurus vulpecula*, female. To be mounted: Leopard, *Felis pardus*, female; Jagarundi, *Felis jagarundi*, male; Long-eared Fox, *Otocyon megalotis*, male; Coati, *Nasua narica;* Collared Peccary, *Dicotyles angulatus*, male; Bennett's Gazelle, *G. bennetti*, male; Rufous-necked Wallaby, *Halamaturus ruficollis*, male; Prevost's Squirrel, *S. prevosti*, male. Skins and skulls: *Cercocebus collaris, C. albigularis, Cercopithecus erythrogaster, Cercopithecus sp., C. callitrichus, C. ludio, C. niger, C. mona, C. nictitans, Macacus maurus, Galera barbara, Canis azaræ, Cholæpus* sp., *Halamaturus ruficollis, Bettongia gaimardi, Sciurus bicolor* (no skull), *Lepus arizonæ* (no skull), *Lynx rufus arizonæ, Coendou prehensilis.* Skins and skeletons: *Otocyon megalotis, Nasua narica.* Rough skeletons: *Ateles ater, Lemur macaco* (2) *Macacus maurus, M. fuscatus, Ursus arctos, Fennecus zerda, Ibex ibex, Bison bison* (two males). Skulls: *Cercopithecus cephus* and *Bassariscus astutus.* Alcoholic: *Cercophithecus pygerythrus* (juv.), two young Monkeys, *Cercopithecus campbelli* (juv.), *Nyctipithecus trivirgatus, Nycticebus tardigradus, Lemur macaco, Lemur albifrons, Dipus jaculus, Neotoma albigula, Didelphis virginianus* (very young).

In exchange: Two alcoholic specimens of *Phyllonycteris planifrons.*

Birds.

American Colonization Society. Two cases of mounted birds from Liberia.

H. C. Borden. Game Rooster, prepared as a skin.

H. G. BRYANT. Marsh Hawk, *Circus hudsonius*, prepared as a skin.

DAVID CONOVER. Mounted Peacock.

S. G. DIXON, M.D. Cooper's Hawk, *Accipiter Cooperi*, Hamburg, Pa., prepared as a skin.

DELAWARE VALLEY ORNITHOLOGICAL CLUB. Seven nests and eggs, and six mounted birds from Pennsylvania, collected by W. L. Baily, Otto Behr, Witmer Stone and Henry Warrington.

GEORGE L. FARNUM. Two Pileated Woodpeckers, *Ceophlœus pileatus*, from Ontario, prepared as skins.

ANNA HARTSHORNE. Two mounted Japanese birds.

HORATIO HALE (est.). Case of twelve mounted birds from the South Pacific, collected on the U. S. Exploring Expedition.

DAVID MCCADDEN. Sternum of *Olor columbianus* and four skulls of *Numenius hudsonius*.

C. J. PENNOCK. Flat skin of *Campephilus principalis*, Florida.

PURCHASED. The Hoopes Collection of North American Birds, some 8,000 specimens.

MRS. CHARLES SCHAFFER. Six bird skins from Glacier, B. C.

H. G. PARKER. Skin of *Junco hyemalis pinosus*.

JOHN CARSON. Triple Robin's nest, Wynnewood, Pa.

HENRY WARRINGTON. Collection of bird skins from California.

ALBERT WHITAKER. Great Blue Heron, *Ardea herodias*.

ZOOLOGICAL SOCIETY OF PHILADELPHIA. The following were prepared as indicated: Skins: *Chrysotis* sp., *Cassicus* sp., *Dendrocygna javanica, Garrulax chinensis.* Skull and sternum: *Tantalus loculator, Porphyrio calvus, Coscoroba coscoroba.* Skull: *Porphyrio, Goura coronata.* Rough skeleton, *Dendrocygna javanica.*

REPTILES AND BATRACHIANS.

ARTHUR ERWIN BROWN. *Varanus varanus* (2), *Tiliqua scincoides* (?), *Chelodina longicollis*.

STEWARDSON BROWN. Collection of twenty-five Snakes and Salamanders from Lake Ganoga, Pennsylvania.

J. L. BUCK. *Alligator mississippiensis* prepared as rough skeleton.

R. D. CARSON. Hamadryas Cobra.

G. A. BOULENGER. A series of European Batrachia.

CLARENCE B. MOORE. Six casts of Snakes.

J. W. Peirce. Four *Amblystoma punctatum*, Clifton, Delaware county, Pa.

C. W. Potts. Mounted *Heloderma suspectum*, Arizona.

Purchased. *Necturus maculatus*, Darby Creek, Delaware county, Pa.

Hon. Walter Rothschild. *Testudo ephippium*, Duncan Island, Galapagos.

Marian Skinner. *Liopeltis vernalis*, Lake George, N. Y.

H. C. Wood, M.D. A small collection of Batrachia from Japan.

Zoological Society of Philadelphia. *Crotalus durissus* (3), *Coluber obsoletus lindheimeri* (2), *Spilotes corais xanthoura*, *Lachesis lanceolatus*, *Boa diviniloqua*, *Macrochelys lacertina*, *Ctenosaura acanthura*, *Tiliqua scincoides*, *Testudo argentina*, *Testudo geometrica*.

Fishes.

H. C. Chapman, M.D. Skeleton, dried specimen and alcoholic specimen of *Callirhynchus antarcticus*, skeleton of *Chimaera* and small shark, articulated skeleton of head of Codfish, alcoholic specimen of *Polistotrema dombey*.

S. G. Dixon, M.D. Egg of Shark, Islesboro, Me.

Louis Paris. Saw of Sawfish.

J. B. Samuel. Boney plate of Sturgeon.

C. S. Tyler. *Lophius piscator* from Ocean City, N. J.

Henry Warrington. Eight fishes from the West Indies.

Recent Mollusca.

C. F. Ancey. Three trays and two bottles of land shells from Algeria.

Mrs. George Andrews. Five trays of land shells from Tennessee.

F. H. Andrus. Five trays and four bottles of land and fresh-water shells from Oregon.

Edwin Ashby. Four trays and one bottle of Chitons from South Australia.

Rev. E. H. Ashmun. One hundred and nine trays and four bottles of land shells from Arizona, New Mexico and California.

F. C. Baker. One tray of *Pisidium* from New York.

F. N. Balch. Nine trays of marine shells from Coldspring Harbor, Long Island Sound.

F. H. Brown. Ninety-three trays of shells from New Jersey and Pennsylvania.

Stewardson Brown. Twenty-seven trays and twelve bottles of land shells from Potter and Clinton counties, Pa.

F. W. Bryant. Five trays of shells and one bottle of *Agriolimax* from California.

F. L. Button. Thirteen trays and two bottles of West Coast land shells.

H. C. Chapman, M.D. Alcoholic specimens of *Nautilus pompilius* L. and one tray of land shells from Gibraltar.

George H. Clapp. Twenty-one trays of land shells from Maine and Tennessee, U. S., and Colombia, S. A.

T. D. A. Cockerell. Seventy-three trays and three bottles of land shells from New Mexico, etc.

J. C. Cox, M.D. Nine trays of land shells from Australia, etc.

W. H. Dall, M.D. Three trays and two bottles of land shells from Cocos Island, W. Mexico, etc.

L. E. Daniels. Four trays of land and fresh-water shells.

S. M. Edwards. Fourteen trays of land and fresh-water shells from North Dakota.

C. H. Eigenmann. Types of *Helicodiscus eigenmanni* Pils.

M. J. Elrod. Thirteen trays and one bottle of land and fresh-water shells from Montana.

J. H. Ferriss. Two hundred and fifteen trays and sixteen bottles of United States land shells.

John Ford. One tray of *Mopalia* from California.

H. W. Fowler. Two trays of fresh-water shells from Pennsylvania and New York.

L. S. Frierson. Nine trays of fresh-water shells from Louisiana.

M. R. Gaines. Three trays of Japanese land shells.

Mrs. E. M. Gaylord. One tray of *Trophon* from Calfornia.

G. K. Gude. Six trays of Japanese land shells.

Addison Gulick. Seven trays of Chinese and Japanese land shells.

A. C. Hartshorne. Eight trays of marine shells from Japan.

S. W. Heaton. Two trays of marine shells from Gloucester, Mass.

Angelo Heilprin. Two trays of land shells from New York and Bermuda.

H. Hemphill. Eight trays of marine shells from California.

J. B. Henderson, Jr. Cotypes of *Crossopoma enganoense* Hend.

Y. Hirase. Two hundred and ninety trays of land shells from Japan.

J. D. Jamison. Seven trays of land and fresh-water shells from North Dakota.

C. W. Johnson. Forty-seven trays and fourteen bottles of land shells from Florida, Panama and Borneo.

Miss E. J. Letson. Eleven trays of *Limnæa* from New York.

J. G. Malone. Eighty-four trays of marine shells from South Africa.

R. C. McGregor. Fourteen trays and ten bottles of land shells from Alaska.

William Meehan. Six trays and one bottle of marine shells from Florida.

Clarence B. Moore. *Scaphella junonia* Kwass. from Florida.

H. A. Pilsbry. One hundred and thirty-two trays and ten bottles of American mollusks.

George Pine. Seven trays of land shells from Aripeka, Fla.

E. Pleas. *Goniobasis plebeius* Anth. from Arkansas.

Sadie F. Price. Two trays of land and fresh-water shells from Kentucky.

J. A. G. Rehn. Two bottles of New Jersey marine shells.

S. N. Rhoads. Twelve trays and one bottle of land shells from Florida and Pennsylvania.

H. E. Sargent. Fifty-nine trays of land shells from Tennessee.

Silas L. Schumo. Twenty trays of fresh-water and marine shells from Europe and America.

Benjamin Sharp, M.D. Seven trays of land and marine shells from Bavaria and Greenland.

J. A. Singley. Three trays of fresh-water shells from Texas.

USELMA C. SMITH. Ten trays and one bottle of land shells from Jamaica and Pennsylvania.

W. W. SMITH. *Terebra cerethina* Lam.

R. E. C. STEARNS. Two trays of land shells from California.

WITMER STONE. Five trays of land shells from Wyoming county, Pa.

D. THAANUM. Sixty trays of land and marine shells from Hawaii and Queensland.

UNIVERSITY OF MICHIGAN. One hundred and six trays of shells.

E. G. VANATTA. Forty-two trays of land and fresh-water shells from Pennsylvania and the Philippine Islands.

T. VAN HYNING. Twelve trays of land and fresh-water shells.

J. W. VELIE. Type of *Calliostoma veliei* Pils. from southwest Florida.

A. E. VERRILL. Twenty-nine trays and thirteen bottles of land shells from Bermuda.

H. VON IHERING. Thirty-three trays of land and marine shells from South America.

BRYANT WALKER. *Somatogyrus* from Columbia, Pa.

J. J. WHITE. Twenty-six trays of land and marine shells from Bahamas.

WALTER F. WEBB. Four trays of land shells.

JOSEPH WILLCOX. *Fulgur pyrum,* Cape Sable, southwest Florida.

H. C. WOOD, M.D. *Melania* from Japan.

LEWIS WOOLMAN. Twenty-one trays of marine shells from New Jersey.

PURCHASED. Two hundred and eighty-six trays of East Indian land shells.

INSECTS.

MRS. C. R. WOODRUFF. A small collection of East Indian Lepidoptera.

H. C. WOOD, M.D. Four hundred and fifty insects from Japan.

ARTHUR ERWIN BROWN. Two Coleopterous larva and twelve specimens of "walking sticks."

H. W. Wenzel. A large collection of New Jersey and Pennsylvania ants.

Philip Laurent. A large nest of paper wasp; two larvæ of *Corydalus cornutus;* egg masses of *Tenodera sinensis;* two blown larvæ of *Hemileuca maia.*

W. F. Bednall. Nine Coleoptera from Australia.

Edward Potts. Ten larvæ of Coleoptera.

Purchased. A collection of Bolivian Odonata.

Crustacea.

H. C. Chapman, M.D. *Limulus polyphemus,* Atlantic City, N. J.

Dr. J. C. Cox. *Cypris,* West Australia.

H. W. Fowler. *Cambarus,* western Pennsylvania and New York.

Clarence B. Moore. *Limulus polyphemus,* Florida.

H. A. Pilsbry. Crabs from Biscayne Bay, Fla.

S. N. Rhoads. *Cambarus pellucidus,* Mammoth Cave, Ky.

Other Invertebrates.

F. H. Brown. Eight trays of Echinoderms, etc., New Jersey.

D. J. Bullock. *Cucumaria frondosa,* Bar Harbor, Me.

E. D. Cope (est.). Six species of *Gordius,* etc., North America.

Howard B. French. *Hyalonema* sp.

J. B. Hatcher. *Terebratula dorsata,* Patagonia.

Anna C. Hartshorne. Glass sponge, Japan.

D. N. McCadden. *Strongylocentrotus,* New Jersey.

H. A. Pilsbry. Sponge, Biscayne Bay, Fla.

Thomas Sharpless. *Limnodrilus* sp., West Chester, Pa.

Ethnology and Archæology.

Mrs. Harrison Allen. Human cranium.

Henry A. Perley. Dress of Blackfoot Squaw, Ravelstoke, B. C.

Est. of Dr. Robert Lamborn. Large collection of Mexican antiquities.

Miss Mary DaSilva. Large polished horn.

Invertebrate Fossils.

Charles Bolles, Jr. *Aturia*, Wilmington, N. C.

Rev. Leander Trowbridge Chamberlain, D.D. Seven hundred and twenty-four trays of Eocene and Oligocene fossils, chiefly from the Gulf States.

J. B. Hatcher. Six species of fossils from Cape Fairweather, Patagonia.

H von Ihering, Ph.D. *Corbula*, Patagonia.

C. W. Johnson. One hundred and forty species of Pliocene fossils from the Caloosahatchie River.

Joseph Willcox. Four species of Eocene and Pliocene fossils.

Minerals.

John Borden, through C. S. Welles. Rose Quartz, Silex quarry, Dutcher county, N. Y.

G. W. Chase. Series of specimens of Zinc Blende, Rush, Ark.

Raphæl Estrada. Galenite, Joplin, Mo.

E. J. Houston. Blende and Dolomite.

Louis Paris. Stalactite, and series of Italian Marbles.

Frances E. Peirce. Collection of Rocks and Minerals.

Theodore D. Rand. Serpentine (2), Beryl (2), Sphene, Galenite.

W. T. Ryder. Garnets, Connecticut.

Students' Mineralogical Club. Limonite Geode.

Purchased for the William S. Vaux Collection, 158 specimens.

Plants.

George M. Beringer. Two species of *Hieraceum*, New Jersey.

Stewardson Brown. Four hundred and twenty-five species of Florida plants, collected in 1894–95 by George V. Nash; 250 species of Pennsylvania and New Jersey plants.

Samuel G. Dixon, M.D. Five species Violets, Rose Glen, Pa.

Mrs. A. F. Ely. *Gyrostachys simplex*, Lancaster county, Pa.

Thomas Meehan. Ten species plants, mostly from cultivation.

Maria Pinckney. *Schweinitzia odorata*, Ell., North Carolina.

Mrs. E. S. Sayres. *Dryopturs Braunii*, New Hampshire.

Uselma C. Smith. Thirty-five species from vicinity of Lynchburg, Va.

United States National Museum. Forty species North American and European plants received in exchange.

E. G. Vanatta. Seventy species of plants collected near Chestertown, Md.

C. F. Saunders. One hundred and fifty species North American plants.

Additions have been acquired through purchase from the income of the Redfield Memorial Fund as follows:

John R. Barrows. One hundred and eight species California plants, the collections of Purpus and Anthony.

Theodore Bornmuller. One hundred and ninety-seven species Thuringian plants, collected in 1899; 255 species African plants from the Kamarun District.

H. E. Brown. Twenty species California and Oregon plants.

Willard N. Clute. One hundred and seventy-three species Jamaica plants, collection of 1900.

C. G. Pringle. Two hundred and sixty species Mexican plants, collection of 1899.

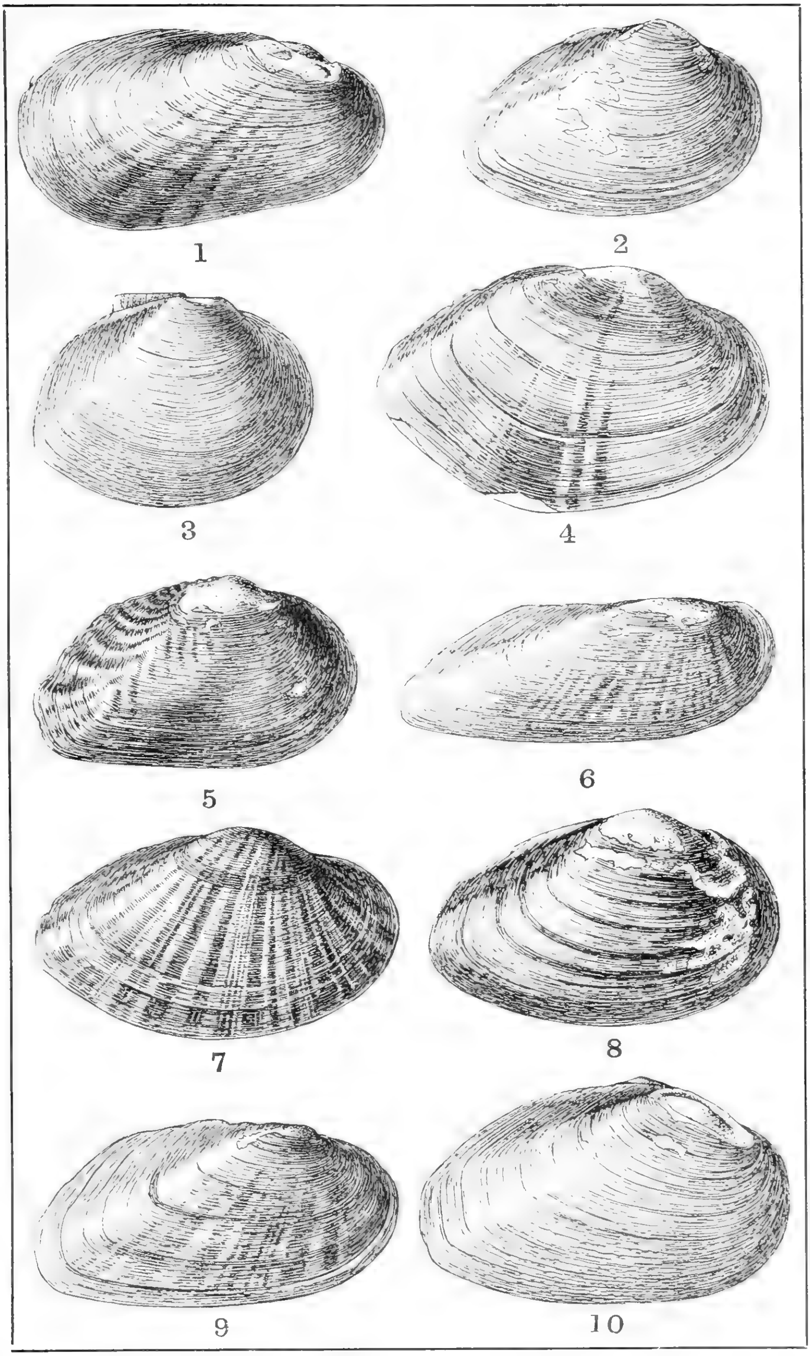
Fossil Plants.

C. B. Nichols. Large slab of Fern impressions, Sibley Mine, near Scranton, Pa.

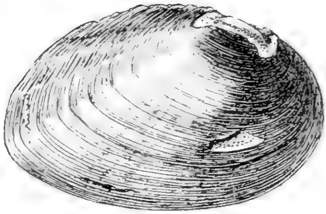
INDEX TO GENERA, ETC., 1900.

GENERAL INDEX.

1900.



SIMPSON. NEW AND UNFIGURED UNIONIDÆ.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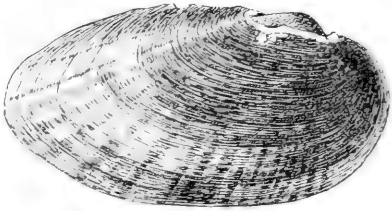
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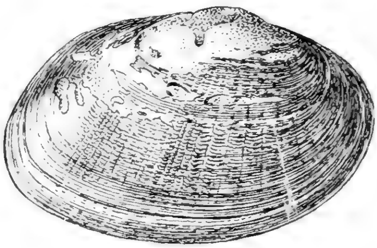
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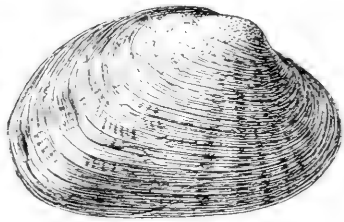
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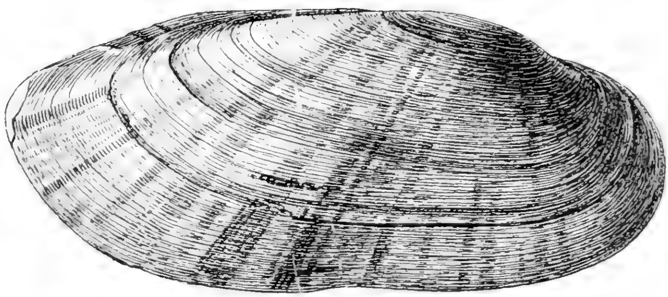
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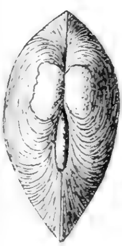
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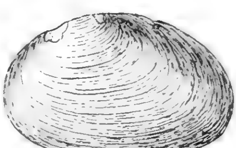
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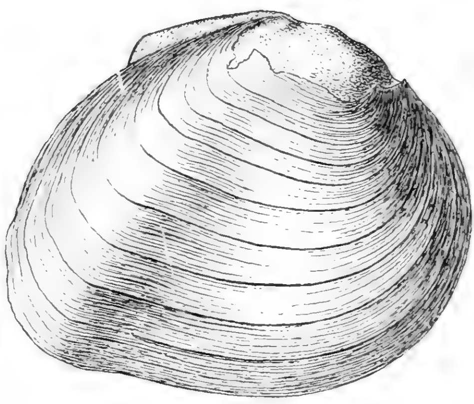
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SIMPSON. NEW AND UNFIGURED UNIONIDÆ.

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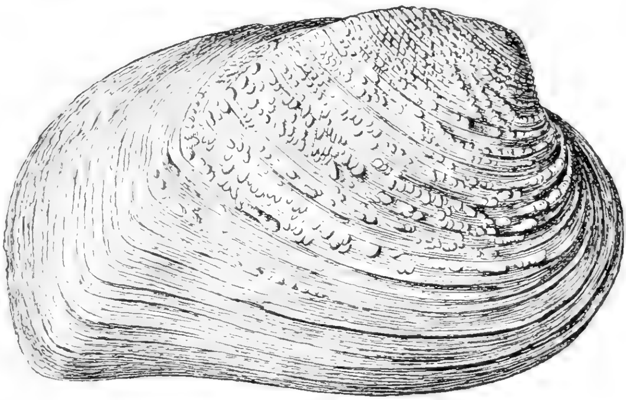

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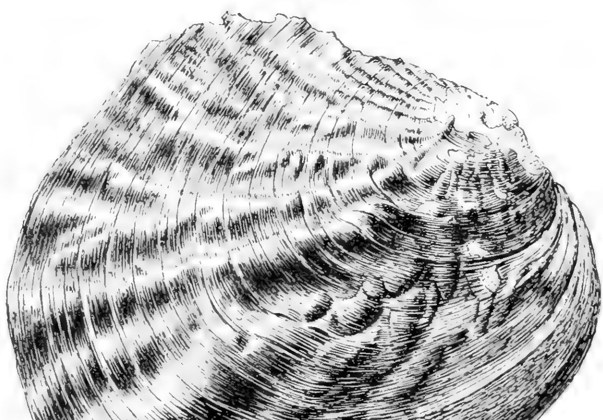

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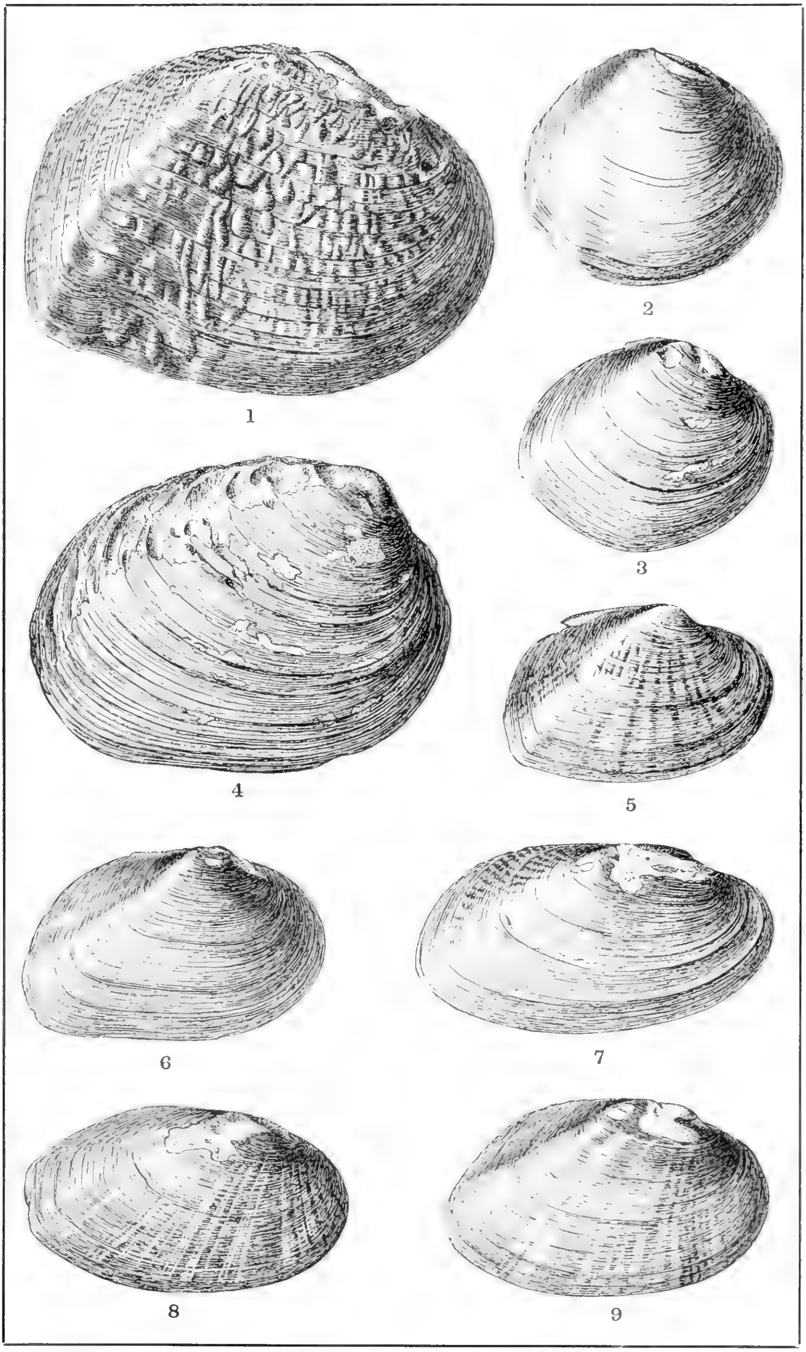

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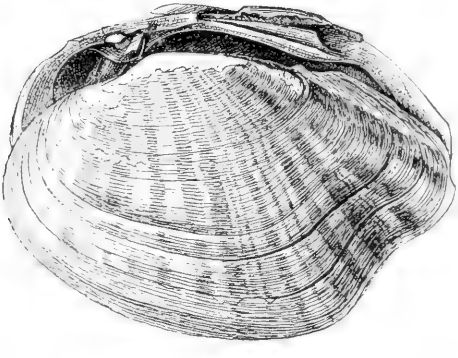

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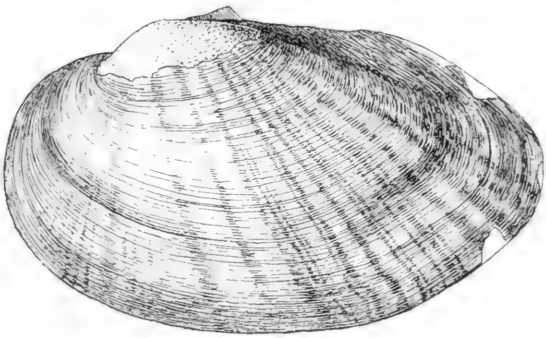

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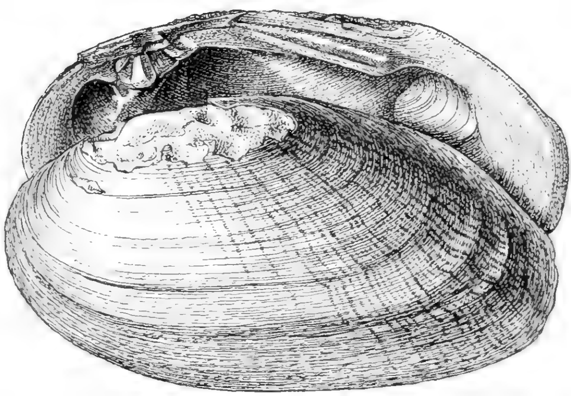

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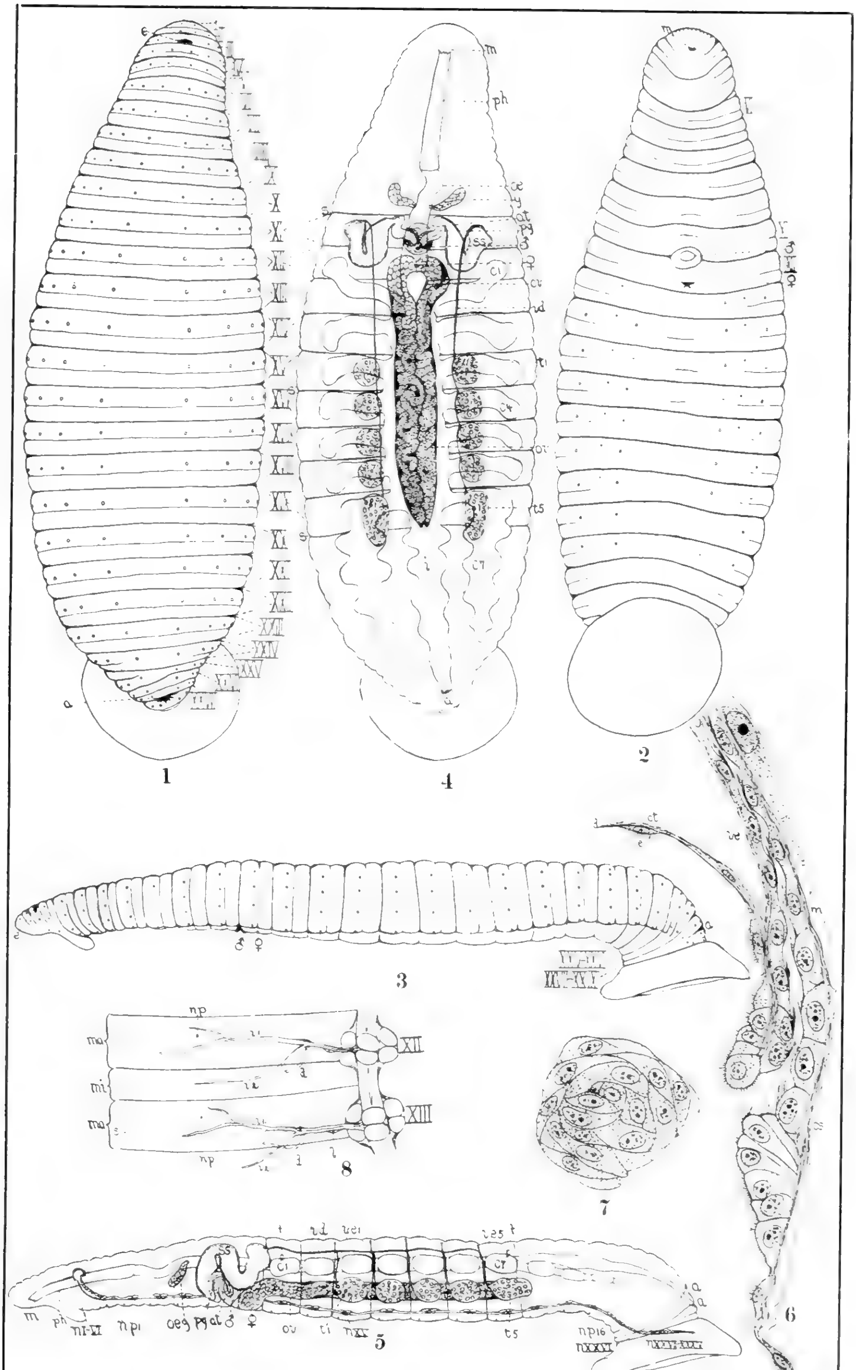
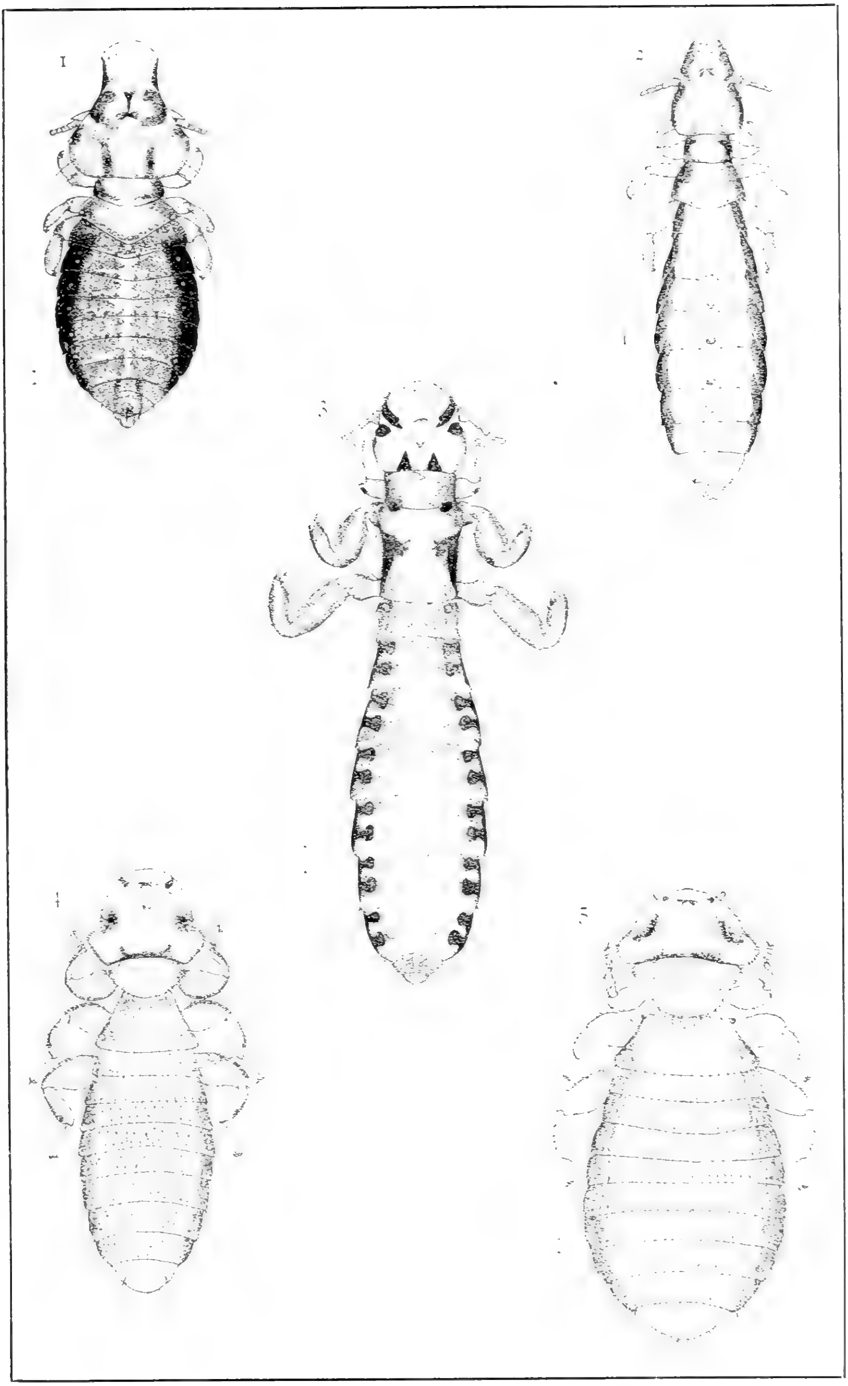
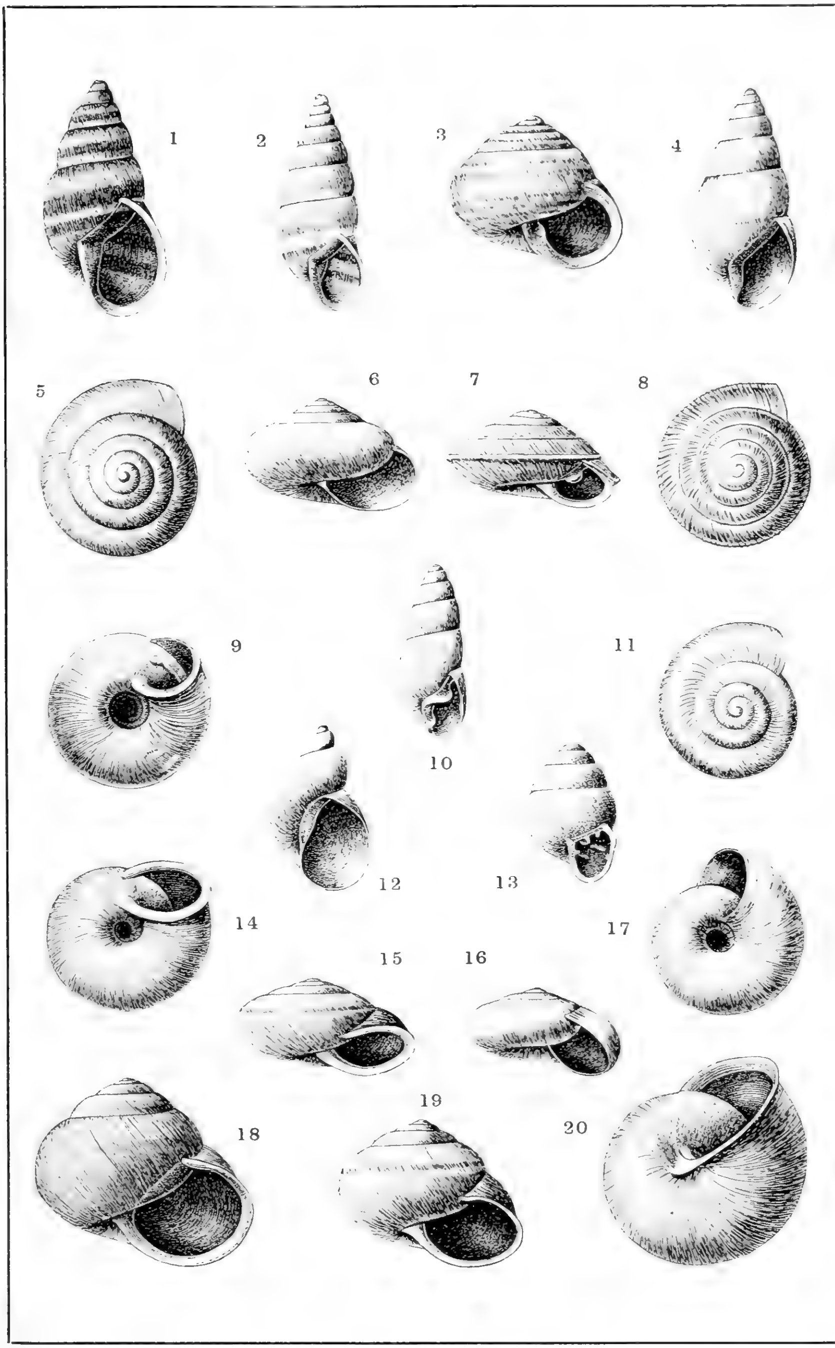


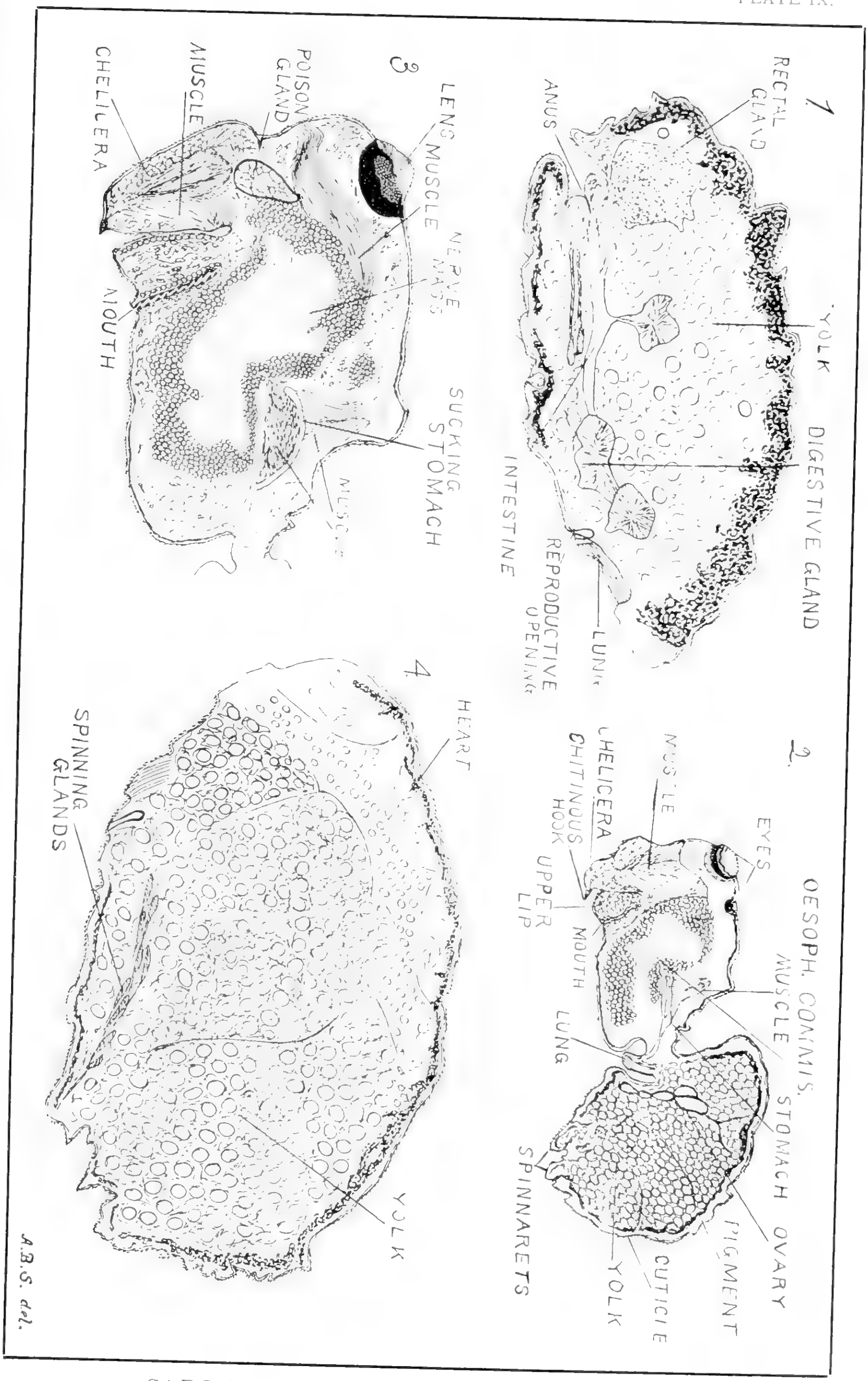
MOORE. MICROBDELLA BIANNULATA.



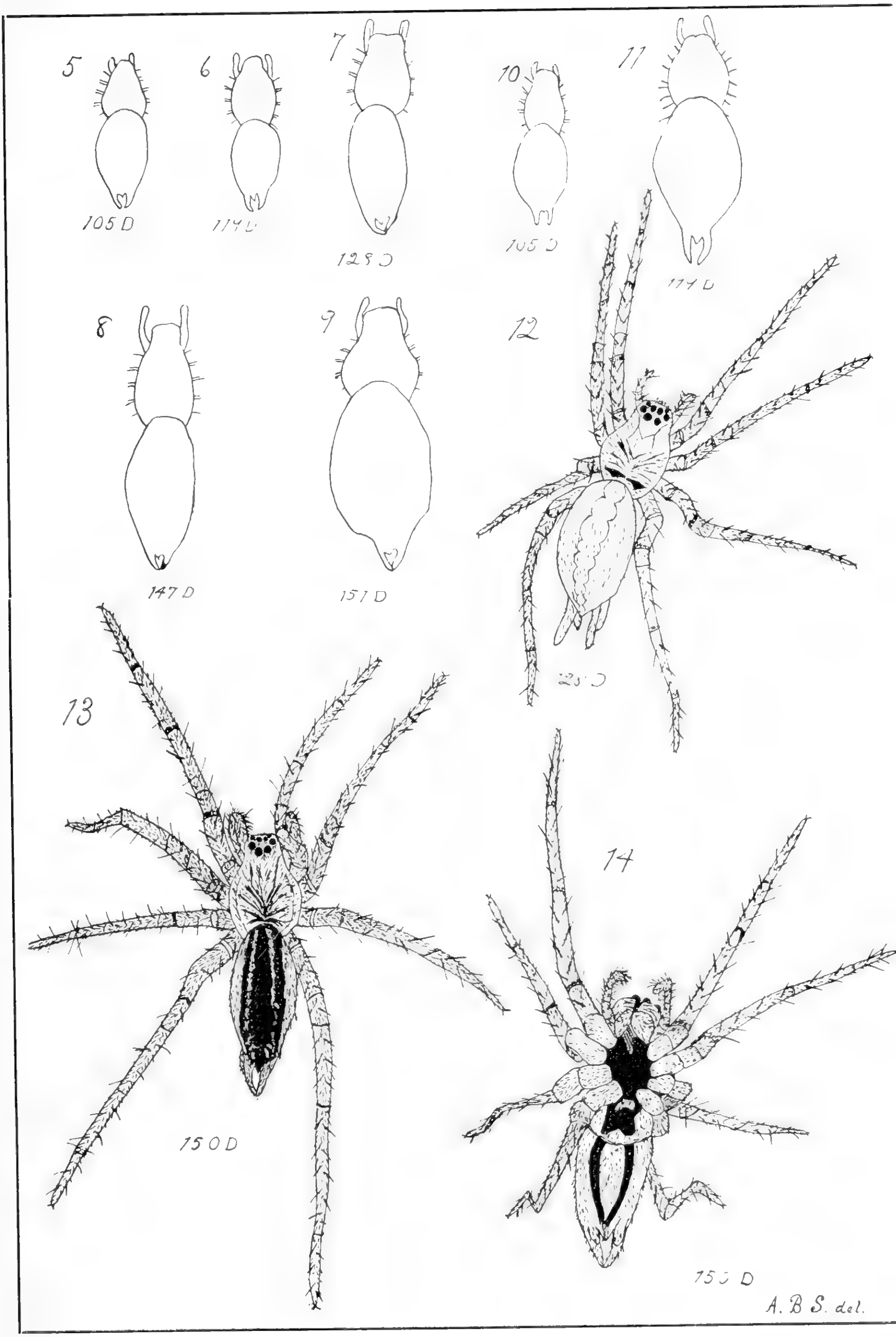
KELLOGG AND KUWANA. MALLOPHAGA FROM ALASKAN BIRDS.



DALL. PACIFIC INSULAR LAND-SHELL FAUNAS.



SARGENT. DEVELOPMENT OF SPIDERS.



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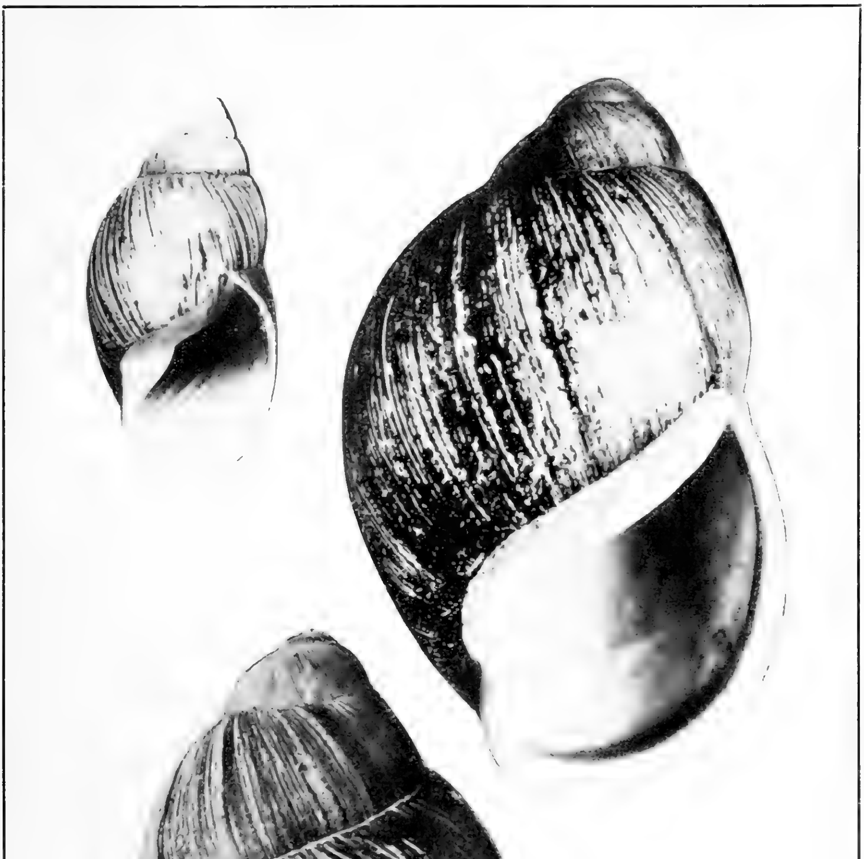
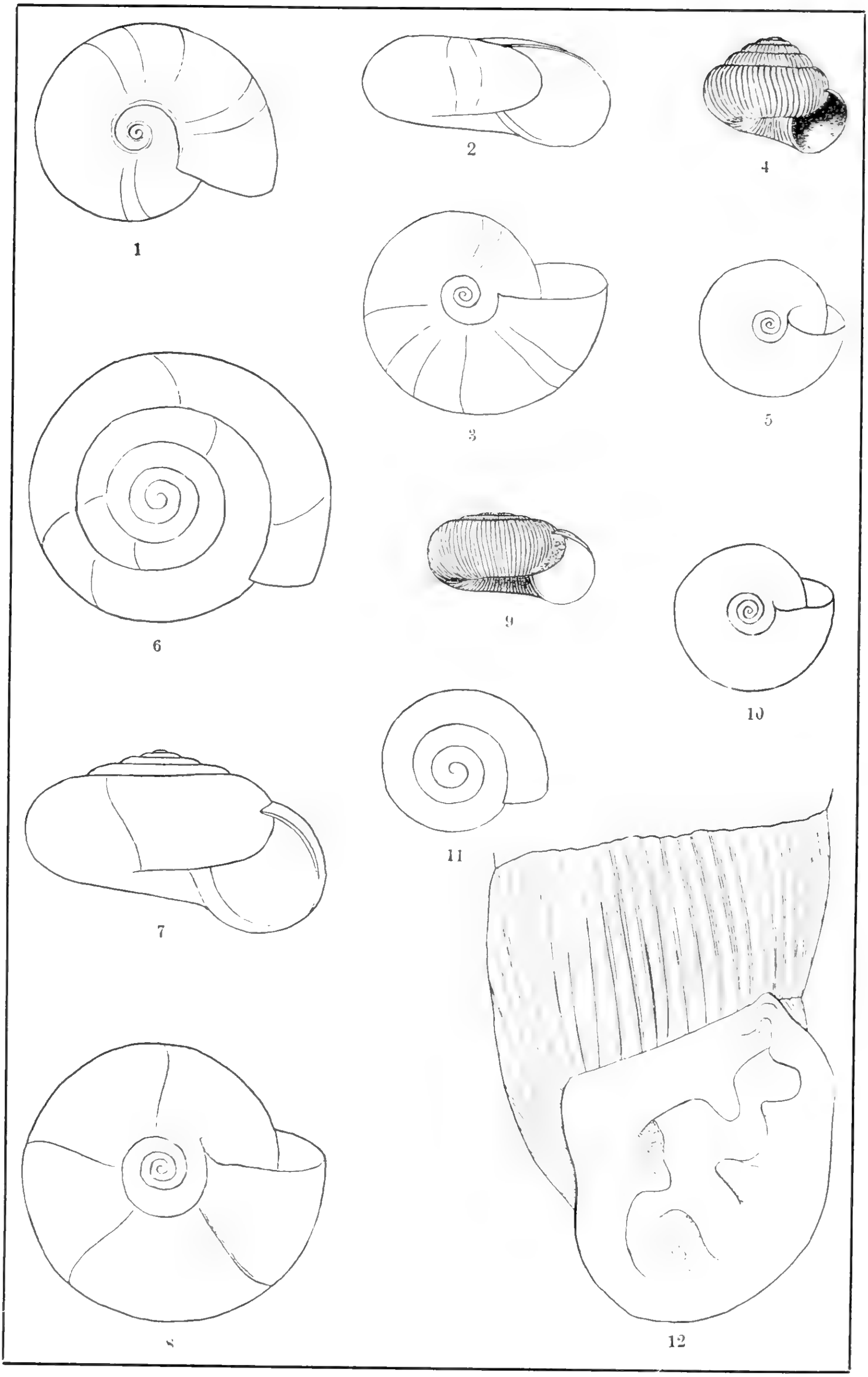
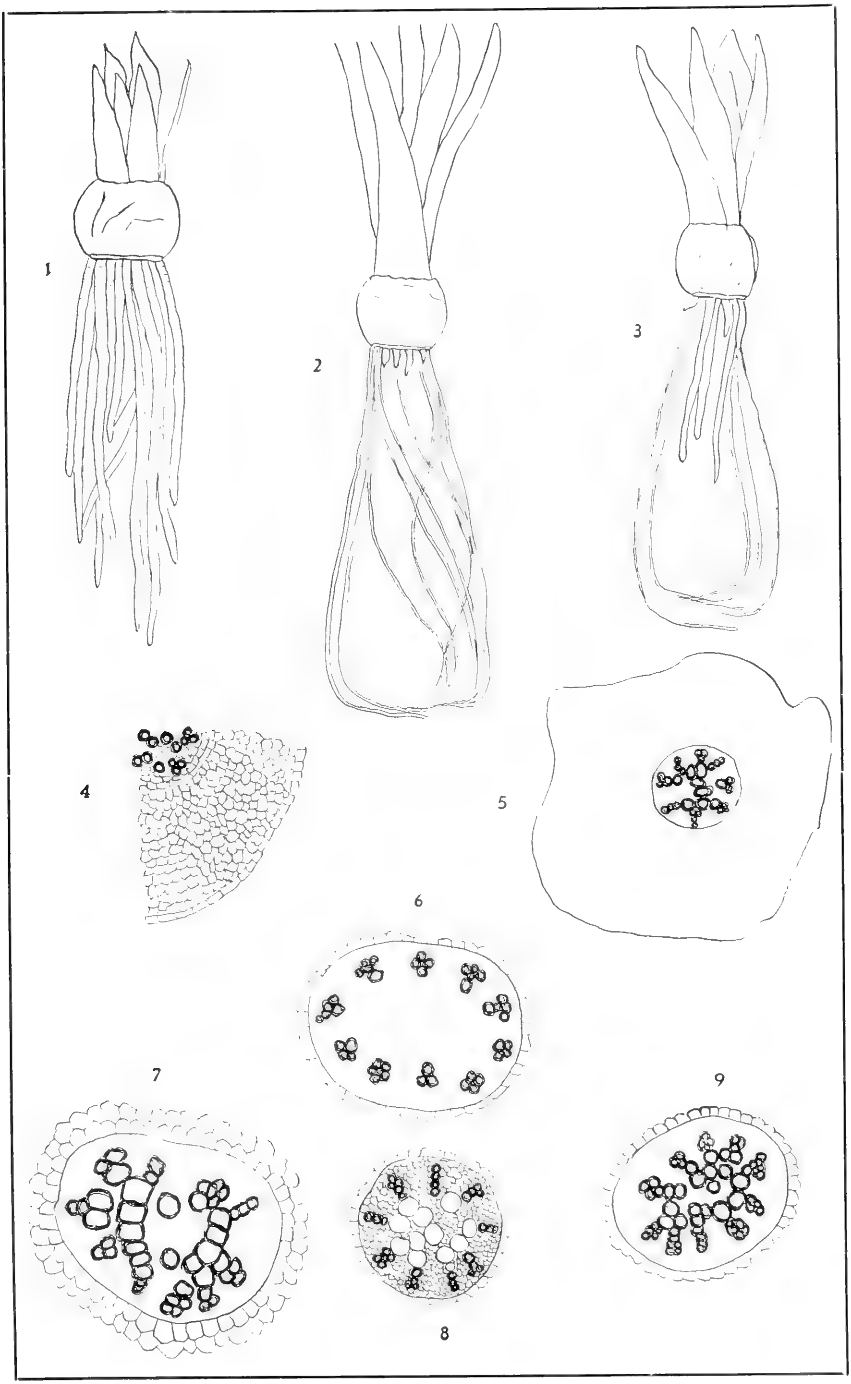


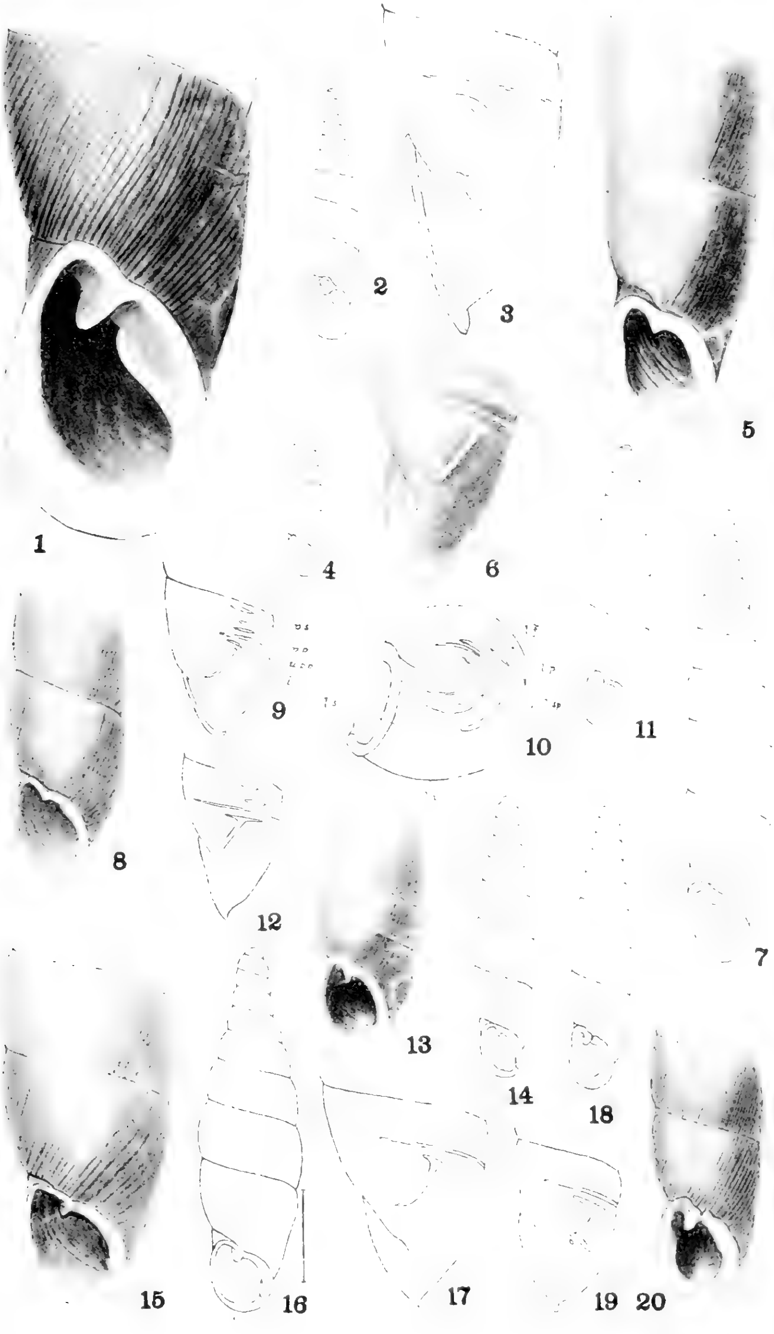
PILSBRY. SOUTH AMERICAN LAND SNAILS.



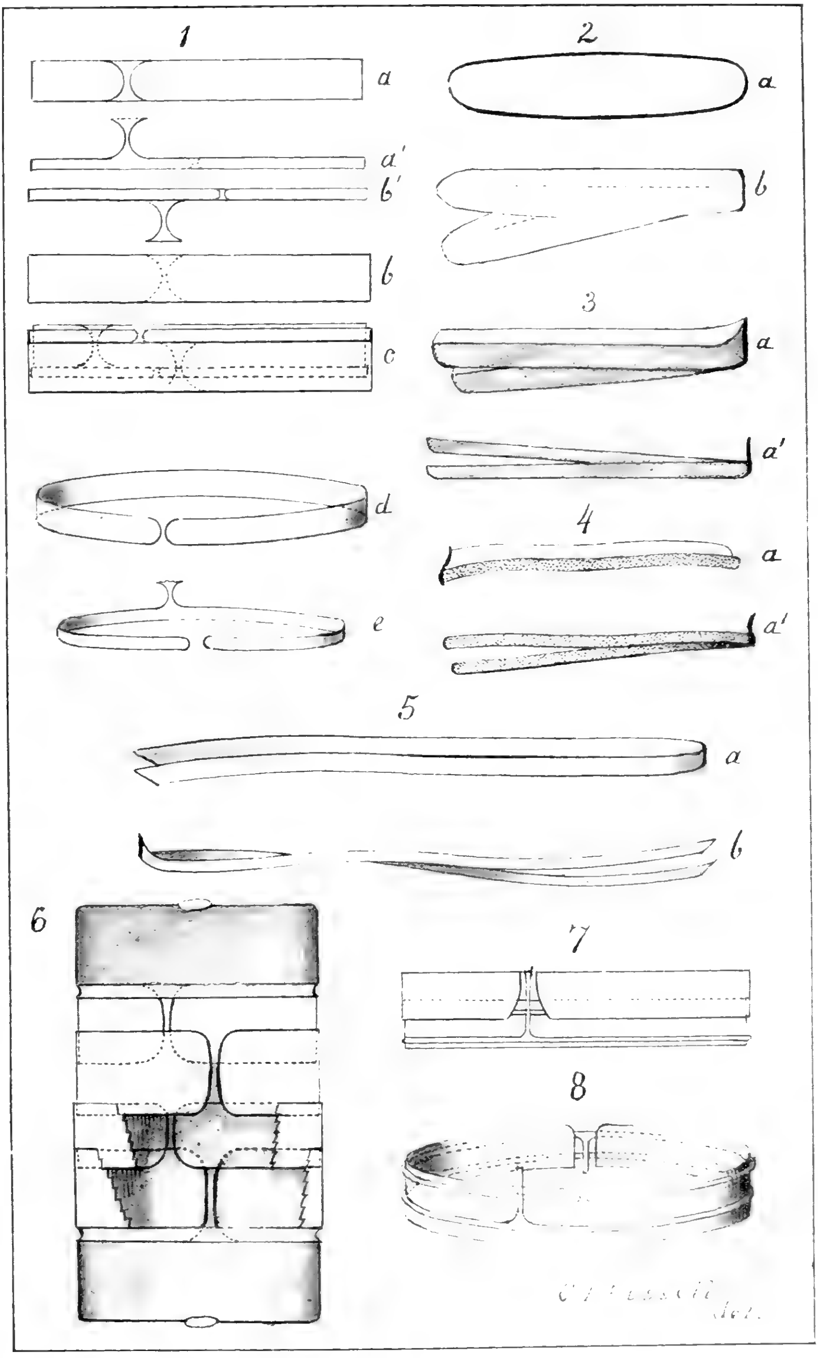
PILSBRY. SOUTH AMERICAN LAND SNAILS.



KELLER. HYACINTH ROOTS.



PILSBRY. JAPANESE LAND SNAIL FAUNA.



PALMER AND KEELEY. GIRDLE OF DIATOMS.

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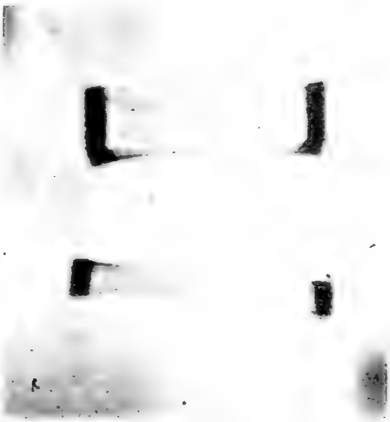

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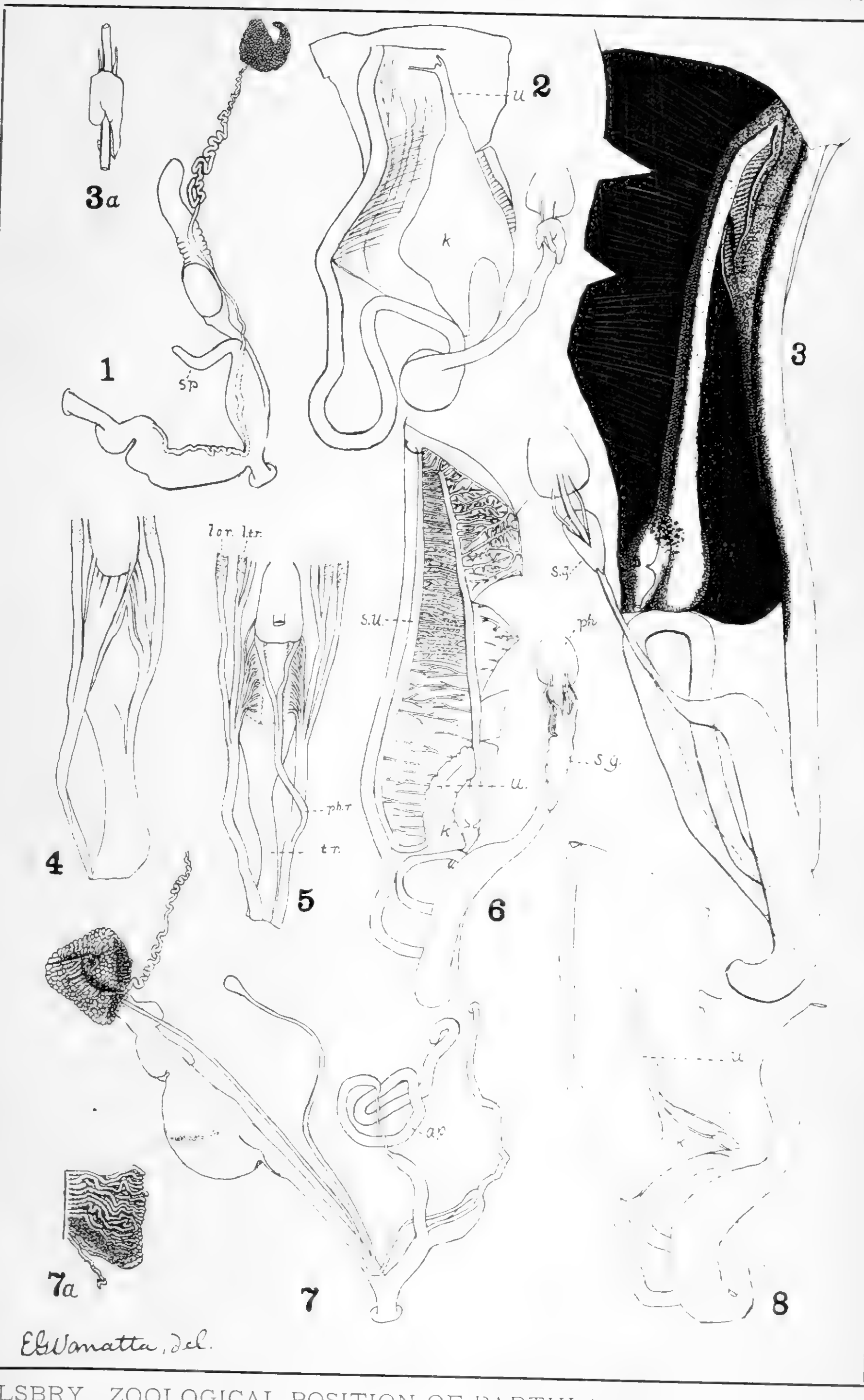
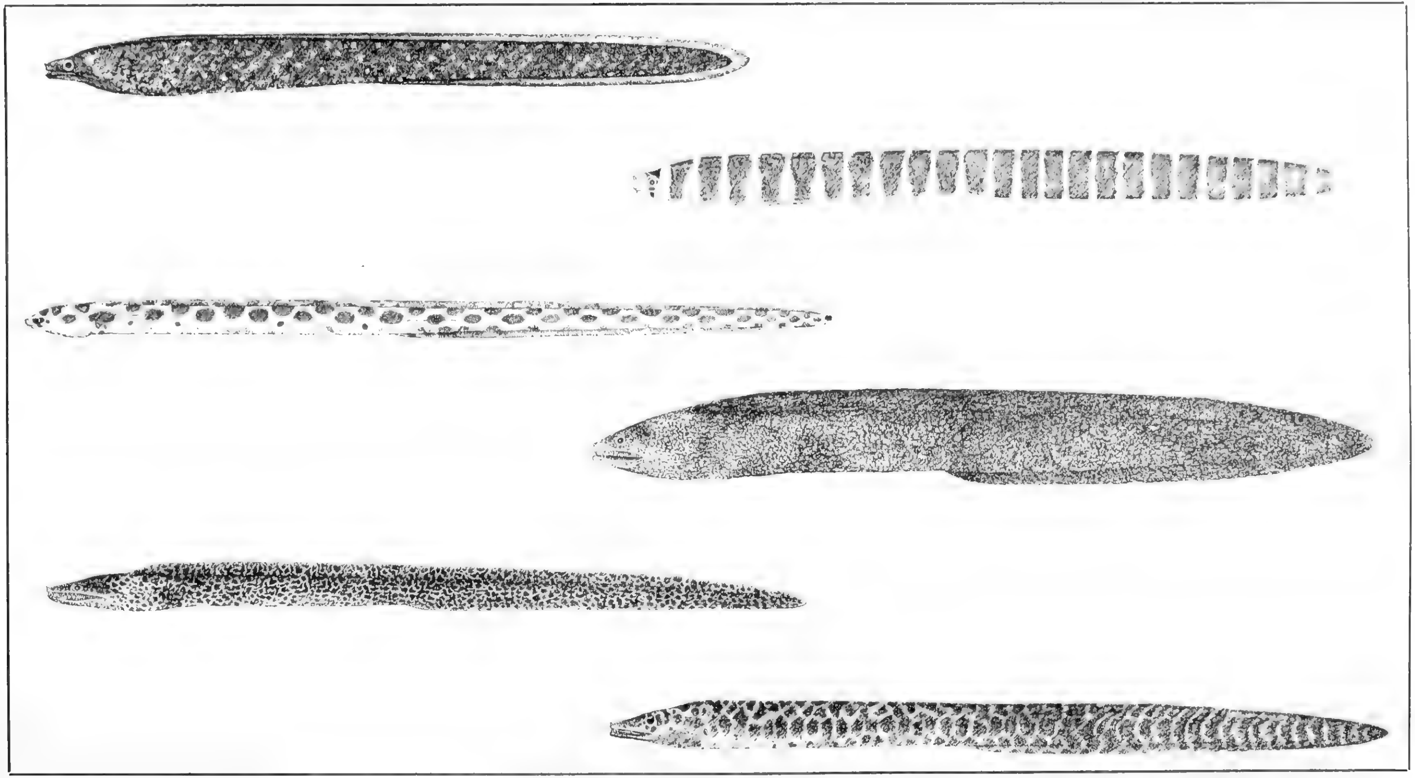
PALMER AND KEELEY. STRUCTURE OF DIATOMS

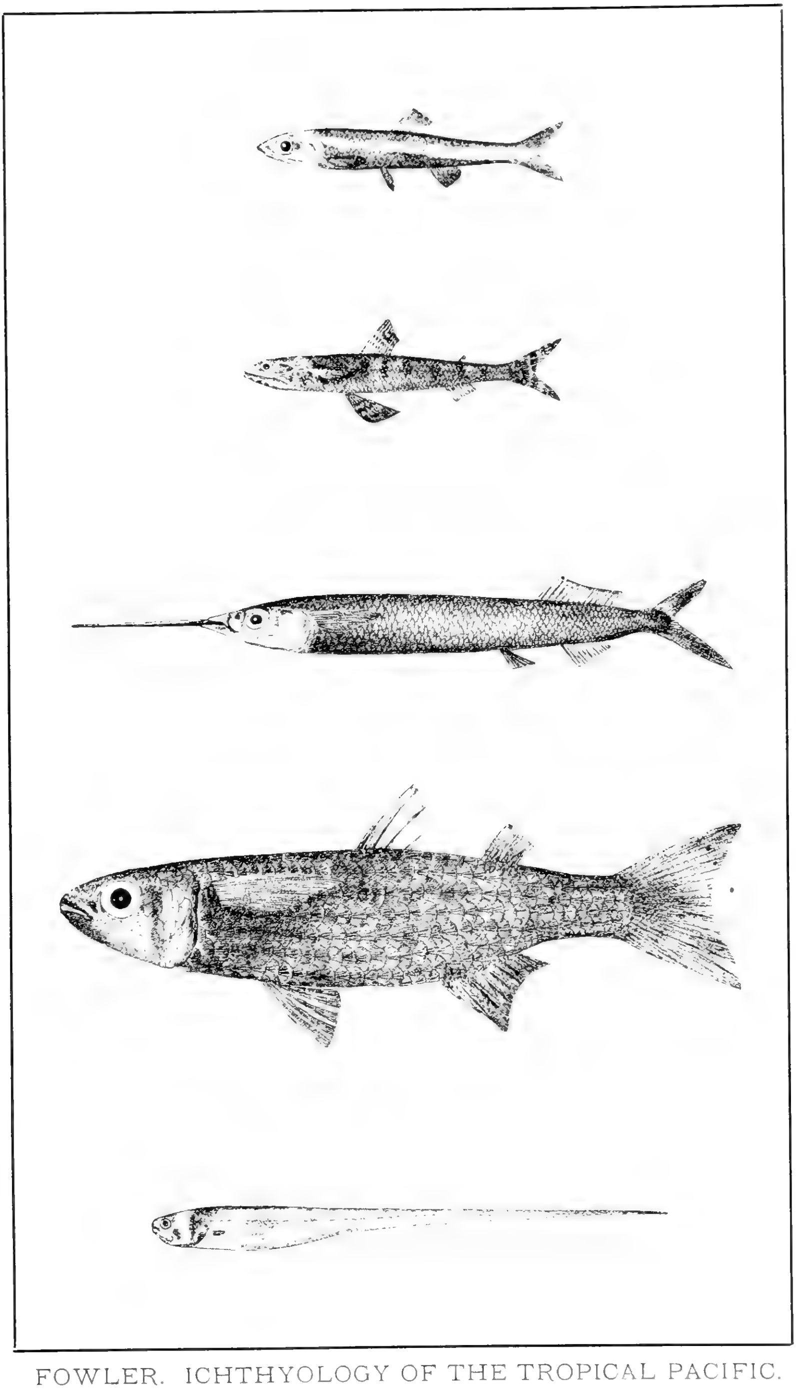


PILSBRY. ZOOLOGICAL POSITION OF PARTULA AND ACHATINELLA.



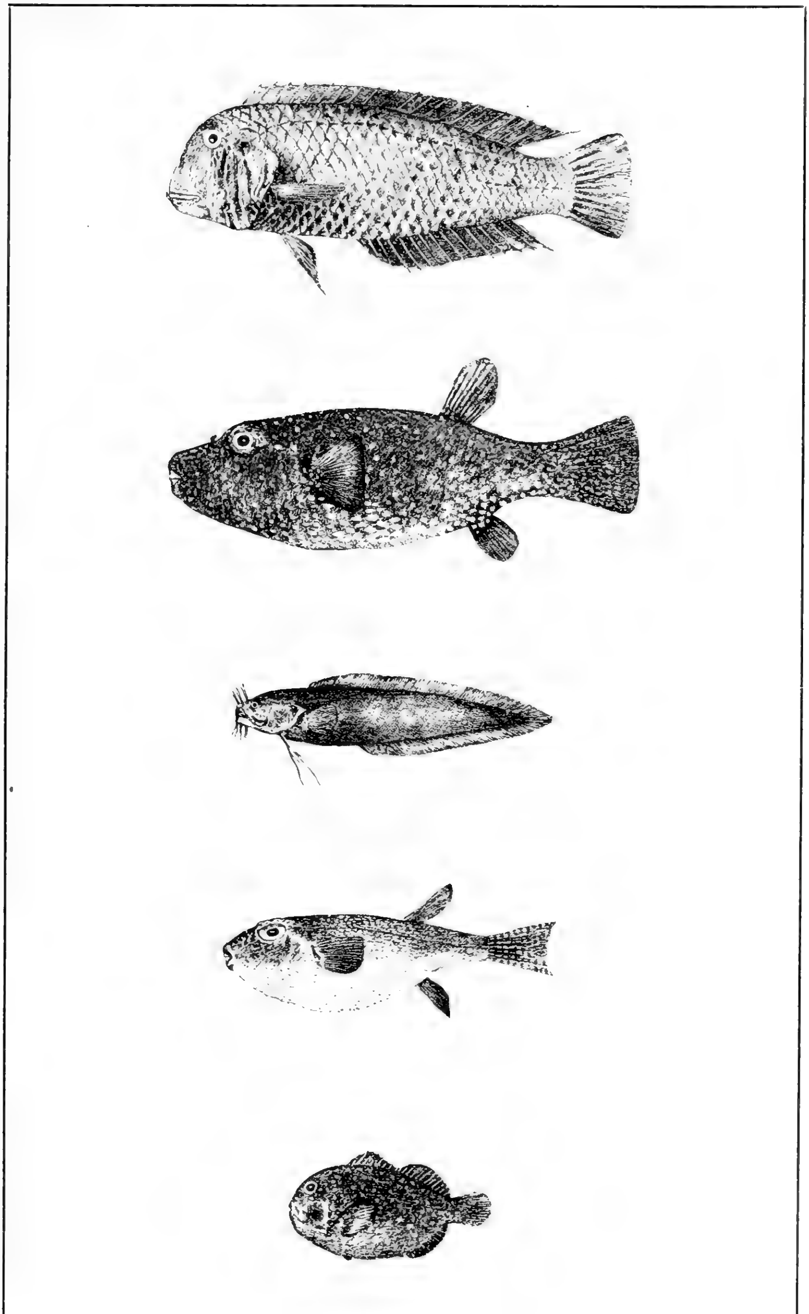
FOWLER. ICHTHYOLOGY OF THE TROPICAL PACIFIC.

1. LYCODONTIS PARVIBRACHIALIS FOWLER.
2. ECHIDNA ZONATA FOWLER.
3. MYRICHTHYS MAGNIFICUS (ABBOTT).
4. LYCODONTIS EUROSTA (ABBOTT).
5. LYCODONTIS ACUTIROSTRIS (ABBOTT).
6. LYCODONTIS KAUPI (ABBOTT).



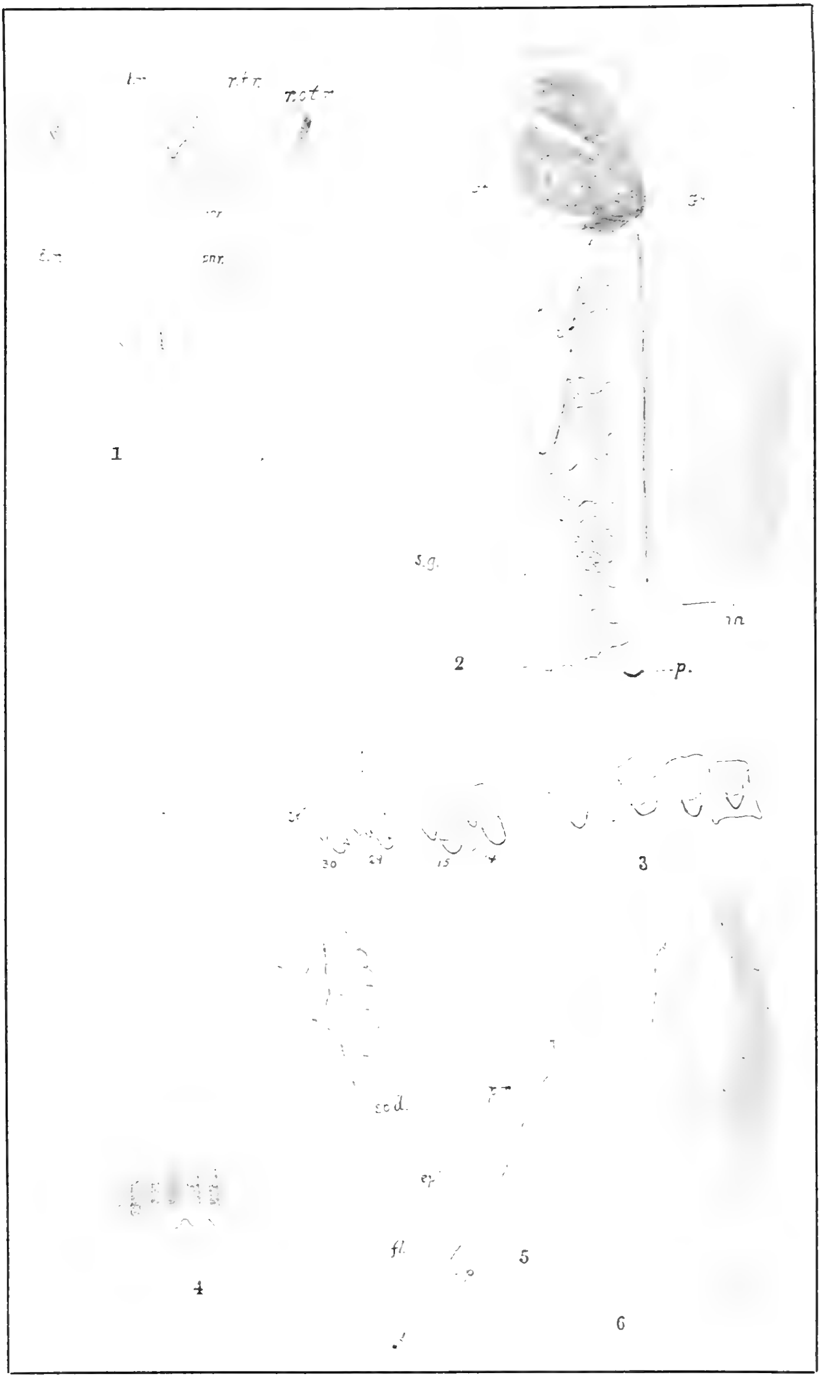
FOWLER. ICHTHYOLOGY OF THE TROPICAL PACIFIC.

1. STOLEPHORUS PURPUREUS Fowler.
2 SYNODUS SHARPI Fowler.
3. HEMIRAMPHUS DEPAUPERATUS Lay and Bennett.
4. MUGIL CALDWELLI Fowler.
5. FIERASFER PARVIPINNIS (Kaup).



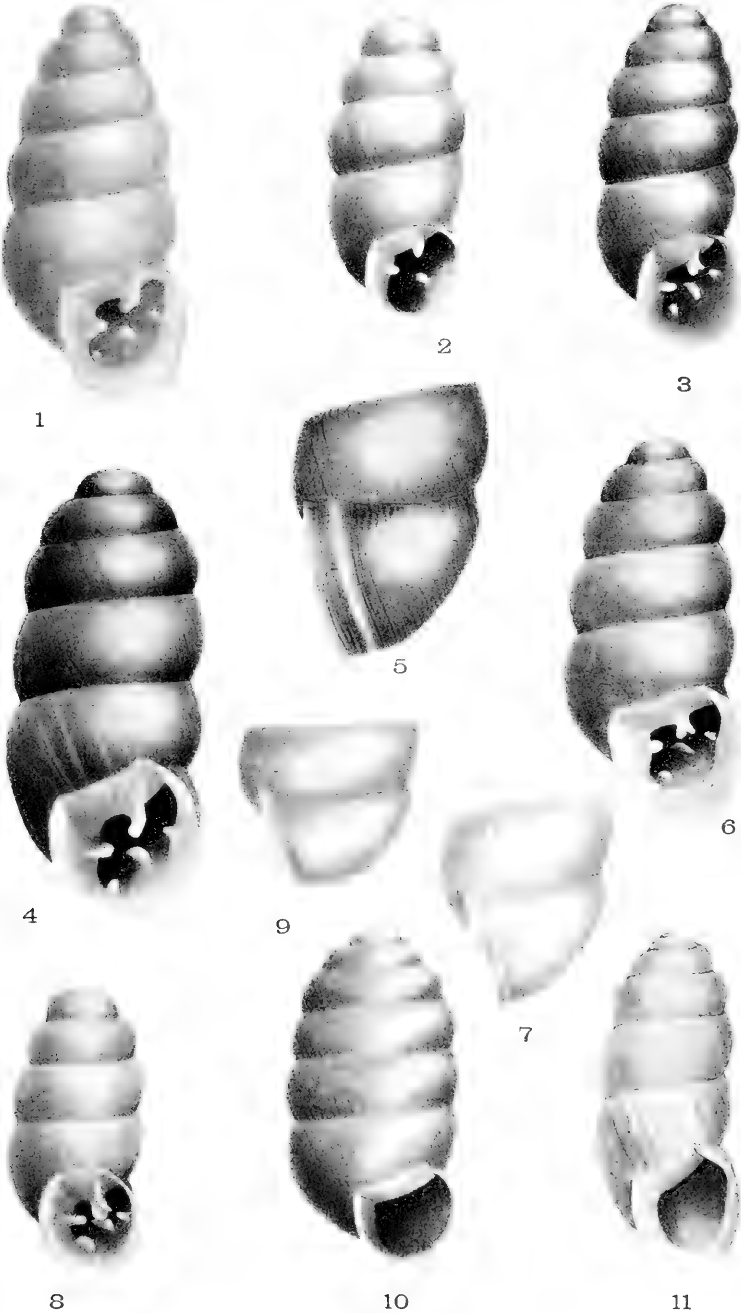
FOWLER. ICHTHYOLOGY OF THE TROPICAL PACIFIC.

1. HEMIPTERONOTUS COPEI Fowler.
2. OVOIDES OPHYRUS (Cope).
3. BROTULA TOWNSENDI Fowler.
4. SPHEROIDES FLOREALIS (Cope).
5. CARACANTHUS MACULATUS (Gray).



PILSBRY DEL.

PILSBRY. SONORELLA.



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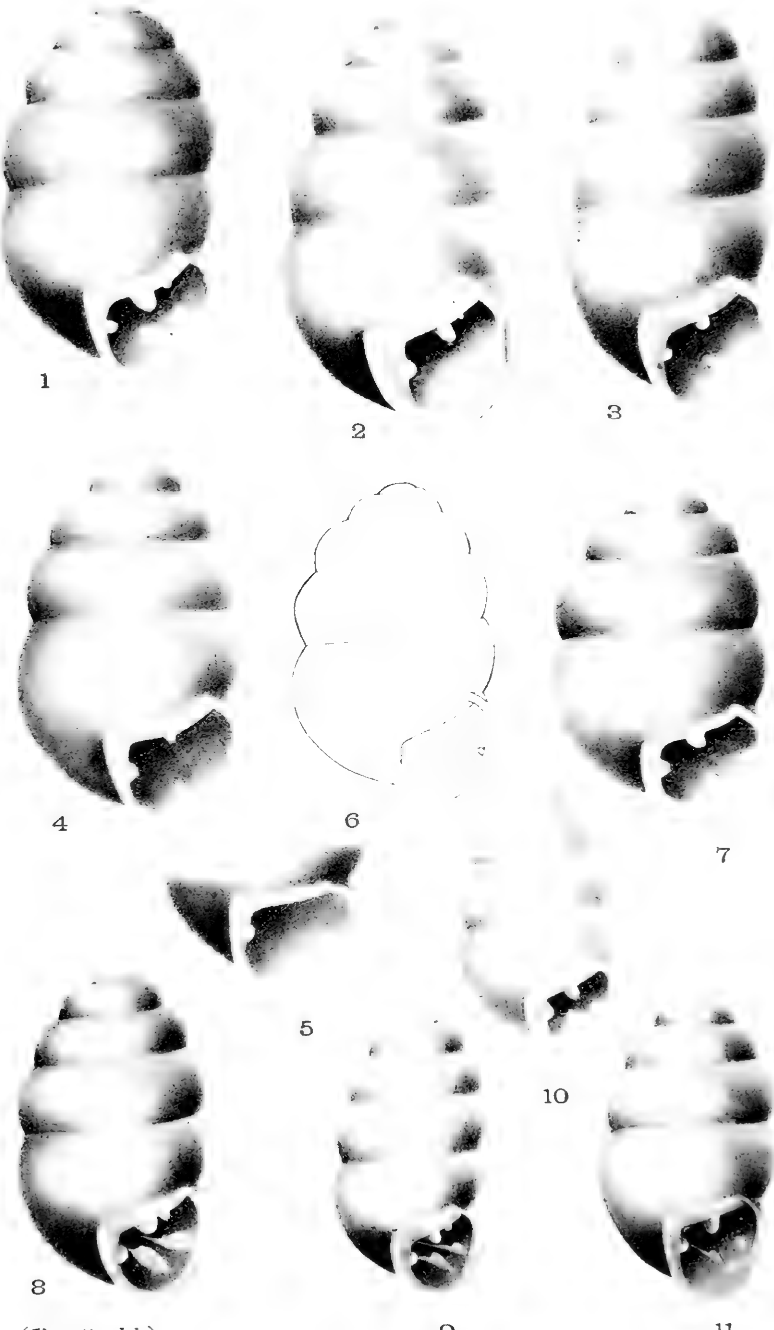
PILSBRY and VANATTA. REVISION OF PUPÆ



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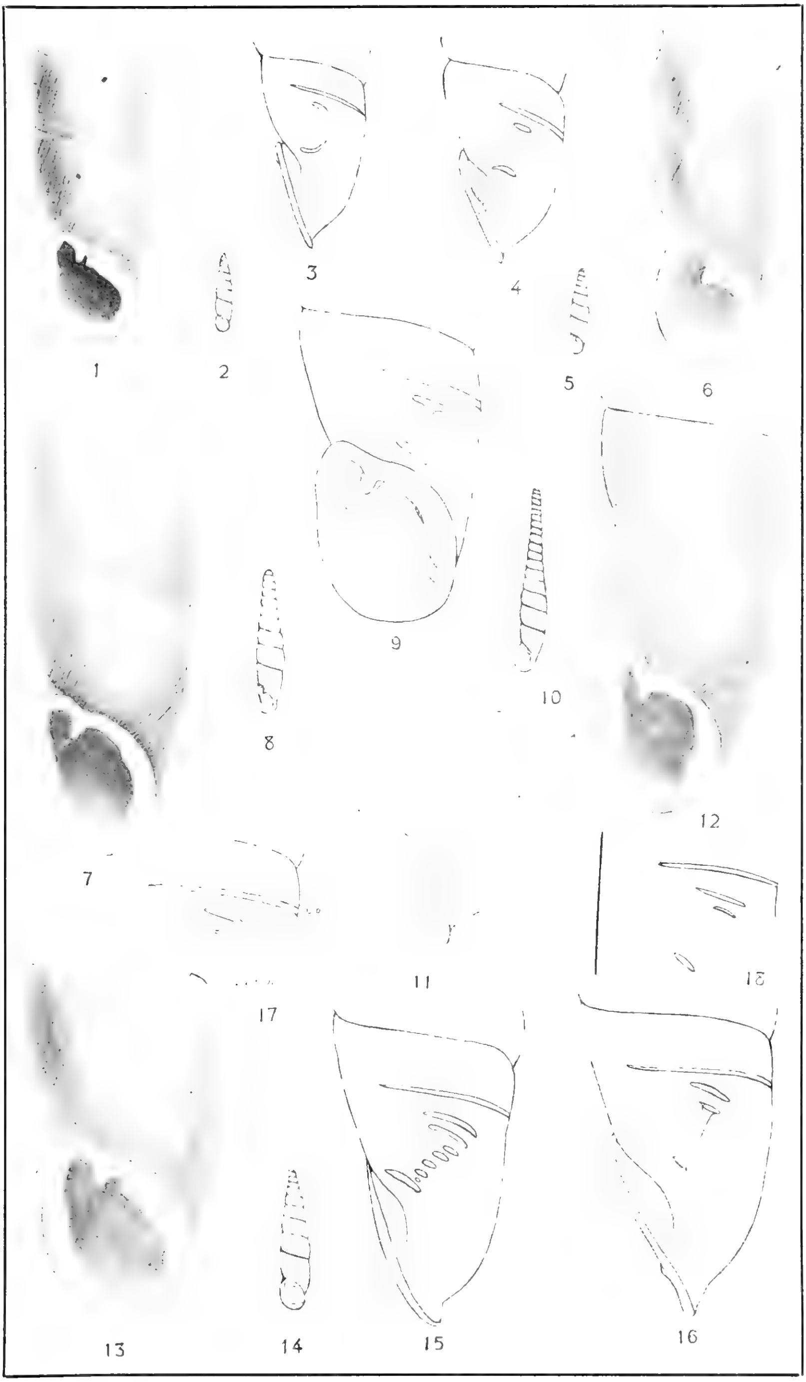
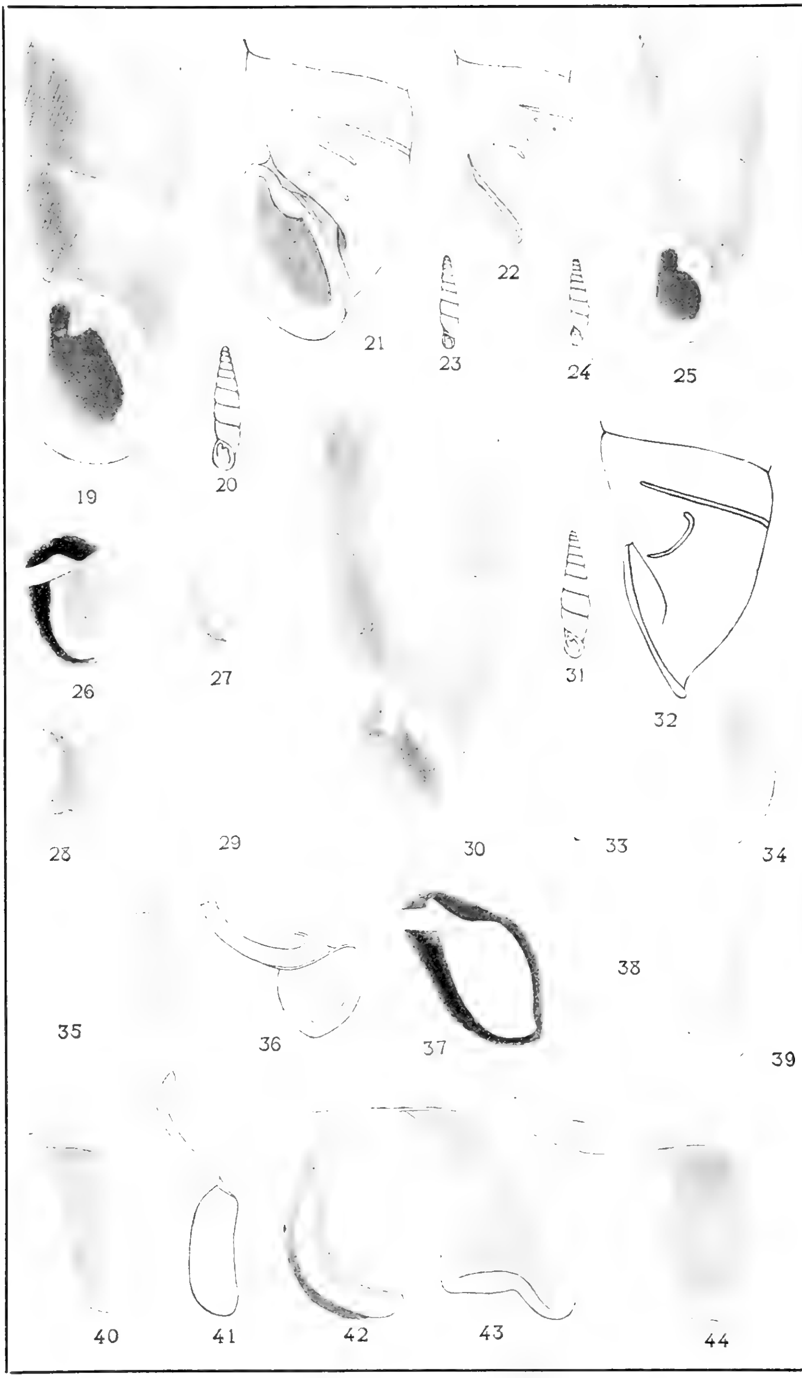
PILSBRY and VANATTA. REVISION OF PUPÆ



PILSBRY. JAPANESE LAND SNAIL FAUNA.



PILSBRY. JAPANESE LAND SNAIL FAUNA.