PROCEEDINGS

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OF

PHILADELPHIA.

1885.

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February 4, 1886.

I hereby certify that printed copies of the Proceedings for 1885 have been presented at the meetings of the Academy, as follows:—

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"	25 to 40	April 7, 1885.
"	41 to 88	April 21, 1885.
"	89 to 96	April 28, 1885.
"	97 to 112	May 12, 1885.
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"	241 to 272	October 6, 1885.
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"	305 to 352	November 17, 1885.
"	353 to 384	December 15, 1885.
"	385 to 416	January 19, 1886.

EDWARD J. NOLAN,
Recording Secretary.

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With reference to the several articles contributed by each.

For Verbal Communications see General Index.

PROCEEDINGS

OF THE

ACADEMY OF NATURAL SCIENCES

OF

PHILADELPHIA.

1885.

JANUARY 6, 1885.

Dr. CHAS. SCHAEFFER in the chair.

Twenty-six persons present.

The following papers were presented for publication :—

" On the American Species of the Genus Umbra," by Willis S. Blatchley.

"A Review of the Species of the Genus Semotilus," by Ernest P. Bicknell and Fletcher B. Dresslar.

JANUARY 13.

The President, Dr. LEIDY, in the chair.

Twenty-four persons present.

On some Parasitic Worms of Birds.—Prof. LEIDY stated that Dr. B. H. Warren, of Westchester, much interested in ornithological pursuits, had submitted to his examination a number of parasitic worms obtained in the preparation of specimens. Recently he had sent to him the carcass of a Snow Bird, *Junco hyemalis*, in which he reported a multitude of worms filling the thoracico-abdominal cavity, and extending into the neck and beneath the skin of the breast and abdomen. From the carcass, seventy-two worms were obtained, of which two-thirds were females ranging from 90 to 120 mm. in length; the rest males, ranging from 40 to 55 mm. From the abdomen of another bird, Dr. Warren obtained five worms, three females from 55 to 90 mm., and two males, 40 and 55 mm. In twenty-two birds examined by Dr. Warren, the parasites were found only in the two indicated. The worms appear to be the *Filaria obtusa* Rudolphi, which infests the *Hirundo rustica*, and other species of European Swallows. The worms of the Snow Bird reach double the length of those of the Swallows, but in other characters agree with the descriptions of *F. obtusa*, as given by Diesing and Dujardin, and also with the figures given by the latter (Hist. Helminthes, pl. iii), except that it is uncertain as to the existence in our specimens of the buccal armature represented by Dujardin. The worms are translucent white, with a chocolate-brown intestine and white uteri and testes. The caudal extremity is obtuse, without appendages, and in the male possesses two spicules, of which the longer curved one is 1·125 mm. long, and the shorter twisted one 0·5 mm. long. The ova, containing developed embryos, are 0·045 mm. long and 0·032 mm. broad.

Six other specimens, apparently also pertaining to *Filaria obtusa*, Dr. Warren obtained from the abdominal cavity partly imbedded in the wall, of a Meadow Lark, *Sturnella magna*. Two are females, 130 and 140 mm. long by 0·625 mm. thick; and four are males, from 50 to 60 mm. long by 0·5 mm. thick.

Six specimens of another *Filaria* were obtained from the abdomen of a female Kingfisher, *Ceryle alcyon*. The species appears to be the *Filaria physalura* of Bremser, described from specimens obtained from several species of Brazilian Kingfishers. Five of the worms are females, ranging from one foot to one foot and a half in length, and from one to one and a half millimetres in thickness. The head is obtuse, and the body gradually tapers to the tail. The mouth is bounded by a pair of small conical papillæ. The five females measure, respectively, 12, 13, 14, 17, and 18 inches. A single male is 35 mm. long by 0·625 mm. thick. The tail is incurved, ends in a minute blunt cone, and is bialate, with the alæ short and quinquecostate. The length of the alated portion is 0·35 mm. The spicule, partially exserted, is recurved. The specimens, when alive, were pink in color, and exhibited a slender chocolate-brown intestine, with large tortuous white uteri.

From the thoracic cavity of a Gray Snipe, *Gallinago Wilsoni*, Dr. Warren obtained five Flukes, 18 mm. long, by 4 mm. broad. These appear to be *Monostomum mutabile*.

From a Whippoorwill, *Antrostomus vociferus*, Dr. Warren obtained four worms, two females of 18 mm., and two males of 12 mm., which appear to be *Ascaris subulata*.

From the Pileated Woodpecker, *Hylotomus pileatus*, Dr. Warren obtained ten worms, which appear to pertain to the *Spiroptera quadriloba* Rudolphi, the female of which was originally described from specimens found in the Green Woodpecker, *Picus viridis*. The specimens are reported as having been found in the abdominal cavity. Six are females from 9 to 12 mm. long by 0·5 mm. thick, and four males 7 and 8 mm. long by 0·375 mm. thick. Body white, nearly equally attenuated towards both ends; transversely wrinkled, and anteriorly minutely, regularly and sharply annulated; mouth quadrilobate. Tail of female conical subacute; tail of male bialate, sexcostate, end acute; spicules two, the longest 1·5 mm. long, the shortest 0·5 mm. long.

The following were ordered to be printed:—

ON THE AMERICAN SPECIES OF THE GENUS UMBRA.

BY WILLIS S. BLATCHLEY.

I have compared numerous specimens of mud-minnows (*Umbra* Müller), from different parts of the United States, with a view of ascertaining whether more than one species exists in our waters. I find, as already noted by Jordan and Bean, two types; the one (*limi*) inhabiting the waters of the great lake region and northwestwardly; the other (*pygmæa*), inhabiting the coastwise streams from Connecticut to North Carolina.

On careful comparison, the only constant difference between these forms, which I am able to appreciate, is the coloration.

The true *Umbra limi* is dull olive-green in color, with about fourteen narrow, pale, transverse stripes, often obscure in the young; dark bar at base of caudal much less distinct, and lower jaw always paler than in *pygmæa*.

The eastern form, which I regard as a geographical subspecies (*Umbra limi pygmæa*), is much darker in color, with about twelve pale, narrow longitudinal instead of transverse stripes, the one beginning at upper angle of opercle being double the width of the others; dark bar at base of caudal very distinct, extending over 1½ scales; lower jaw dark, almost black in adults.

The following is the synonymy of each of the two forms:—

Umbra limi.

Hydrargyra limi Kirtland, Bost. Journ. Nat. Hist., iii, 1840, 277 (Northern Ohio).

Melanura limi Agassiz, Amer. Journ. Sci. Arts, 1855, 217; Packard & Putnam, Amer. Nat., Jan., 1872 (Mammoth Cave); Jordan, Man. Vert., 1st ed., 1876, 253, 2d ed., 1878, and 3d ed., 1880, 265; Jordan, Rept. Geol. Surv. Ind., 1875, 33; Jordan & Copeland, Check List Fresh Wat. Fish. N. A., 1877, 143; Jordan, Bull. U. S. Nat. Mus., ix, 1877, 49 (Ohio Valley); Jordan, Annals N. Y. Acad. Sci., i, 1877, No. 4, 103 (Suamico R., Fox R., Rock R., Wisconsin R., White R.); Nelson, Bull. Ill. Lab. Nat. Hist., i, 43; Jordan, Bull. Ill. Lab. Nat. Hist., ii, 1878, 52 (Johnson and Union Counties, Illinois; Crystal Lake, McHenry Co., Ill.); Jordan & Brayton, Bull. U. S. Nat. Mus., xii, 1878, 84 (Ohio and Ill. R. Basins); Forbes, Bull. Ill. Lab. Nat. Hist., ii, 1878, 78 (Food of *Melanura limi*).

Umbra limi Gunther, Cat. Fish. Brit. Mus., vi, 1866, 232; Jordan, Proc. Acad. Nat. Sci. Philad., 1877, 44 (Lakes, Laporte Co., Ind.;

St. Joseph's R., Maumee R., Tippecanoe R , White R.); Jordan, Rept. Geol. Surv. Ohio, iv, 1882, 912; Jordan & Gilbert, Synopsis Fish. N. A., 1883, 350.

Hydrargyra fusca Thompson, Nat. Hist. Vt., 1842, 137 (Lake Champlain).

Hydrargyra atricauda De Kay, New York Fauna, Fishes, 1842, 220 (Lake Champlain).

Umbra limi pygmæa.

Leuciscus pygmæas De Kay, N. Y. Fauna, Fishes, 1842, 214 (Tappan, Rockland Co., N. Y.).

Melanura pygmæa Baird, Ninth Smithson. Rept., 1855, 28 (New Jersey Coast); Jordan, Man. Vert., 2d ed., 1878, and 3d ed., 265, 1880; Jordan, Annals N. Y. Acad. Sci., i, 1877, No. 4, 104; Jordan & Brayton, Bull. U. S. Nat. Mus., xii, 1878, 84 (James R., Neuse R.).

Umbra pygmæa Bean, MSS.; Jordan, Bull. U. S. Nat. Mus., x, 1874, 53 (Delaware R.); Jordan, Rept. Geol. Surv. Ohio, iv, 1882, 913; Bean, Cat. Fish. International Fish Exhibition, London. 1883, 84 (Kingston, N. C.).

Fundulus fuscus Ayres, Bost. Journ. Nat. Hist., iv, 1843, 296 (Brook Haven, Long Island).

Melanura annulata Agassiz, Amer. Journ. Sci. Arts, 1855, 217 (not *Exoglossum annulatum* Rafinesque).

A REVIEW OF THE SPECIES OF THE GENUS SEMOTILUS.

BY ERNEST P. BICKNELL AND FLETCHER B. DRESSLAR.

In this paper we give the synonymy of the species of the genus *Semotilus*, with an analytical key by which they may be distinguished.

The specimens which we have studied belong to the Museum of the Indiana University, most of them having been collected by Professor David S. Jordan.

SEMOTILUS.

Semotilus Rafinesque, Ichth. Ohiensis, 1820, 49 (*dorsalis.*)

Leucosomus Heckel, "Russegger's Reise, 1841, 1042" (*argenteus.*)

Cheilonemus Baird, Storer's History Fishes Mass., 1855, 285 (*pulchellus.*)

Analysis of Species of Semotilus.

a. Origin of dorsal fin about midway between middle of orbit and base of caudal; body rather robust, especially anteriorly. Vertebræ[1] 22 + 20; the interneural spine of first dorsal ray inserted between fifteenth and sixteenth neural spines. A distinct black spot on anterior part of base of dorsal; coloration dusky, little silvery, rosy below in spring.

b. Scales comparatively small, crowded anteriorly, their number about 10–54–7; head large and broad, its length $3\frac{1}{2}$ in head; maxillary barbel very small, indistinct in young specimens; eye small, 6 to 7 times in head (in adult); dusky bluish above, paler below; belly white; size medium, reaches a length of about a foot. *atromaculatus.* 1.

bb. Scales rather large, not crowded anteriorly, their number about 9–48–5; head $3\frac{3}{4}$ in length; maxillary barbel well developed; eye rather large, its diameter about four in head in young; dark bluish above and on upper part of sides, becoming rather abruptly light below lateral line; size small, attains a length of 3 inches or more. *thoreauianus.* 2.

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[1] In *Semotilus atromaculatus.* This character has not been verified in *S. thoreauianus.*

aa. Origin of dorsal fin about midway between nostril and base of caudal; scales not crowded anteriorly, their number about 8–45–5; body rather more slender; vertebræ 22+20; interneural spine of first dorsal ray inserted between thirteenth and fourteenth neural spines; head moderate, about 4 in length; maxillary barbel very small; eye high up, about 4½ in head; color bright metallic bluish on upper part of body, becoming white below; no black spot on base of dorsal; size comparatively large, reaching a length of 18 inches. *bullaris.* 3.

1. Semotilus atromaculatus. Creek Chub, Horned Dace.

Cyprinus atromaculatus Mitchill, American Monthly Magazine, ii, 1817, 324 (Wallkill R.).

Leuciscus atromaculatus De Kay, N. Y. Fauna, Fishes, 1842, 210, plate xxxii, fig. 102; Storer, "Synopsis Fishes N. A., 1846, 409" (copied).

Semotilus atromaculatus Girard, Proc. Acad. Nat. Sci. Phila., 1856, 204.

Leucosomus atromaculatus Cope, Proc. Acad. Nat. Sci. Phila., 1861, 523.

Semotilus dorsalis Rafinesque, Ichth. Ohiensis, 1820, 49 (Kentucky); Kirtland, "Zoölogy Ohio, 1838, 169;" Kirtland, Boston Journal Nat. Hist., 1841, vol. iii, 184, 345.

Leuciscus dorsalis Storer, "Synopsis Fishes N. A., 1846, 411."

Semotilus cephalus Rafinesque, Ichth. Ohiensis, 1820, 49 (Kentucky); Kirtland, Zoölogy Ohio, 1838, 169; Kirtland, Boston Journal Nat. Hist., 1840, vol. iii, 345.

Leuciscus cephalus De Kay, N. Y. Fauna, Fish., 1842, 214; Storer, "Synopsis Fishes N. A., 1846, 409."

Leuciscus storeri Cuvier & Valenciennes, Hist. Nat. Poissons, vol. xvii, 1844, 319 (N. Y.).

Leuciscus iris Cuvier & Valenciennes, Hist. Nat. Poissons, 1844, vol. xvii, 255, plate 496 (N. Y. and Carolina).

Leuciscus pulchelloides Ayres, "Proc. Boston Society Natural History, 1849, vol. iii, 157."

Leucosomus pallidus Girard, Proc. Acad. Nat. Sci. Phila., 1856, 190 (Antelope Creek, Arkansas); Girard, Pacific R. R. Rept., 1858, 251, Pl. 61, fig. 6; Girard, Proc. Acad. Nat. Sci. Phila., 1858, 251–2 (Antelope Creek, Arkansas).

Semotilus pallidus Cope, Cyprinidæ Penn., 1866, 364 (Platte R.), (no description); Jordan, Manual Vertebrates, 1st ed, 1876, 279.

Leucosomus incrassatus Girard, Proc. Acad. Nat. Sci. Phila., 1856, 251–2 (Near Choctaw Agency); Girard, Pacific R. R. Rept., 1858, 252, Pl. 61, fig. 1 (Near Choctaw Agency).

Semotilus speciosus Girard, Proc. Acad. Nat. Sci. Phil., 1856, 204 (Sweet Water R., Nebraska); Girard, Pacific R. R. Rept., 1858, 283, Pl. 61, fig. 11 (Tributary of Platte River).

Semotilus macrocephalus Girard, Proc. Acad. Nat. Sci. Phil., 1856, 204 (Fort Pierre).

Leucosomus macrocephalus Girard, Pacific R. R. Rept., 1858, 252, Pl. 61, fig. 1 (Fort Pierre).

Semotilus hammondi Abbott, Proc. Acad. Nat. Sci. Phil., 1860, 474 (Kansas).

Semotilus corporalis Putnam, Bulletin Museum Comparative Zoölogy, 1863, 8 (synonymy only, not *Cyprinus corporalis* Mitchill); Cope, Proc. Acad. Nat. Sci. Phil., 1865, 85 (Platte River); Cope, Cyprinidæ Penn., 1866, 363, Pl. 10, fig. 2; Storer, History Fishes Mass., 1867, 256 (near Williams College, no description); Cope, Hayden's Geological Survey, Wyoming, for 1870, 1872, 442, 472 (Platte R.); Abbott, "American Naturalist, April, 1870, 12" (Delaware R.); Jordan, Indiana Geological Survey, 1874, 223; Jordan, Manual Vertebrates, 1st ed., 1876, 277; Jordan, Bulletin Buffalo Society Nat. Hist., 1876, 94; Jordan, Annals Lyceum Nat. Hist. N. Y., 1877, 327, 362, 368, 369, 376 (Ocmulgee R., Etowah R., White R., Ind.); Jordan, Annals N. Y. Acad. Sciences, vol. i, No. 4, 107, 1877 (Housatonic R., Hudson R., Cayuga Lake, Genesee R., Delaware R., L. Erie, L. Michigan, Fox R., Rock R., Peckatonica R., Wisconsin R., Suamico R., White R., Illinois R., Ohio R., Kentucky R., Rock Castle R., Cumberland R., Salt R., Powell's R., French Broad R., Etowah R., Ocmulgee R.); Jordan & Brayton, Bulletin U. S. National Museum, 1878, xii, 26, 38, 54, 68, 80, 86 (Saluda R., Ocmulgee R., Clinch R., French Broad R., Rock Castle R., Alabama Basin, James R., Neuse R., Santee R., Gt. Pedee R., Tennessee R., Ohio R., Illinois R., and other streams); Hay, Proc. U. S. National Museum, 1880, 512 (Catawba Creek, Miss.); Jordan, Manual Vertebrates, 1880, ed. iii, 304; Hay, Bulletin U. S. Fish Commission, 1882 (Big Black R., Miss.); Jordan, Rept. Fishes Ohio, 1882, 863; Jordan & Gilbert, Synopsis Fishes N. A., 1882, 221; Bean, Catalogue Fishes exhibited International Exhibition, London, 1883.

Leucosomus corporalis Günther, Catalogue Fishes British Museum, 1868, 269 (Susquehanna R., Tioga Co., N. Y.; Lake Erie).

Habitat.—Dakota to Western Massachusetts, South to Georgia and Indian Territory, especially abundant in the Mississippi Valley. It is found especially in small brooks in the grass and weeds.

The specimens before us are from near Bloomington, Indiana; Clifty Creek, Ind.; French Broad River, Tenn.; Rock Castle River, Ky.; Rolling Fork, Ky.; Wolf Creek, Ky. We adopt for this species the specific name *atromaculatus*, instead of *corporalis*, by which it has been usually known, because, in our judgment, the original *Cyprinus corporalis* of Mitchill is *Semotilus bullaris*, as was formerly stated by Dr. Abbott, while the present species is evidently Mitchill's *Cyprinus atromaculatus.*

The following is Mitchill's account of *Cyprinus corporalis*:—

"*Cyprinus corporalis.* This fish is called by the Dutch, Corporalen, or corporal, and inhabits the Hudson in the neighborhood of Albany, the Wallkill through its whole extent, and the western streams and lakes from Wood Creek to the Oneida Lake, and so on.

"The length of a middle-sized individual is about thirteen inches, and the girth five; though he frequently grows larger.

"The head is smooth, roundish, thick, and without scales. The body is thickly covered with scales; on the back, more especially between the head and the dorsal fin, the hue is dusky; on the belly it is uniformly white, and on the sides the forepart of each scale is covered with a blackish film or pigment.

"Mouth toothless, and of a moderate gape; tongue distinct, but not free; gill-covers smooth.

"The tail is forked; the lateral line bends downward, and ends in the middle of the tail.

"The dorsal fin is near the middle of the back, and consists of seven rays; the caudal fin is composed of nineteen rays or thereabout.

"The anal has seven, the ventral seven, the pectorals have thirteen, the branchiostegous membrane has three rays, the dorsal and caudal fins are tipped with a blackish tinge.

"Takes the hook, if baited with dough, when let down through holes in the ice, at midwinter, in the Hudson at Albany; flesh eatable, but rather soft and coarse."

2. Semotilus thoreauianus.

Semotilus thoreauianus Jordan, Bulletin U. S. National Museum, x, 63, 1877 (Flint River); Jordan, Bulletin U. S. National Museum, 1878, xii, 43 (Flint River); Jordan & Gilbert, Synopsis Fishes N. A., 1882, 221 (Flint River).

The specimens of this species in the Indiana University Museum were taken by Professors Gilbert and Swain, near Tuscaloosa, Alabama.

The original types were from the Flint River; no others have been reported.

This species is very close to *S. atromaculatus*, differing chiefly in the size of the scales.

3. **Semotilus bullaris.** Fall-fish, Roach, Dace.

Cyprinus bullaris Rafinesque, American Monthly Magazine, 1817, 120 (Hudson R).

Semotilus bullaris Jordan, Annals N. Y. Acad. Sciences, vol. i, No. iv, 1877, 108 (Connecticut R., Delaware R., Susquehanna R.); Jordan, Manual Vertebrates, 1878, 304; Jordan & Gilbert, Synopsis Fishes, N. A., 1882, 222.

Cyprinus corporalis Mitchill, American Monthly Magazine, i, 1817, 289 (Hudson R.).

Leuciscus corporalis De Kay, N. Y. Fauna, Fishes, 1842, 213 (copied).

Semotilus corporalis Abbott, Proc. Acad. Nat Sci. Phil., 1861, 152, 154 (Trenton).

Leuciscus argenteus Storer, Rept. Fishes Mass., 1839, 90 (Worcester County).

Leucosomus argenteus Heckel, "Russegger's Reise, 1841."

Semotilus argenteus Putnam, Bulletin Museum Comparative Zoölogy, 1863, 8 (synonymy only); Jordan, Manual Vertebrates, 1876, 278.

Leuciscus pulchellus Storer, Rept. Fishes Mass., 1839, 91 (Walpole, Mass.); De Kay, N. Y. Fauna, Fishes, 1842, 208; Cuvier & Valenciennes, Hist. Nat. Poissons, xvii, 320, 1844.

Leucosomus pulchellus Girard, Proc. Acad. Nat. Sci. Phil., 1856, 189.

Cheilonemus pulchellus Storer, History Fishes Mass., 1867, 286.

Leucosomus pulchellus Günther, Catalogue Fishes British Museum, 1868, vii, 268 (Montreal; Rangely Lake, Me.; Delaware River).

Leucosomus chrysoleucus Heckel, "Russegger's Reise, 1841" (not *Cypr. chrysoleucus* Mitchill).

Leucosomus nitidus De Kay, N. Y. Fauna, Fishes, 1842, 209 (Lake Champlain).

Hybognathus nitidus Girard, Proc. Acad. Nat. Sci. Phil., 1856, 210 (Lake Champlain).

Leuciscus chrysopterus De Kay, N. Y. Fauna, Fishes, 1842, 211 (New York Bay).

Leucosomus rhotheus Cope, Proc. Acad. Nat. Sci, Phil., 1861, 523 (Susquehanna River).

Semotilus rhotheus Cope, Synopsis Cyprinidæ Penn., 1866, 362; Jordan, Manual Vertebrates, 1876, 278.

Leucosomus cataractus (Baird MSS.), Cope, Proc. Acad. Nat. Sci. Phil., 1861, 523 (Susquehanna River).

Squalius hyalope Cope, Proc. Acad. Nat. Sci. Phil., 1864, 280 (Conestoga River).

Habitat.—Southern Canada and Eastern United States, as far south as Chesapeake Bay.

The specimens examined by us are from Massachusetts.

JANUARY 20.

Mr. GEORGE W. TRYON, Jr., in the chair.

Thirty-two persons present.

The death of Prof. Wm. Wagner, a member, was announced.

A paper entitled "Description of a new Colias from the Rocky Mountains, and of an example of Polymelianism in Samia Cecropia," by Hermann Strecker, was presented for publication.

A New Locality for Beegerite.—Prof. GEORGE A. KOENIG placed on record the determination of *Beegerite*, from the "Old Lout," San Juan County, Colorado. This species was described in 1881 by the speaker as $6PbS,Bi_2S_3$, from Park County Colorado. It crystallizes in isometric cubo-octohedrons, with orthorhombic habitus. Only one specimen was then known to be in existence. Since, Dr. F. Genth has examined a specimen, massive, from Summit County, Colorado, which is *Beegerite*, in which 15 per cent. of lead is replaced by as much silver. Some months ago the speaker received among other bismuth minerals from the Old Lout Mine, Colorado, a small specimen of a fine granular, lead-gray mineral, mixed with chalcopyrite, pyrite, barite, and quartz. After a preliminary examination, revealing the peculiar composition of the substance, about 1·2 gram. were selected with great care, but it was not possible to exclude all pyrite and chalcopyrite.

Of this the analysis gave:

Bi = 19·35
Pb = 45·87
Ag = 9·98
Cu = 1·12
Fe = 2·89
S = 16·39
Insoluble = 0·12

95·72

If copper, iron, and the corresponding amount of sulphur are eliminated as chalcopyrite and pyrite, the ratio between (Pb_1Ag_2) and Bi is as 5·74 : 2, which, in connection with the loss of 4 per cent. in the analysis, is near enough to the ratio : 6 : 2 to admit of no doubt that this mineral is Beegerite, now known from three localities in Colorado.

JANUARY 27.

Dr. W. S. W. RUSCHENBERGER in the chair.

Twenty-eight persons present.

The deaths of Thomas Clyde, a member, and of Friedrich Ritter v. Stein, a correspondent, were announced.

The following minute was adopted :

The Academy of Natural Sciences of Philadelphia learns with profound regret of the death of Prof. Wm. Wagner, one of its earliest members, whose generous encouragement of scientific pursuits has done much to foster a study of the natural sciences in this country.

Observations on Tenacity of Life, and Regeneration of Excised Parts in Lumbricus terrestris.—MISS ADELE M. FIELDE remarked that the observations recorded before the meeting held Jan. 6, were made in the laboratory of the Academy of Natural Sciences of Philadelphia. The temperature had been nearly constant at about 60°, and varied only from 55° to 65°. The observations began Nov. 29, 1884. No worm lived more than a few hours when exposed to the air. Worms kept in water, without food, the water changed daily, lived from eleven to fourteen days. It made no apparent difference in the duration of life, whether the worms were kept in darkness or in light.

Eight portions of worms, consisting of from twenty to thirty segments, taken from the posterior end, had lived in earth during the forty days of observation, and though plump, healthful, and with blood of its usual redness, showed no signs of growth at either end. Between the segments, however, new half-segments had been inserted, after a method which ladies in sewing call a gusset. Some of these worms had five such insertions, while no similar half-segments were observed in many worms that were examined, in order to ascertain whether such half-segments existed in whole and healthy worms. These new half-segments appeared at irregular distances apart, between the old segments, on the sides of the portions of worms, and appeared to be a manner of growth not heretofore observed in earthworms regenerating exsected parts.

Nine worms from which the five anterior segments were excised Nov. 29, had been kept in moist earth, with which comminuted leaves of oak and maple were mingled. The brain of the earthworm lies in the third segment, and the first subœsophageal ganglion in the fourth segment, so that the brain and œsophageal collar were removed by the excision. All these worms were living, and a part of them had wholly regenerated the excised segments.

Ten worms, which at the same date lost five anterior and from twenty to thirty posterior segments, were all alive and were regenerating the excised portions.

Eight worms, which at the same date lost their posterior segments to within ten behind the clitellum, were all living and had regenerated some portion of the excised part.

The manner of regeneration of the excised anterior five segments had been:—

1. A union of the outer coat of the body with the lining of the alimentary canal, roughly healing the wound.

2. A prolongation of these coats, forming a translucent white tube which could be protruded from and retracted into the projecting border of the wound. This tube was at first but a third or a half the diameter of the body.

3. The formation of the lip or proboscis on the superior side of the end of the tube.

4. Segmentation proceeding from the anterior end of the regenerated part backward, until the normal number of segments were reproduced.

5. The deposit of coloring matter in the epidermis of the new segments, and their enlargement to the diameter of the old segments.

Reference was made to the observations published by Dr. Bülow in the "Archiv für Naturgeschichte," 1882.

Miss Fielde now further reports having found a completely regenerated brain, œsophageal collar, and subœsophageal ganglion, all of normal size and in normal site, in earthworms, which had fifty-eight days previous been decapitated at the fifth segment. The worms had been kept in earth, at a temperature of about 60°.

The precautions taken to ensure accuracy in these observations had been, first, a thorough examination of all the earth into which the decapitated worms were put, making it certain that the earth contained no other worms than the decapitated ones; secondly, care that nothing containing earthworms was at any time added to the earth in which the decapitated worms were kept; thirdly, repeated examinations, at intervals of less than a week, of all the earth holding the decapitated worms, and the careful removal of minute worms bred therein; fourthly, frequent counting of the decapitated worms, with examination under a lens, the evident wound constantly showing that the worms under observation were the individuals decapitated. The paler color of the new portions also distinguished these worms from others.

Forty days after decapitation, the excised segments had been regenerated, so as to present an external appearance of completeness, but no brain was visible in dissection. Forty-five days after decapitation the blood-vessels were seen ramifying on the completely regenerated pharynx in a normal manner, but no brain was found. In one of the worms dissected on the fifty-eighth day after decapitation, the subœsophageal ganglion and the œsophageal collar were found to be complete and of the normal size, but the brain lobes were of but half the normal size, and were separated by an interspace of the width of one of the lobes. The blood-vessels united normally on the median line between the lobes. Another worm decapitated at the same date, though of apparently weaker vitality, had regenerated all the excised portions, and showed a completely formed brain, with lobes of the normal size in contact.

Messrs. Burnett Landreth and J. Addison Campbell, and Mrs. Cornelius Stevenson, were elected members.

FEBRUARY 3.

Mr. GEORGE W. TRYON, Jr., in the chair.

Twenty-seven persons present.

FEBRUARY 10.

Rev. H. C. McCOOK, D. D., Vice-President, in the chair.

Twenty-two persons present.

The Internal Cambium Ring in Gelsemium sempervirens.—Dr. J. T. ROTHROCK, at the meeting of the Botanical Section held February 9, called attention to the internal cambium ring in the stem of *Gelsemium sempervirens.* It might well be designated as the inner cambium. His attention was attracted by the fact that in a *stem* of three-eighths of an inch diameter, the pith was actually less in diameter than in a *twig* of a quarter the size of the *stem.* Microscopic examination showed that in the larger stem there were ordinarily four or more points, at which a well-defined swelling curved inward from the circumference of what should have been the pith-cavity. These swellings resolved themselves when closely examined into:—

1. Toward the centre an imperfectly defined membrane, resembling cuticle, which was not always present.
2. One or more rows of large cells like the parenchyma we find under the epidermal layer.
3. Several poorly defined layers of smaller cells, such as often mark the limits of growth in bark.
4. The frequent presence of bast fibres or of sclerenchyma cells.
5. An evident layer of thin-walled, square cells, closely resembling, though somewhat smaller than those of the external cambium. They showed signs of division, which indicated that they were still a living tissue.

These facts explained at once why the pith was constantly being encroached upon until it at length almost disappeared. The medullary rays dipped down through, and widened out, in this inner cambium, *inwardly*, just as they did *outwardly*, in the usual form of cambium layer. He also remarked that bast fibres had long been known to exist in the pith of *Tecoma radicans*, and in this case something like an inner cambium would be found, though it is more obscure. *Sambucus Canadensis* also exhibited in the very large stems a smaller pith than in those of moderate size. In this there was nothing comparable to the inner cambium. He also remarked that for the past two winters his attention had been called to the presence of considerable quantities of chlorophyll in the pith of *Lycium vulgare*. This was not confined to the smallest stems, but was found also in those of over a quarter of an inch in diameter, and where of course a considerable belt of hard wood was found between the pith and the outer zone, where chlorophyll is expected. It was also observed in *Lycium* that the chlorophyll was not in the form of bodies but diffused in character, as it is said to be in some infusorians. In *Lycium* the cells of the pith showed, in winter, abundance of protoplasm which had the nucleus on one side and very striking bands extending thence across the cell to the further side.

The following was ordered to be printed :—

DESCRIPTION OF A NEW COLIAS FROM THE ROCKY MOUNTAINS, AND OF AN EXAMPLE OF POLYMELIANISM IN SAMIA CECROPIA.

BY HERMANN STRECKER.

Colias elis.

♀ expands 1⅞ inches; with the exception of the primaries being slightly more pointed apically, of the same shape as *Hecla*, of which species it may probably be a form, as it resembles it closely in many particulars.

Head, collar and antennæ dark pink or rosy; body black with greenish hairs.

Upper surface. Primaries bright orange, with blackish exterior margin of moderate width until towards the costa where it widens considerably; this margin encloses a row of seven ovate lemon-yellow spots or dashes which are rounded interiorly and somewhat pointed exteriorly; the two nearest the costa are much the smallest, the others are nearly uniform in size, though varying a trifle from each other in shape. A black discal spot, small and somewhat linear in one example, and nearly round and of fair size in another. Costa and fringe deep pink. Secondaries are orange, somewhat obscured with black atoms, a submarginal row of yellow spots, not quite as conspicuous as those of primaries, exterior to these at the apex and the apical half of costal and exterior edge, the wing is blackish; a good-sized deep orange or red lead-colored discal spot, round in one example and in another somewhat oblong, or rather the shape produced by a smaller round spot being joined and partly merged into a larger one; fringe same color as on primaries.

Under surface. Primaries orange on disk, with greenish exterior border of same width as the blackish border of upper surface; also greenish along the costa; edge of costa and fringe deep pink. A black discal spot with pale centre. Secondaries green, the inner two-thirds darker, leaving an exterior border of the same color but a shade paler. Costa and fringe as in primaries; discal spot silvery white, ringed with deep pink.

Albinous ♀ form. Upper surface white of greenish yellow tinge, the disk of primaries, especially towards the inner margin faintly suffused with a very pale ochraceous tint. On one example the blackish border and the discal spots are about the same as in the orange form, on another the spots enclosed by the border of primaries are reduced to mere streaks and on the secondaries there are no traces of the border at all. In all examples of both forms there is a powdering of dark scales on the base of wings and along the inner margin of secondaries interior to the abdominal fold. Under surface as in the orange form, except that the orange of superiors is replaced by yellowish white, and the green of all wings is somewhat paler.

Taken by Capt. Gamble Geddes at an elevation of 10,000 feet, on the summit of "Kicking Horse Pass," in the Rocky Mountains, between Alberta Territory and British Columbia, at the boundary between the United States and the British possessions, about 300 miles north of Montana.

It is an act of temerity to describe a Colias as new under any circumstances in these days, and doubly so to describe it from examples of the female sex alone, yet I have no apprehension that the above insect will not stand as a valid species.

Capt Geddes took about fifteen examples, all females, nine of the orange form, and about six of the white; but nothing that could possibly be considered as the male. The other examples of *Colias* captured in the same locality were lemon-colored males and females probably of one species, and allied to *Pelidne*, but bearing no kinship to the above. The most remarkable and distinctive feature of this *C. elis* is the white female; as the species, I am positive, will be found, whenever the male is discovered, to belong to a group in which albinous females are unknown, its congeners being *Hecla*, *Hela Standingeri* and *Eogene*, species in which no instance of the pale female has yet been known to occur; all of which are found only at great altitudes or at the North Polar Regions and are in the male distinguished from the other red or orange species by the absence of the mealy kidney- or oval-shaped spot on the upper surface of the costa of secondaries near the body.

It is curious, in regard to these albinous females of the Coliades, that in one group they should occur in one species only, whilst in another there should be but one species, *C. Meadii*, found also at great elevation. in which they do not occur; and in yet another species, *C. Vautierii*, of the same group with the last mentioned *Meadii*, found in Chili, the female is always white, such a thing as a red one being entirely unknown.

An Example of Samia Cecropia having a Fifth Aborted Wing.—I have lately received from Mr. Ph. Laurent, of Philadelphia, an example of *Samia Cecropia*, bred by him from a cocoon, having an aborted, or rather the portion of a third primary. It is a male of the ordinary size, expanding about 5½ inches, and is one of those smoky varieties in which the red portion of the transverse bands on wings is very much narrowed. The right primary and both secondaries are normal in shape and marking. The left primary is in length from base to apex exactly the same as is the right; but in width from inner angle across to the costa, it is $\frac{3}{16}$ inch less; the markings are the same, allowing for a little condensing owing to the difference in the width. The venation is normal in all wings; the left primary is also somewhat narrower at the base where it joins the body; the inner margin is in exact line with that of its fellow, thus causing the wing at costa, where it joins the thorax, to be further in from the collar and head than its opposite.

The third primary, or rather portion of a primary, emerges from the side of the collar, and consists mainly of the costal and subcostal nervures, a small part of the median nervure, and a strip of wing about a quarter of an inch wide; but the latter was much curled and twisted in drying, and does not show this width fully. Its length is about two-thirds that of the normal wing with which it runs parallel, but it is in no way visibly connected therewith.

This form of monstrosity is apparently of exceedingly great rarity. I have heard of only three other instances—those recorded by Prof. Westwood in the Trans. Ent. Soc. Lond., 1879, pp. 220, 221, in which three diurnals are described, each possessing a third aborted right-hand secondary. In one of them, an example of *Gonepteryx Rhamni*, the normal right wing is much less than the left, the same with the second example, a *Vanessa Urticæ*, leading to the conclusion in those cases as with the *Cecropia*, that the abnormal wing was produced at the expense of the normal.

In the two cases just cited, the extra wing is joined at the base of the costa to the proper wing; in the third case mentioned by Prof. Westwood, it is apparently a streak or strip, as it were, on the inferior surface of right secondary, distinguished from the rest of the wing, or the part thereof, by the difference in color and marking alone.

It will be noticed that in the case of the three diurnals, that the extra wing is always a right secondary, whilst in the *Cecropia* it is a left primary.

FEBRUARY 17.

Mr. THOMAS MEEHAN, Vice-President, in the chair.

Twenty-five persons present.

FEBRUARY 24.

Mr. JACOB BINDER in the chair.

Twenty-one persons present.

A New Fresh-water Sponge from Nova Scotia.—Mr. E. POTTS described a form recently identified by him as follows:—

HETEROMEYENIA PICTOUENSIS, n. sp.

Sponge light green, even when dry, massive, encrusting; texture very compact; spicules non-fasciculated, persistent; surface mostly smooth.

Gemmules very scarce, spherical, crust thick.

Skeleton spicules cylindrical, short, robust, rounded or abruptly terminated; entirely spined, spines conical at the centre of the spicule, elsewhere generally curving *forward*, or towards each extremity. Rounded terminations of spicules covered with short spines, though frequently a single large spine or acute termination is seen at one or both extremities.

Dermal spicules absent or undiscovered.

Birotulates of the longer class surrounding the gemmules, rather numerous, one-half longer than the others; shafts conspicuously fusiform or largest at the centre, where are frequently found one or more long spines. Their rotules consist of three to six irregularly placed rays, recurved at the extremities.

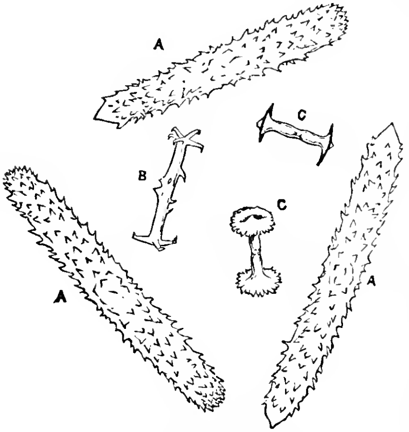
Birotulates of the shorter class abundant and compactly placed around the gemmule; shafts mostly smooth, though sometimes bearing a single spine; irregularly cylindrical, but rapidly widening to support the rotules, which are large, umbonate, nearly flat, and finely lacinulate at their margins; occasionally bearing spines.

Measurements.—Skeleton spicules 0·0075 inch long, by 0·00075 inch thick; length of long birotulates 0·0021 inch; of short birotulates 0·0012 inch; diameter of disc of latter 0·0009 inch.

Habitat.—On submerged wood, etc.

Locality.—Collected only by or for Mr. A. H. McKay, B. A., B. S., of Pictou, Nova Scotia, from several lakes upon the watershed of that region.

This beautiful and interesting sponge was first discovered by Mr. McKay, during the summer of 1884. At that time its novelty, as indicated by its unusually robust, entirely spined skeleton spicules was easily recognized, but the absence of gemmules at that season precluded the determination of its generic relations, and it has continued unnamed. During the last week of December, however, a further search was rewarded by the finding of other "specimens upon sticks pulled up through a break made in the ice," and amongst these a few, and but a few gemmulæ have now been discovered.



A. A. A. Skeleton spicules; B. Long birotulate; C. C. Short do. Magnified 250 diameters.

These suffice to place it clearly within the genus *Heteromeyenia*, near *H. Ryderii*, while the peculiarities of its birotulates distinguish it from that or any other species.

Mr. Potts called attention to its green and apparently living and growing condition, during midwinter, in that northern latitude, as indicating that like *Spongilla aspinosa*, of the New Jersey swamps, this species also is an "evergreen," continuing its life in the normal state throughout the year, and for this reason not needing to form "protected gemmules" in such abundance as do other species.

At the suggestion of Mr. McKay, to whose enthusiastic search we owe its discovery, the local specific *Pictouensis* has gladly been given to this species.

The following were elected members:—

Charles Harrod Vinton, M.D., Henry Leffmann, M.D., S. Frank Aaron and Edw. Longstreth.

March 3.

The President, Dr. Leidy, in the chair.

Twenty-seven members present.

The following papers were presented for publication:—

"A Review of the American Genera and Species of Batrachidæ," by Seth E. Meek and Edw. A. Hall.

"A Review of the Species of the Genus Pimephales," by Willis S. Blatchley.

The deaths of Mrs. S. R. Barton, a member, and of John Gwynn Jeffries, a correspondent, were announced.

Spicate Inflorescence in Cypripedium insigne.—Mr. THOMAS MEEHAN referred to a specimen on the table of *Cypripedium insigne*, an orchid from the cooler parts of the East Indies, which had a spike with two flowers and other undeveloped buds, the normal character being a one-flowered scape. These departures from the normal form afforded valuable lessons, though frequently passed over as mere freaks of nature. A spicate inflorescence was a common characteristic in allied species. From the illustration before us, we might infer that the one-flowered kinds were species in which the power to develop a proper spike had been arrested. We might expect to see attempts at this form of inflorescence in *Cypripedium acaule* of our own country.

A very important lesson from these occasional departures had but recently the attention given to it that it properly deserved, and that was that whenever any particular plant departed from its normal form, other characters came into existence, which, in a separate plant would, and often did, obtain for the new departure the rank of a species. In this instance, the second flower on the spike was different from the lower and normal one in the upper segment of the perianth (sepals) having a regular outline. In the normal form it was so crumpled as to present a trilobed appearance. In the normal form the labellum was so elongated as to be three times the length of the column. In the upper flower the labellum was but double the length, giving it a somewhat globular appearance. There were other variations that formed a combination of characters quite sufficient to mark a species if they were constantly produced in a separate state. Why could not this rare occurrence become a continuous one, and thus a new species be formed—created, we may say—out of an older one? There can be no reason. We may call this a freak of nature, but it could not have occurred without that combination of circumstances which we call law. We have no warranty for saying that a law which has operated to produce a departure in a solitary instance like this, might not have a more permanent power at some other time. Nor is there any warranty for believing that a law that has operated as we see here on one plant, might not operate on a hundred, or on all the plants of a district, or even on plants in separate districts widely separated from each other.

In a paper by himself published in the Proceedings of the Troy Meeting of the American Association for the Advancement of Science, "On the introduction of species by sudden leaps," as well as elsewhere, he had given illustrations of the sudden appearance of identical forms in widely separated localities. If we may generalize from these facts, as we seemed almost warranted in doing, we need not be always looking for the links supposed to be missing, which the belief in the hypothesis of development by slow modifications compelled us to search for, nor need we be reduced to the only alternative of believing that all new species sprang from one parent, which formed a centre of distribution in each particular case. A whole species might be called into existence in the shape of hundreds of individuals or in numerous centres, if only a law that we know from these instances can operate suddenly and exceptionally should continue regularly to act. Such a belief would tend materially to remove difficulties in the way of theories of evolution, that now prevented a full acceptance thereof.[1]

If we can conceive that a suddenly introduced and yet permanently acting force was introduced to operate on some lower beings, the difficulty might be removed. It seemed to him that in some palæontological fields there are evidences of rapid evolution at certain periods, and of greater permanency at others, and this could only be by the introduction of a force equal to the emergency, as in this sudden case brought to the notice of the Academy above.

It would be an interesting study to endeavor to trace the laws that operated in these changes. In this study we must leave behind us impressions which we have imbibed from the idea of mere freaks, hybrids, a return to primitive forms, and other mere guesses with which scientific literature abounds. On the table before us, he observed, are the recent Proceedings of the Royal Society of Tasmania, in which is an account of a remarkable change in a potato, a variety brought from Scotland a few years previously, known as Patterson's Victoria, a variety with white flowers and round white tubers, which, after a culture of a few years in the new climate, produced purple flowers, flat ovate tubers, and these tubers with pink eyes. The members of that society looked at it as a return to the original form of some hybrid variety. We here, with other facts before us, would rather regard it as the effect of environment operating on some innate, and so far unknown, cause of change which might lie dormant through long ages till the peculiar conditions of the environment called them into active life. There seemed in fact seeds for form, as well as seeds for individuals, awaiting the required conditions for germination and rapid growth. In the one case we were able to perceive and appreciate them, except in some of the lowest

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[1] Principal Dawson has suggested that one difficulty in the way of accepting the prevalent theories of the evolution of man, comes from the fact that anthropology affords no "missing link" in the human skull. The oldest hitherto found shows as full a development as in modern man.

organisms. The principle that contained the germ of form was, however, yet as wholly unknown as that of the supposed disease-germs of the atmosphere.

MARCH 10.

The President, Dr. LEIDY, in the chair.

Twenty-four persons present.

The following papers were presented for publication:—

"New Genera and Species of Fossil Cockroaches from the Older American Rocks," by Samuel H. Scudder.

"A Revision of the North American Melicæ," by F. Lamson Scribner.

"A Review of the American Eleotridinæ," by Carl H. Eigenmann and Morton W. Fordice.

The deaths of Samuel Powell and Geo. Whitney, members, and of Benjamin Silliman, Jr., a correspondent, were announced.

Rhinoceros and Hippotherium from Florida.—Prof. LEIDY directed attention to some fossil remains, recently received from Dr. J. C. Neal, of Archer, Florida, and obtained by him from the same deposit noticed in the Proceedings of 1884, p. 118. Dr. Neal writes that he had again examined the locality in company with Prof. L. C. Johnson, who reports that the deposit overlies the Vicksburg limestone of Eocene age. Dr. Neal adds that the deposit appears to be the portion of the border of a lagoon of post-Tertiary age, and that it is now about 100 feet by 50 feet in extent. He also remarks that he has anxiously looked for relics of man, but thus far in vain. The fossils are mingled together in the greatest confusion, are badly fractured, but not water-worn.

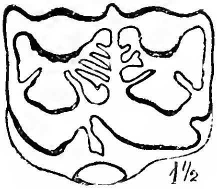
The remains submitted, besides several less characteristic fragments of a crocodile, a carnivorous animal about the size of a fox, and of a lama, consist of two well-preserved teeth of a Rhinoceros and a Hippotherium.

The tooth of the rhinoceros fortunately happens to be one of the most characteristic of the series, and presents differences sufficiently from those of the many extinct forms of this country to render it probable that it indicates another species. The specimen is the crown, but slightly worn, of a last upper molar of the left side. It is especially remarkable for the extent of production of the intermediate folds of the chief lobes of the crown, in comparison with their condition in known forms of the genus. The fold of the anterior lobe is directed backward about half the interval of the lobes, and extends from the base to the triturating border of the crown. Its upper portion is half cylindrical; its lower portion compressed from without inward, and half elliptical in the length. It has the shape of a knife with a cylindrical handle and a wider half elliptical blade. The posterior fold, as long and wider than the former, curves forward and outward in advance of the free border of the anterior fold, coming into contact with the outer face of this below, but separated from it by an open crevice above. The meeting folds divide the interval of the lobes of the crown into an outer trilateral pit over two inches in depth, and an inner nearly rectangular recess about an inch and a half in depth. A well-produced basal ridge occupies the forepart of the crown; a feeble one, produced behind in a tubercle, the outer part of the crown; and a broad tubercle occupies the base of the interval of the lobes internally. The measurements of the specimen are as follows:—

Greatest transverse diameter at the anterior third,	56 mm.
Greatest fore and aft diameter externally, .	63 “
Greatest fore and aft diameter internally, .	55 “
Greatest depth at the antero-external border, .	63 “

The species may be distinguished by the name of RHINOCEROS PROTERUS. The subgenus, whether *Aceratherium*, *Aphelops*, or other, is of course only to be determined by the supply of other portions of the animal. The inferior molars and bones of a rhinoceros, indicated in the former communication on fossils from the same deposit, most probably also pertain to this species.

The extinct genus *Hippotherium*, a three-toed ancestor of our horses, was originally described from remains found in the Miocene and later Tertiary deposits of Europe. Remains of the same genus were first discovered in this country in the Ashley River phosphate beds of South Carolina, noticed in our Proceedings of 1853, p. 241, under the name of *Hipparion venustum*, and described in Holmes' post-Pliocene fossils, 1860, 105, pl. xvi, figs. 32, 33, as *Hippotherium venustum*. Since then a number of other species have been described by the speaker and Prof. Cope from remains found in various localities of this country. The tooth now under inspection is an upper molar, perhaps the fourth large one of the series. It indicates a small species, little more than half the size of the domestic horse, or of the *Hippotherium gracile* of Europe, and exhibits sufficient difference to assume that it indicates another species from those already described. The folding of the contiguous borders of the interior enamel islets of the worn triturating surface is less complex than in *H. venustum*, and the internal islet is elliptical instead of circular. The species may be named HIPPOTHERIUM INGENUUM. The measurements of the tooth are as follows:—



Hippotherium ingenuum.

Length at antero-internal corner of crown,	42 mm.
Breadth fore and aft of triturating surface,	19 “
Breadth transversely of triturating surface,	17 “

NEW GENERA AND SPECIES OF FOSSIL COCKROACHES, FROM THE OLDER AMERICAN ROCKS.

BY SAMUEL H. SCUDDER.

Since the publication of my essay on Palæozoic cockroaches,[1] a considerable number of new types of Palæoblattariæ have come to hand, largely through the endeavors of Mr. R. D. Lacoe, to whose favor I owe the opportunity of studying them, and partly from my exploration of an interesting locality in South Park, Colorado. Some of the former have since been published in a revision of the species of *Mylacris*,[2] and the more interesting of such as remain are described in this paper.

The two new genera of Mylacridæ are closely allied to, but differ considerably from, the known genera. Of the Blattinariæ, the species of *Oryctoblattina* is the first secured from America, and the Triassic genera and species are interesting, not only from the deposit in which they occur, but also from their relation to Carboniferous and Liassic types.[3] They will all be figured on another occasion.

PROMYLACRIS (*πρό, μυλακρίς*), nov. gen.

The mediastinal vein, though large and abundantly supplied with veins, terminates not far beyond the middle of the wing; most of the branches fork more than once; the scapular vein runs in a nearly straight course, and terminates a short distance beyond the mediastinal, playing a very insignificant part; the externomedian vein is far more important, crowding back the scapular vein on the one side and the externomedian on the other; the anal furrow is very deeply impressed and the anal area strongly convex, its veins regular, frequent and strongly curved.

Promylacris ovale, nov. sp.

Represented by a single specimen and its reverse in a nodule preserving well the anterior half of the body. The pronotum is regularly arched, about one-fourth as high as broad, and twice as

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[1] Mem. Bost. Soc. Nat. Hist., iii, 23, *et seq.*

[2] *Ibid.*, iii, 299, *et seq.*

[3] Amer. Jour. Sc. (3), xxviii, 199, *et seq.*

broad as long. The front wings have a strongly developed humeral lobe and a costal margin of considerable convexity. The mediastinal branches are clustered into three groups; the scapular vein is composed of only two branches, each of which forks with slight divarication; the externomedian vein has three principal branches, all of which originate far toward the base of the wing; the internomedian area is unusually small, apparently not reaching so far out as the scapular area. The fragment is 20 mm. long and the wing 12 mm. broad, but it was probably about 29 mm. long.

Carboniferous deposits of Mazon Creek, Ill. Received from Mr. Wm. Gurley.

PAROMYLACRIS (πάρος, μυλακρίς), nov. gen.

The mediastinal vein consists of at least seven or eight principal branches, several of them forking close to the base, the outermost extending far toward the tip of the wing, making this area unusually important; the scapular is also important, the main vein running through the middle of the wing in a straight course to the tip; the externomedian branches do not separate widely, and occupy on the margin of the wing only the lower half of the broad apex; the anal furrow is deeply impressed, and strikes the middle of the inner margin.

Paromylacris rotundum, nov. sp.

The single specimen shows the larger portion of the upper surface, and all the more important parts, visible from above. The whole body is strongly arched, and the central portion of the pronotal shield, which is twice as broad as long, is elevated about 4·5 mm. above the margins. The front wings are obovate, scarcely narrower at tip than at base, barely twice as long as broad; the humeral angle very prominent. The scapular vein has four or five straight superior branches; the externomedian vein runs parallel to the scapular, and has two dichotomizing branches. The length of the wing is 29·5 mm., and its width 15 mm.

Carboniferous deposits of Mazon Creek, Ill. Mr. R. D. Lacoe, No. 2026.

SPILOBLATTINA (σπῖλος, Blattina) nov. sp.

This genus is allied to *Etoblattina*, but differs from it and from all other genera of Blattinariæ in the divergence of the scapular and externomedian veins beyond the middle of the wing, and then their rapid convergence beyond a more or less conspicuous elongated spot (whence the generic name) which fills the space so produced; a similar arrangement is seen even more conspicuously between the the externomedian and internomedian veins, where the spot is much larger and round. All the species are Triassic.

Spiloblattina Gardineri, nov. sp.

A number of specimens of this were found, some of them nearly perfect. The wing is long and slender, more than three times longer than broad, the tip roundly produced. The mediastinal vein terminates some way beyond the middle, approaching the margin very gradually; the scapular runs parallel to the costal margin, slightly more removed from it in the apical than in the distal half, and terminates a little before the tip of the wing; it has many branches, usually compound; the externomedian vein begins to branch usually in the middle of the wing, about opposite the stigma in the interspace between it and the scapular vein, and its branches fill the apex of the wing. To form the enlarged cell for the median stigma, the curve of the main externomedian vein is graceful and very gradual. The anal terminates far before the middle of the wing. Length of wing about 17·5 mm., width 5·5 mm. Named after my son who obtained the first and best specimen seen in our exploration of the beds.

Triassic beds near Fairplay, Colorado.

Spiloblattina triassica, nov. sp.

In this species the wing appears to be more slender than in the others, although the exact proportions cannot be given from the imperfection of the specimens; all the branches have a more longitudinal and less arcuate course, the externomedian and scapular veins scarcely part from each other to give place to the stigma, and the divergence of the former and the internomedian veins is also less conspicuous. The wing was probably about 18 mm. long, and 5 mm. broad.

Triassic beds near Fairplay, Colorado.

Spiloblattina guttata, nov. sp.

This species differs from the others in the stoutness of the wing, which is proportionally much shorter than any of the others; in keeping with this peculiarity is the greater width of both the mediastinal and scapular areas, and the more rapid descent to the margin of the termination of at least the former. In other respects the species completely resembles *S. Gardineri*. Two fragments only were obtained, which indicate a wing about 15 mm. long, and 7 mm. broad.

Triassic beds near Fairplay, Colorado.

Spiloblattina marginata, nov. sp.

This species, of which only a single specimen was found, is remarkable for the paucity of its neuration, and for the fact that all the veins and branches are margined with a slender dark edging. The scapular vein recedes more than usually from the costal margin opposite the very slight median stigma, and the externomedian vein is consequently more than usually curved to make place for it. The probable length of the wing was 18 mm. The inner margin being lost, the width can hardly be more than conjectured, but it was perhaps 7 mm.

Triassic beds near Fairplay, Colorado.

Oryctoblattina occidua, nov. sp.

The veins appear to originate from the middle of the upper half of the base of the wing, and have scarcely the least basal arcuation. The mediastinal vein runs at but slight distance from, and nearly parallel to, the costal border, in the outer half constantly but gradually approaching it, emitting numerous oblique, generally simple branches; the vein terminates in the middle of the outer half of the wing, and shows no such peculiarities at its tip as characterize *O. reticulata* of Europe. The scapular vein is also not so peculiar as there; it runs in near proximity and parallel to the mediastinal vein, but there is the same slight bend in its course at the base of the principal branch; the mass of the branches, which are fewer than in *O. reticulata*, do not arise as there from a vein emitted abruptly from near the base of the second branch, to which they are inferior, but from the principal branch itself, to which they are superior. The internomedian vein terminates at about the end of the middle third of the wing, and has only a few branches. The externomedian branches all terminate on the inner margin. The length of the wing is 19 mm., its breadth 7 mm.

Carboniferous beds of Mazon Creek, Illinois; R. D. Lacoe, No. 2039.

Petrablattina æqua, nov. sp.

Mediastinal vein terminating scarcely beyond the middle of the costal margin, with numerous, closely crowded, simple branches; scapular vein terminating above the tip of the wing, and beyond the basal curve nearly straight, with four or five singly forking branches; branches of externomedian vein straight, superior, mostly simple, parallel to the main scapular vein; the internomedian area extending to some distance beyond the middle of the wing. It is a tolerably large species, the wing measuring 24 mm. in length and 10 mm. in breadth.

Triassic beds near Fairplay, Colorado.

Petrablattina Meieri, nov. sp.

Mediastinal vein terminating a long way beyond the middle of the costal border, with comparatively distant, usually simple branches. Scapular vein terminating just below the tip of the wing and beyond the basal curve, gently arcuate throughout, with branches similar to those of *P. æqua*, but occupying a larger area. In consequence, the externomedian area is of less importance than in *P. æqua*, and it has but few branches, which appear to be generally simple, and slightly declivent, though superior. Unfortunately this portion of the wing in the single specimen known is very obscure. The internomedian vein is not preserved in its outer portion, but it evidently reached the border nearer the base than the mediastinal vein, and the anal furrow is strongly curved. The wing is broken at the base, but its probable length was 19 mm., and its breadth 7 mm. It is named after Mr. Robert A. Meier, of Garo, Col., in whose shaft all these specimens were obtained, and who afforded our party all possible assistance in working them.

Triassic beds near Fairplay, Colorado.

POROBLATTINA (πόρος, Blattina), nov. gen.

Allied to *Petrablattina*, and especially the species of that genus found in the same Triassic rocks, differing from them principally in the insignificant part played by the mediastinal area and the corresponding importance of the scapular area. The mediastinal vein extends no further out than the anal, terminating far before the middle of the wing, and has consequently but a few offshoots; while the mediastinal, sweeping downward, away from the costal margin at the termination of the mediastinal, occupies nearly half of the wing before curving upward again to terminate above the apex. The externomedian vein is arcuate and terminates on the lower margin not far from the tip, and has only three or four superior longitudinal branches. The anal furrow is strongly arcuate. The anal veins are nearly parallel to the inner margin, but impinge upon it near the anal furrow.

Poroblattina arcuata, nov. sp.

The costal border is considerably convex. The scapular vein is unusually arcuate and has a large number of mostly simple oblique branches. The externomedian and internomedian veins, on the contrary, have few and distant branches, and the former is also strongly arcuate. The whole surface of the wing is broken by closely crowded cross-veins, which are more transverse to the whole wing than to the interspaces. A single, rather imperfect specimen is known, indicating a species with a wing about 10 mm. long; the width is 4 mm., and apparently the wing was well rounded and much shorter in proportion to its breadth than in the next species.

Triassic beds near Fairplay, Colorado.

Poroblattina Lakesii, nov. sp.

The costal border is nearly straight and the wing elongate. The scapular vein is much less arcuate than in the preceding species and has a comparatively small number of distant, singly or doubly forked, oblique branches. The much less oblique branches of the internomedian vein are more frequent but appear less crowded from their simplicity, while those of the externomedian are more distant than the latter, and equally simple. There is no sign of any cross-venation. This species, like the preceding, is small, the wing measuring about 12 mm. long, and 4·5 mm. broad. Named after Prof. Arthur Lakes of the School of Mines at Golden, Colorado, the first discoverer of these fossils.

Triassic beds near Fairplay, Colorado.

A REVISION OF THE NORTH AMERICAN MELICÆ.

BY F. LAMSON SCRIBNER.

The determination of our North American species of the genus *Melica*, and the notes relative to their distribution, etc., contained in the present paper, are based upon the collections in the herbarium at Cambridge, the Torrey herbarium, and the herbarium of the Department of Agriculture at Washington, all of which have been kindly loaned me for this purpose, by those having them in charge. I have also consulted the herbarium of the Academy of Natural Sciences of Philadelphia, as well as several valuable private collections.

The following is a synopsis or analytical key of the species, as they appear to me, by which it is hoped they may be readily identified without the aid of more extended descriptions.

§ 1. GLYCERIÆ.

Spikelets 1–5 flowered, flowering glumes herbaceo-coriaceous, with a narrow scarious margin above, strongly 7-nerved.

- Culms not bulbiferous, panicle many-flowered, spikelets 1½–2½ lin. long, with 1, or sometimes 2 perfect flowers.
  - Empty glumes shorter than the spikelet, rudimentary floret large, and nearly sessile. *M. imperfecta.* 1.
  - Empty glumes as long as the floret, the second one exceeding it, rudimentary floret small, long stipitate. *M. Torreyana.* 2.
- Culms bulbiferous, panicle simple, few-flowered with short divergent branches, spikelets 4–7 lin. long, with 3–5 perfect florets, flowering glumes 2–3 lin. long, joints of the thickened rhachilla about 1 lin. long. *M. fugax.* 3.

§ 2. EUMELICA.

Spikelets 4–8 lin. long, with 2–8 perfect florets, flowering glume apparently many-nerved below (at least when dry), with a broad scarious margin above.

- Culms not bulbiferous.
  - Empty glumes very unequal and decidedly shorter than the 3–5 flowered spikelets.
    - Panicle diffusely branched, many-flowered, the flexuose pedicels smooth or slightly pubescent. *M. diffusa.* 4.

Panicle narrow, the slender branches erect, or the lower slightly divergent, pedicels flexuose or recurved, densely pubescent. *M. Porteri.* 5.

Empty glumes unequal, the second nearly or quite as long (6–8 lin.) as the 4–6-flowered spikelets.

Panicle with 6–15 large, pendulous spikelets forming a simple secund raceme. *M. stricta.* 6.

Panicle strict, densely many-flowered above, interrupted below, branches and short, straight pedicels erect. *M. frutescens.*[1] 7.

Empty glumes subequal, nearly as long (4–5 lin.) as the 2-flowered spikelets.

Panicle few-flowered, sparingly branched below, often reduced to a simple raceme. *M. mutica.* 8.

Culms bulbous at base (excepting in occasional samples of No. 10).

The second glume decidedly shorter than the third.

Panicle nodding, loosely few-flowered, the slender branches erect spreading, flowering glume very broadly acuminate, obtuse or notched at the tip, terminal floret acute. *M. spectabile.* 9.

The second glume as long as the third.

Panicle erect, densely many-flowered, branched below, spicate above, spikelets about 4 lin. long, with about 3 perfect florets the rudimentary one obtuse. *M. Californica.* 10.

Panicle erect, branches appressed, few-flowered, spikelets 5–6 lin. long, with 5–8 perfect flowers, terminal floret acute. *M. bulbosa.* 11.

§ 3. BROMELICA.

Spikelets of 3–8 perfect florets, the lower exceeding the empty glumes; lower palet prominently 7-nerved, apiculate or distinctly awned by the excurrent midnerve at the notched or bifid or narrowly truncate or rarely long attenuated tip (Thurber).

Culms bulbiferous, panicle with spreading, very unequal few-flowered rays, the upper rays and spikelets mostly solitary.

Flowering glumes smooth or minutely scabrous, notched at the acute tip, the midnerve ending as a short point or awn between the teeth. *M. bromoides.* 12.

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[1] *Melica frutescens* approaches, by intermediate forms, very closely to *M. Californica*, but the membraneous character of its glumes, the unusual length of the outer ones, and the comparatively short palea (this being scarcely half as long as its glume) suggest a nearer relationship with *M. stricta.*

Flowering glumes ciliate on the margin and hirsute, especially below, with scattered hairs, long attenuated into a narrow subulate point, but not awned. *M. subulata.* 13.

Culms not bulbous at the base, panicle contracted.

Flowering glume about 4 lin. long, ciliate on the margin below with long shining hairs, apex truncate or obtusely lobed, awn when present not exceeding 3 lin. in length. *M. Harfordii.* 14.

Flowering glume 5–6 lin. long, strongly scabrous, with a few stiff marginal hairs near the base, awn 4–7 lin. long. *M. aristata.* 15.

1. **Melica imperfecta,** Trin. in Mem. Acad. St. Petersb., 1840, 59, and Icon. Gram., t. 355; Bolander, Proc. Calif. Acad., 1870, iv, 101; Thurber in S. Wats. Bot. Calif., ii, 303. *M. colpodioides,* Nees. in Tayl. Mag. Nat. Hist., 1, 282; *M. panicoides* and *M. poæoides,* Nutt. in Pl. Gambl., 188.

HAB.—*California:* Hills, San Bernardino Valley, Parish Bros., No. 885, April, 1881; San. Bernardino Co., Parry and Lemmon, No. 403, 1876; G. R. Vasey, No. 664, 1880; Southern California, Parry and Lemmon, No. 404; Santa Maria, Sta. Barbara Co., Lorenzo Jared, 1881; Santa Barbara, Mrs. E. Cooper, 1879; "Abundant in dry rock places," Mrs. R. F. Bingham, 1882; Fall Brook, M. E. Jones, No. 3092, March, 1882 (spikelets 2½ lin. long); Guadaloupe Island, off Lower Calif., E. Palmer, No. 98, 1875; Los Angelos, Bolander, Kellogg & Co. (a form with unusually broad and obtuse outer glumes). Two-flowered forms, the *M. poæoides* of Nuttall, come from San Francisco, Bolander, No. 6076, in part; Hills, San Diego, C. G. Pringle, 1882; Miss Scott, 1880; Dr. Cleveland, 1882.

Var. refracta, Thurber in S. Wats. Bot. Calif., ii, 303.

HAB.—Near San Bernardino, Calif. J. G. Lemmon, No. 1471, 1879.

Var. flexuosa, Bolander, Proc. Calif. Acad., iv, 101; Thurber, l. c., 303.

On the road from Mariposa to Clarks, Bolander; Santa Inez Mission, Brewer, No. 569 (teste Thurber).

I do not recognize this variety among the specimens I have in hand.

Var. minor.

Characterized by its comparatively low and densely tufted habit, short and chiefly radical leaves, compressed or angular culms, slender few-flowered panicle, the short branches divergent or even reflexed; the spikelets are generally smaller than in the species and the outer glumes usually shorter and more obtuse.

HAB.—San Bernardino Mts., Parish Bro., No. 856, May, 1882.

2. **Melica Torreyana.** *M. imperfecta*, var. *sesquiflora*, Torrey in Herb.

The specimens thus ticketed by Dr. Torrey were collected in California, by Dr. Bigelow, in 1853–4.

This proposed new species is distinguished from *M. imperfecta*, with which it is very closely allied, by its more membraneous, longer and more acute glumes—the second one equaling or exceeding the floret—by the hairs on the back of the flowering glume above the middle and by the *long-pedicelled* rudimentary floret, characters which seem to me to be of specific value.

Bigelow's specimens are immature, but the typical form is well represented by the specimens distributed by Bolander, Kellogg & Co. (1872). In these specimens the culms are 3 ft. high or more, leaves numerous, flat, 2–3 lin. wide, 6–8 in. long; ligule 3–4 lin. long, lacerated; panicle 6–10 in. long, diffuse, the slender flexuose branches 2–4 in. long and few-flowered at the ends, naked below. The characters of the spikelets are well shown in fig. 3, Pl. I.

Forms with two-flowered spikelets occur, but the second floret and rudiment are long-pedicelled, while in similar two-flowered forms of *M. imperfecta*, these are both nearly sessile.

No. 13 Bolander. and No. 6076 Bolander in part belong to this species. No. 586, collected by Dr. Torrey at New Almaden, California, in 1865, is a narrow-panicled form of *M. Torreyana*, closely resembling *M. imperfecta*, but at once recognized by the characters above noted.

3. **Melica fugax,**[1] Bolander, Proc. Calif. Acad., iv, 104; Thurber in S. Wats. Bot. Calif., ii, 304. *M. Geyeri*, Thurber, Bot. Wilkes' Exped., 492, not Munro.

HAB.—*California*: J. G. Lemmon, 1875; Sierra Valley, J. G. L., 1873 and 1874; Donner Lake, Bolander, Kellogg & Co., 1872; Plumas Co., Mrs. Austin, 1877. *Oregon:* Dry mountain sides, Union Co., W. C. Cusick, No. 1032, June, 1882. *Washington Territory:* Open pine woods, Falcon Valley, W. N. Suksdorf, Nos. 61 and 16, 1883.

In the spikelets of *Melica fugax*, the rhachilla is smooth, thickened and of a peculiar spongy texture, quite unlike that of any other North American species.

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[1] The *Melica*, from Mt. Shasta, referred to in my List of Pringle's Grasses (see Torr. Bull., x, p. 31, No. 72), is not *M. fugax*, nor am I able to identify it with any of the known species, unless it be an unusual form of *M. bulbosa*, Geyer. The specimens in hand are too meagre for more definite conclusions.

4. **Melica diffusa,** Pursh Flor., i, 77; Kunth En. Pl. i, 377; Stendel Gram., 291: *M. altissima,* Walt, Flor. Carol., 78. *M. glabra,* Michx., i, 62 (in part). *M. mutica,* var. *diffusa,* Gray in Man., 626. *M. scabra,* Nutt., Fl. Ark., 148.

Var. **nitens.**—*M. nitens,* Nutt. in Herb. Phila. Acad. *M. mutica,* Torr. in Marcy's Rept.

Differs from the species in its more leafy culms, narrower leaves, more densely flowered panicle, and in its much broader and more unequal outer glumes, the second one being nearly as long as the spikelet.

DISTRIBUTION.—Pennsylvania, Illinois, southward and westward to Texas. The variety = No. 3464 *a*, Curtiss' Distribution N. Am. Plants, coll. in Texas by J. Reverchon; also 389, Lindheimer, and 2062, C. Wright. Nos. 729, Lindheimer (1847), and 769, C. Wright (1849), belong to the species.

5. **Melica Porteri,** Scribner in Rusby's Arizona plants, No. 881½, 1883, and in Pringle's distribution of 1884. *M. mutica,* var. *parviflora,* T. C. Porter in Porter & Coulter's Fl. of Colorado, 149: *M. stricta,* Brandegee, Fl. Southwestern Colorado, p. 244.

HAB.—*Colorado:* Glen Eyrie, near Colorado City, T. C. Porter, July, 1872, and August, 1873. "This Melica, which I have from several stations in Colorado, I am now inclined to think a good species, as you do." T. C. P. in litt., December, 1882; Chiann Cañon, M. E. Jones, No. 1550, June, 1879; Cañon of the Rio La Plata, and Parrott City (alt., 8500 ft.), T. S. Brandegee; Hall and Harbour, No. 228. *Arizona:* Rusby, 1883; Santa Rita Mts., Pringle, 1884; Sierra Blanca, J. T. Rothrock, No. 805, 1874; J. G. Lemmon, 1884 (specimens differing from the type in their smaller spikelets, scarcely exceeding 4 lin. in length, while in the ordinary forms they are two lines longer). *New Mexico:* C. Wright, No. 2063, 1851, and Fendler, No. 924, 1847; G. R. Vasey, No. 142, July, 1881. *Texas:* Chixos Mts., V. Havard, No. 19, 1883 (a small flowered form like that collected by Lemmon in Arizona).

6. **Melica stricta,** Bolander, Proc. Cal. Acad., iii, 1863, p. 4, and iv, p. 104; Watson, Bot. King's Exped., 384: Thurb. in S. Wats. Bot. Cal., ii, 303.

HAB.—*California:* Virginia City, Bolander, No. 47; Yosemite Valley. Bolander, No. 6089, 1866; Sierra Co., J. G. Lemmon, No. 223, 1874; Bolander, Kellogg & Co., 1872 (alt. 7000 ft.): Sierra Nevada, "crevices of high rocks, 9000 ft.," E. L. Greene, No. 417, Oct., 1884; same district, alt. 9500 ft., C. G. Pringle, Sept., 1882; Plumas Co., R. M. Austin, 1878; Soda Springs, alt. 9000 ft., M. E. Jones, July, 1881; "Dry ridges, among rocks," Bear Valley, San Bernardino Mts., Parish Bros., No. 1553, Aug., 1882. *Nevada:* East Humboldt Mts., alt. 8000 ft., Aug., and Pah Ute Mts., alt. 5500 ft., June, S. Watson, No. 1305, 1868.

Note.—The inflorescence of this alpine species is similar to that of *M. Porteri*, but the panicle is much shorter, with only about a dozen spikelets, rarely more than 20, and the spikelets themselves are very much larger.

7. **Melica frutescens.**

Culms $2\frac{1}{2}$–$3\frac{1}{2}$ feet high, simple or branched near the base, leafy; leaves narrow, involute near the tip, scabrous, as are also the sheaths. Panicle 6–12 inches long, strict, densely flowered and spicate above, interrupted below, the appressed branches 1–3 inches long, densely flowered, or the longer ones naked below. Spikelets about 6 lin. long, with usually 5 perfect florets; first glume about 5 lin. long; the second a line longer, nearly equaling the spikelet; third glume about 4 lin. long, obtuse, the papery-membraneous tip occupying fully a third of its length. Palea usually about one-half the length of its glume.

Hab.—*California:* Southern California, Parry and Lemmon, No. 401, 1876; Mountains San Diego Co., C. G. Pringle, April 20, 1882; Lower California, near the United States border, C. R. Orcutt, No. 513, May, 1883; Near the Tia Juana, M. E. Jones, No. 3748, April 6, 1882.

8. **Melica mutica,** Walt., Flor. Carol., 78 (1788). *M. glabra,* Pursh.; Mx. (in part.), *M. mutica,* var. *glabra,* Gray in Man., 626. *M. speciosa,* Muhl., Ind. Fl. Lanc. (1791), 161, and Gram., i, 87. *M. racemosa,* Muhl. Gram., 88. *M. Muehlenbergiana,* Schult, Mant., 2, 294 (after Kunth).

Distribution.—Pennsylvania, southward and westward to Texas, (781, E. Hall).

Distinguished from *M. diffusa,* with which it has been united by some authors, by its more slender habit, less branched and fewer flowered panicle, which is often reduced to a simple raceme. The spikelets also rarely have more than two perfect florets, the outer glumes are more nearly equal in length, and often quite as long as the spikelet, while the flowering glumes are broader and more obtuse.

9. **Melica spectabile.** *M. bulbosa,* S. Wats., Bot. King. Exp., 383; Porter & Coulter, Fl. Colorado, 149.

Hab.—*Montana:* Crow Creek Mts., etc., alt. 6000 ft., Scribner, No. 385, 1883; Bozeman Pass, Wm. M. Canby, No. 368, 1883. *Colorado:* Twin Lakes, Upper Arkansas, and Plains near Ogden, T. C. Porter. 1872. Yellowstone Park, C. C. Parry, No. 295, 1873. *Utah:* Cottonwood Cañon, alt. 10,000 ft., S. Watson, No. 1303, July, 1869. *Idaho:* Beaver Cañon, S. Watson, No. 455, July, 1880.

This grass has been referred to Geyer's *M. bulbosa* by authors, but aside from its affecting higher elevations, it is readily distinguished from that species by its usually taller and more slender culms, by its more open and nodding panicle, by the more slender and flexuose pedicels, by its shorter empty glumes, and by its broader flowering glumes, which taper abruptly to a rounded and usually two-lobed summit.

10. **Melica Californica,** *M. poæoides*, Torrey, in Pac. R. Rep., iv, 157, non Nutt. *M. bulbosa*, Thurber, in S. Wats. Bot. Calif., ii, p. 304, non Geyer.

Hab.—*California:* Bolander, Nos. 32 and 6120; Kellogg & Harford, No. 1133, 1868–9: San Bernardino, Parish Bro., No. 865, 1881.—Mud Springs, Upper Yellowstone, T. C. Porter, 1871.

The bulbous character of the base of the culm, although usually manifest, is sometimes wholly wanting, as in Prof. Porter's specimens from the Upper Yellowstone.

Prof. Thurber's description in the Botany of California applies only to the Californian plant (*M. Californica*); from the distribution given, however, and the authors cited, it is evident that he supposed this to be identical with Geyer's plant, which is typically represented by Cusick's specimens, and also my *M. spectabile.* I have endeavored to point out the characters that distinguish these three species, which, to me, appear sufficiently well marked to leave little doubt of their specific rank.

11. **Melica bulbosa,** Geyer, in Hook. Jour. Bot., viii, 1856, 19 (without description); Gray, Proc. Am. Acad., viii, 409.

Culms bulbous at the base, growing singly or densely tufted, usually about 2 ft. high, simple; sheaths and upper surface of the leaves scabrous or (in Howell's specimens) retrosely pubescent; panicle slender erect, the short 1–3 flowered branches appressed; spikelets 5–7 lin. long with 6–8 perfect florets; empty glumes obtuse, the first about 3 lin. long, the second a line longer and nearly equaling the third or first flowering glume, which is oblong lanceolate, obtuse or notched at the tip and generally larger and firmer in texture than in *M. Californica.*

Hab.—*Oregon:* "Rocky ravine, Upper Platte, and only seen in one grassy spot," Geyer, No. 11; Union Co., W. C. Cusick, No. 900, 1880 and 900 *a*, 1882; Bolander, Kellogg & Co., 1872; Henderson, 1882; E. Hall, No. 635, 1871; Howell, 1881. *Washington Territory:* T. S. Brandegee, No. 1182, 1883. *Nevada:* Wheeler, 1872; West Humboldt Mts., alt. 8500 ft., S. Watson, No. 1304, 1867. *Idaho:* Bois City, Dr. J. E. Wilcox, 1883. *Utah:* Wasatch Mts., alt. 9000 ft., M. E. Jones, 1879; Ogden, J. M. Coulter, 1872. *Montana:* Belt Mts., alt. 6000 ft., Scribner, No. 386, 1883 (spikelets crowded above, 7–8 lin. long and 5–7 flowered).

12. **Melica bromoides,** Gray, Proc. Am. Acad., viii, 409; Thurber in S. Wat. Bot. Cal., ii, 304. *M. Geyeri,* Munro, ex Bolander, Proc. Cal. Acad., iv, 130. *M. poæoides* and *M. p.* var. *bromoides,* Nos. 6120, 40 and 6119 of Bolander's distributed sets. *Glyceria bulbosa,* Buckley, Proc. Phila. Acad., 1862, 95!

HAB.—*California:* Redwoods, Coast Range, Mt. Dana, Bolander, No. 6119; San Francisco, No. 6120; Woods, Ukiah, Mendocino Co., Bolander, No. 40. *Oregon:* Near Waldo, Thos. Howell.

Note.—Mr. Howell sends from Oregon (No. 335, 1884) a form that differs from the type in its more open and fewer-flowered panicle; the flowering glumes are also considerably longer, and entire, or but slightly notched at the tip, without any awn. This form has a decided festucoid "look," and may be designated as var. *Howellii.*

13. **Melica subulata.** *Bromus subulatus,* Griseb. in Ledeb. Fl. Ross., iv, 358; Gray, Proc. Am. Acad., viii, 410. *M. acuminata,* Bol., Proc. Cal. Acad., iv, 104; Thurber in S. Wats. Bot. Cal., ii, 305. *M. poæoides,* var. *acuminata,* of Bolander's distribution, No. 4698.

HAB.—*California:* Mendocino Co., Bolander, 1866. *Oregon:* E. Hall, No. 645, 1871; "Low mountains," Union Co., W. C. Cusick, No. 876, 1880; "Along mountain streams," Howell, 1880, distributed sub nom. "M. Geyeri"; Kellogg and Harford, No. 1112, 1868–9; Suavie's Island, Howell, 1883. *Washington Terr.:* Woods, Columbia River, W. N. Suksdorf, 1882; G. R. Vasey, No. 129, 1883.

Festuca subulata, Brong., is cited as a synonym for this species by Dr. Gray and Prof. Thurber. The description, in Led. Fl. Ross., of *F. subulata,* Brong., and the synonyms there quoted point to a very different grass. I would rather concur with the opinion expressed by Prof. E. Hackel, that *F. pauciflora,* Thurber, in S. Wats. Bot. Cal., ii, 318 (No. 6073, Bolander), is the *F. subulata,* of Brongard, and not Thunberg's *F. pauciflora.*

14. **Meliea Harfordii,** Boland. in Proc. Calif. Acad., iv, 102; Thurber in S. Wats, Bot. Calif., ii, 305.

HAB.—*California:* Cañons, Santa Cruz Coast, Bolander, and Redwood on the Upper Mattole River, No. 6424: Sierra, alt. 4000 ft., Bolander, Kellogg & Co., 1872; G. R. Vasey, 1875 (these specimens show well the tufted habit of the species); J. G. Lemmon. *Oregon:* Waldo, Howell, June, 1884; L. F. Henderson, 1883. *Washington Territory:* Willamette Slough, Howell, May, 1882; Dry rocky hillsides, Columbia River, Kliekitat Co., W. N. Suksdorf, 1882.

"This grass I collected in June, 1864, in a gulch near the summit of Santa Cruz Mts. It grows in large tufts 3–6 ft. high, the spikelets breaking asunder, even in what appear to be young specimens, at the slightest touch. Panicle contracted, erect, slightly drooping at the apex, caused by the club-shaped heavy top, often 9 in. long, with a few or even a single branch far below the main panicle. This spring I noticed the same grass near Ukiah."—*Bolander in Herb. A. Gray.*

In Bolander's specimens the spikelets are about 5 lin. long, and less than a line in width; the second empty glume is scarcely 3 lin. long, and the slender awn of the flowering glume is about a line in length. In the Oregon specimens the spikelets are 8 lin. long and nearly 2 lin. in width, with the second glume nearly 5 lin. long.

15. **Melica aristata**, Thurb. in Bolander's Revision of the *Melicæ*, Proc. Calif. Acad., iv, 103, and in S. Wats. Bot. Calif., ii, p. 305.

HAB.—*California:* Yosemite Valley, Bolander, No. 4861, 1866 (sheaths and leaves densely pilose); Bolander, Kellogg & Co., 1872 (culms stout, 3 ft. high, panicle a foot long, purplish); Emigrant Gap, M. E. Jones, 1882; Mt. Shaster, alt. 6000 ft.; C. G. Pringle, August, 1881 (culms slender, smooth, sheaths and leaves scabrous, panicle simple, few-flowered, dark purple). *Washington Territory:* W. N. Suksdorf, 1883 (panicle few-flowered, green.)

EXPLANATION OF PLATE I.

FIG. 1. Spikelet of *Melica imperfecta.*
" 2. Same with the outer glumes removed, showing the nearly sessile rudimentary floret, *r*.
" 3. Spikelet of *M. Torreyana.*
" 4. Same with outer glumes removed.
" 5. Spikelet of *M. fugax.*
" 6. Spikelet of *M. Californica.*
" 7. Spikelet of *M. bulbosa*, from the typical plant.
" 8. Anterior view of floret of same, showing palea.
" 9. Terminal empty glume and rudiment of same.
" 10. Spikelet of *M. bulbosa*, the florets raised above the empty glumes; unusually large, from the Idaho specimens.
" 11. Spikelet of *Melica spectabile.*
" 12. Terminal empty glume and rudiment of same.
" 13. Anterior view of flowering glume of same, flattened to show veins, etc.
" 14. Seed of *M. bulbosa* from Howell's specimens.
" 15. Spikelet of *Melica frutescens.*
" 16. Floret of same.
" 17. Spikelet of *Melica Porteri.*
" 18. Dorsal view of flowering glume, flattened out above.
" 19. Spikelet of *Melica subulata.*
" 20. A floret from the spikelet of *Melica bromoides.*

All enlarged on the same scale, excepting fig. 14.

MARCH 17.

Mr. GEORGE W. TRYON, Jr., in the chair.

Twenty-four persons present.

The following papers were presented for publication:—

"Entomologia Hongkongensis.—Report on the Lepidoptera of Hongkong," by F. Warrington Eastlake.

"Description of a supposed new species of the genus Cyanocorax," by Alan F. Gentry.

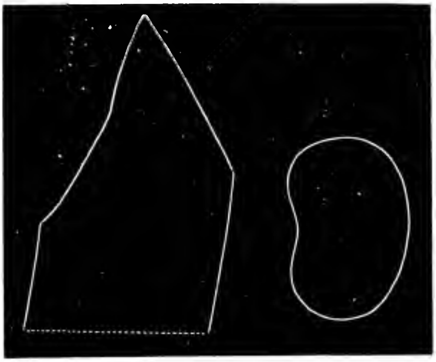
The death of Titian R. Peale, a member, was announced.

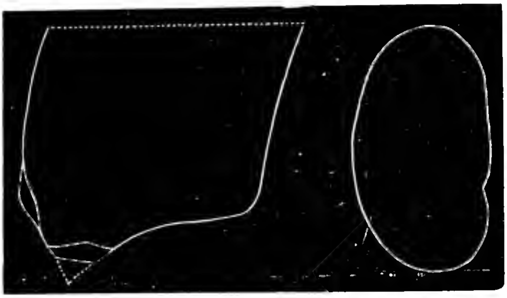
MARCH 24.

The President, Dr. LEIDY, in the chair.

Twenty-six persons present.

Remarks on Mylodon.—Prof. LEIDY remarked that among the fossils of *Mastodon*, *Equus*, etc., from the salt mines of New Iberia, La., noticed in the Proceedings of 1884, p. 22, there are three teeth, which are probably to be referred to the reputed *Mylodon Harlani*. Of this species we are sufficiently well acquainted with the posterior three lower molars, but know little of the first lower molar, and nothing of the upper teeth. One of the Louisiana specimens accords in form and size with the third lower molar, in the best preserved jaw-fragment (see Extinct Sloth Tribe, pl. xiv, 1, 2), from Big-bone-lick, Ken., regarded as characteristic of *Mylodon Harlani*. The other Louisiana specimens, in comparison with the complete dental series in both jaws of *Mylodon robustus*, as represented in the famous memoir of Prof. Owen, are so unlike any of the teeth of this animal, that they might readily be considered as pertaining to another genus. One of the specimens, of which the triturating extremity and a transverse section are represented in the outline figures 1; 2, he took to be a first lower molar. It has lost all its cementum, but is otherwise well preserved. It is worn off in deep slopes, of which the posterior is more than an inch long, and the anterior little less than an inch. The transverse section is reniform, widest in front, and agrees in shape and size with a fragment of the corresponding tooth (*op. cit.*, pl. xvi, 19 *a*) retained in the jaw-fragment from Kentucky. In all the teeth of *Mylodon robustus*, the triturating surface inclines comparatively little from a level. Such also is the case in all the teeth of the ramus of a lower jaw, from Natchez, Miss., attributed to a half-grown animal of *Mylodon Harlani*, preserved in our museum. In this, among some rude casts in plaster, the originals of which were described by Dr. Harlan, under the name of *Orycterotherium missouriense* (Am. Jour. Sci., 1843, 69), and subsequently referred to *Mylodon Harlani*, is one of a lower-jaw fragment, which contains the first molar, and the mutilated base of the second. The latter, in the perfect state, would appear to accord in shape and size with the corresponding tooth in the Kentucky jaw-fragment, referred to *Mylodon Harlani*. The first molar is unlike that of *Mylodon robustus*, but sufficiently accords in size, shape, and condition of wear, with the Louisiana tooth to regard this as pertaining to the same animal. The remaining Louisiana specimen is not only unlike any of the teeth of *Mylodon robustus*, but differs from them to such a degree as to render it doubtful whether it belongs to the same genus. In comparison with other teeth of the lower or upper series, in size and shape, it accords with the canine molars of *Megalonyx* more than it does with any of the teeth of *Mylodon*. The triturating extremity and transverse section are represented in the outlines 3 and 4. It is more uniformly elliptical in transverse section than in the canine molars of *Megalonyx*, and is devoid of the abrupt median bulge


1. 2.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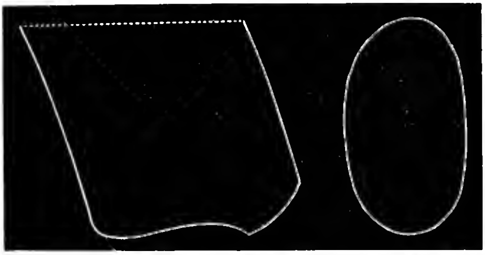
5. 6.

inwardly of the latter. Regarding it as a first upper molar, it is twice the breadth of the corresponding tooth of *Mylodon robustus*, not only absolutely, but also proportionately in comparison with all the other teeth, except the last one of the lower series. The triturating extremity is worn away obliquely and concavely behind for about two-thirds the breadth of the tooth, and obliquely in front the remaining third of the breadth, but the slopes extend only half the depth observed in the accompanying specimen of the first lower molar. In view of the dentition of *Mylodon robustus*, it seems improbable that this tooth should belong to an animal of the same genus, nor would it appear to be adapted as an opponent to the comparatively narrow, long-pointed tooth which accompanies it. Nevertheless, he was suspicious that both these teeth may pertain to the *Mylodon Harlani*, partly from the fact that the lower-jaw fragment, originally referred to *Orycterotherium missouriense*, and then to the latter, contains a first molar like the Louisiana specimen, and partly from the fact that the jaw-fragment was accompanied by an isolated molar tooth nearly resembling the supposed upper first molar from Louisiana. A plaster cast of the tooth referred to *Orycterotherium*, of which the triturating extremity and transverse section are represented in the outlines 5 and 6, though rather smaller, is sufficiently like the corresponding Louisiana tooth to render it probable this belonged to the same animal. Admitting that the two Louisiana specimens may not belong to the reputed *Mylodon Harlani*, he felt that the coincidence of facts is such as not to justify a conclusion to refer them to a new genus, and if further discovery should demonstrate that they really pertain to this animal, it becomes a question whether the difference of the teeth from those of *Mylodon robustus* is not sufficient to restore the name of *Orycterotherium missouriense*.

Fig. 1. Outer view of the first lower molar; Louisiana specimen; length, 85 mm. Fig. 2. Transverse section; the front above, the outer side to the right; fore and aft, 24 mm.; short diameter, 17 mm. Fig. 3. Outer view of the first upper molar, Louisiana specimen; length, 83 mm. Fig. 4. Transverse section; fore and aft, 34 mm.; short diameter, 19 mm. Fig. 5. Outer view of cast referred to *Orycterotherium*: length, 67 mm. Fig. 6. Transverse section; fore and aft, 29 mm.; short diameter, 17 mm.

The following were ordered to be printed:—

A REVIEW OF THE AMERICAN GENERA AND SPECIES OF BATRACHIDÆ.

BY SETH E. MEEK AND EDWARD A. HALL.

In the present paper we have attempted to collect the synonymy of all the genera and species of Batrachidæ known from American waters.

The specimens examined by us all belong to the Museum of the Indiana University.

Analysis of Genera of Batrachidæ.

a. Dorsal spines two; opercle very small, its posterior part developed as a single strong spine; subopercle feebly developed, narrowed and not ending in a spine; body scaleless.

  b. Spines of dorsal fin and operculum hollow and connected with venom glands; lateral line on sides of body single; no canine teeth. THALASSOPHRYNE. 1.

  bb. Spines solid, without venom glands; several lateral lines on sides of head and body, composed of pores and shining spots, some of these accompanied by cirri; canine teeth present; vertebræ 12 + 31; frontal region depressed, forming a triangular area below level of temporal region, its median ridge very low. PORICHTHYS. 2.

aa. Dorsal spines three; opercle developed as two strong diverging spines; subopercle rather strong, with two spines similar to those of opercle.

  c. Body scaleless; branches of subopercular spine parallel, the lower branch much the shorter; vertebræ 10 + 22; frontal region not depressed, its median ridge prominent. BATRACHUS. 3.

  cc. Body scaly; branches of subopercular spine subequal and diverging; frontal region broad, flat and slightly depressed, its median ridge rather prominent. BATRACHOIDES. 4.

1. THALASSOPHRYNE.

Thalassophryne Günther, Cat. Fish. Brit. Mus., iii, 1861, 174 (*maculosa*).

In this genus only five species are recognized. These have been well described by Dr. Günther and Dr. Steindachner. They are noted for the development of poison glands in connection with their spinous armature.

Analysis of Species of Thalassophryne.

Common Characters.—Dorsal spines two; opercle very small, its posterior part developed as a single strong spine; subopercle feebly developed, narrowed and not ending in a spine; no scales on body. Spines hollow and connected with venom glands. Lateral line on sides of body single; no canine teeth. America.

a. Dorsal and anal fins joined to the caudal; teeth on premaxillaries smaller than on lower jaw; eye very small; lower jaw the longer. D. II–20; A. 18 or 19.

  b. Anterior teeth on jaws in two rows.

    c. Pectoral fins short, their tips reaching just to front of anal; head as wide as long; opercular spine about $\frac{1}{4}$ length of head; caudal $\frac{1}{2}$ length of head. Color chocolate-brown; no distinct dark bands on head; body, except belly and under side of head covered with numerous small, dark, round spots; anal clear brownish gray, edged with dark brown; no dark bands on sides of body. (*Steindachner.*) *Punctata.* 1.

    cc. Pectoral fins longer, reaching past third or fourth anal ray; head $1\frac{1}{3}$ times as long as wide; opercular spine about $\frac{1}{3}$ length of head; caudal $\frac{2}{3}$ of length of head; mouth very oblique. Color brownish, marbled with darker; two distinct bands on head; dorsal and anal with brown spots arranged in distinct rows; six dark bands on sides of body, the first at spinous dorsal, the others along the base of soft dorsal. (*Steindachner.*) *Amazonica.* 2.

  bb. Anterior teeth on lower jaw forming a band; mouth moderately oblique; head less than 3 in length of body; interorbital width $5\frac{1}{3}$ to $5\frac{1}{2}$ in length of head. Color more or less clear reddish brown; belly brownish yellow; base of fins reddish brown or whitish, the upper part of the fins deep dark brown, the two colors separated by a distinctly marked whitish streak. (*Steindachner.*) *Nattereri.* 3.

aa. Dorsal and anal fins not joined to the caudal.

    d. Dorsal and anal fins rather short (D. II–19; A, 18); pectoral fins short, their tips reaching to origin of anal. Color brown, marbled with darker; pectoral fins and sides of body with some round black spots; chin and ventrals brownish; belly white. (*Günther.*) *Maculosa.* 4.

dd. Dorsal and anal fins longer (D. II–24; A, 24); pectoral fins longer, their tips reaching to sixth anal ray. Color of head, body, and fins brown, with a network of yellowish lines; dorsal, anal, caudal and pectoral fins with white margins. (*Günther.*) *Reticulata.* 5.

1. **Thalassophryne punctata.**

Thalassophryne punctata Steindachner, Ichthyol. Beiträge, v, 1876, 121 (Bahia; Porto Segro.)

Habitat.—Coast of Brazil.

This species is known to us only from Steindachner's description.

2. **Thalassophryne amazonica.**

Thalassophryne amazonica Steindachner, Ichthyol. Beiträge, v, 1876, 113 (Amazon River).

Habitat.—South America, Amazon Basin, in fresh water.

This species is known to us only from the description of Steindachner.

3. **Thalassophryne nattereri.**

Thalassophryne nattereri Steindachner, Ichthyol. Beiträge, v, 1876, 115 (Para).

Habitat.—Amazon Basin; Para.

This species is known to us only from the description of Steindachner.

4. **Thalassophryne maculosa.**

? ? *Batrachus gronovii* Cuvier & Valenciennes, Hist. Nat. Poiss., xii, 1837, 482 (America).

? ? *Callionymus niqui* Gronow, Cat. Fish., Ed. Gray, 1854, 45.

Thalassophryne maculosa Günther, Cat. Fish. Brit. Mus., 1861, 175 (Puerto Cabello); Günther, Fishes of Central America, 1869, 436, pl. 68, fig. 1 (Puerto Cabello).

Habitat.—Eastern Coast of Central America; Puerto Cabello.

This species is known to us only from the description of Dr. Gunther.

Batrachus gronovii of Cuvier & Valenciennes = *Callionymus niqui* Gronow, perhaps, belongs to some species of this genus; but of this there can be no certainty, the descriptions are too imperfect.

5. Thalassophryne reticulata.

Thalassophryne reticulata Günther, Proc. Zoöl. Soc. London, 1864, 150 155 (Panama); Günther, Fish. Central America, 1869, 437, pl. 68, fig. 2 (Panama); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 626 (Panama).

Habitat.—Western Coast of Central America; Panama.

This species is known to us only from the accounts of Dr. Günther and Professors Jordan and Gilbert.

2. PORICHTHYS.

Porichthys Girard, Proc. Acad. Nat. Sci. Phila., 1854, 141 (*notatus* = *margaritatus*).

This genus is remarkable for the development of its mucous pores, or "lateral lines." The number of vertebræ in *Porichthys* is much greater than in *Batrachus*, and the skull is somewhat different.

Analysis of Species of Porichthys.

Common Characters.—Dorsal spines two; opercle very small, its posterior part developed as a strong, single spine; suboperculum feebly developed, narrowed and not ending in a spine; no scales on body; spines solid, without venom glands; several lateral lines on sides of head and body, composed of pores and shining spots, some of these accompanied by cirri; canine teeth present; vertebræ 12 + 31; frontal region depressed, forming a triangular area below level of temporal region, its median ridge very low. Branchiostegals 6; interorbital area short, wide, and with shallow grooves. Air bladder more or less deeply divided into lateral parts. Pyloric appendages none.

a. Abdomen with two longitudinal series of pores, none of them accompanied by shining bodies; vomer with one canine tooth on each side. Color above brown, sides and belly silvery; dorsal fin with four oblique dark bands; posterior half of the caudal blackish, or with blackish spots; anal with two blackish spots posteriorly. Head $4\frac{2}{3}$ in total length. D. II–34; A. 33. *Porosus.* 6.

aa. Abdomen with four longitudinal series of pores; each of which is accompanied by a shining silvery body; four rows of pores on sides of body. Color dark brownish above, below with brassy reflections; dorsal and anal with dark margins, a dark blotch below eye. Head $3\frac{3}{4}$ in length. D. II–37; A. 33.

b. Teeth on palatines numerous, subequal, none of them much enlarged; two canine teeth on each side on vomer, the inner ones usually about $\frac{1}{2}$ length of outer ones. *Margaritatus.* 7.

bb. Teeth on palatines unequal, few; one to three on each side enlarged and canine-like; one canine tooth on each side on vomer. *Porosissimus.* 8.

6. **Porichthys porosus.**

Batrachus porosus Cuvier & Valenciennes, Hist. Nat. Poiss., xii, 1837, 506 (Valparaiso); Gay, "Hist. Chili Zool., ii, 1844–54, 296 (Chili)."

Porichthys porosus Günther, Cat. Fish. Brit. Mus., iii, 1861, 177 (Chili); Jordan, Proc. U. S. Nat. Mus., 1884, 41.

Habitat.—Western Coast of South America, Chili.

We have not seen this species; we only know it from the accounts above cited.

7. **Porichthys margaritatus.** Midshipman; Singing-fish; Cabezon; Sapo.

Batrachus margaritatus Richardson, "Voyage Sulphur, Fishes, 1844–45, 67 (Pacific Coast of Central America)."

Porichthys margaritatus Jordan & Gilbert. Proc. U. S. Nat. Mus., 1882, 368 (Cape San Lucas; no description); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 626 (Central America; no description); Jordan & Gilbert, Syn. Fish. N. A., 1883, 958; Jordan, Proc. Acad. Nat. Sci., 1883, 291 (Panama; Vancouver's Island); Jordan, Proc. U. S. Nat. Mus., 1884, 41.

Porichthys notatus Girard, Proc. Acad. Nat. Sci., 1854, 141; Girard, U. S. Pacific R. R. Survey, 1859, 134 (San Francisco); Goode, Bull. U. S. Nat. Mus., 1879, 32 (Pacific Coast).

Porichthys porosissimus Günther. Cat. Fish. Brit. Mus., iii, 1861, 176 (in part; Vancouver Island); Gill, Proc. Acad. Nat. Sci. Phil., 1862, 280 (California); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1880, 25 (San Diego; no description); Bean, Proc. U. S. Nat. Mus., 1880, 83 (West Coast; San Diego; Santa Barbara; Monterey; no description); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1880, 454 (Puget Sound; San Francisco; Monterey Bay; San Luis Obispo; Santa Barbara; San Pedro; San Diego; no description); Rosa Smith, Ichth. San Diego, 1880 (San Diego); Jordan & Jouy, Proc. U. S. Nat. Mus., 1881, 5 (Santa Barbara; Monterey; San Francisco; Puget Sound; no description); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1881, 65 (West Coast U. S.; no description); Bean, Proc. U. S. Nat. Mus., 1881, 263 (Puget Sound); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1881, 274 (Gulf of California; no description); Jordan & Gilbert, Syn. Fish. N. A., 1883, 751; (not *Batrachus porosissimus* Cuvier & Valenciennes).

Habitat.—Western Coast of North America, from British Columbia to Panama.

This species has been confounded with *porosissimus*, but the absence of canine teeth on palatines (a constant character in all known specimens), warrants its separation. Professor Jordan has also examined the specimens in the British Museum. Those in that collection from the Atlantic have canine teeth on the palatines, the character assigned to *P. plectrodon*, while these are wanting in the examples from the Pacific.

A letter from Dr. H. E. Sauvage to Professor Jordan, states that the type of *Batrachus porosissimus* Cuv. and Val. "has a strong canine tooth on each side of the vomer ; on the palatines are seen at first a strong, then some small teeth, and finally a strong curved tooth."

The application of the name *porosissimus* to the present form is thus shown to be improper.

8. **Porichthys porosissimus.**

Batrachus porosissimus Cuvier & Valenciennes, Hist. Nat. Poiss., xii, 1837, 501 (Surinam ; Cayenne ; Rio Janeiro ; St. Catherine); Jenyns, "Zool. Beagle, 1842, 99."

Porichthys porosissimus Günther, Cat. Fish. Brit. Mus., iii, 1861, 176 (Brazil); Jordan, Proc. U. S. Nat. Mus., 1881, 41 ; Jordan & Gilbert, Syn. Fish. N. A., 1882, 751 ; Jordan, Proc. Acad. Nat. Sci. Phil., 1883 (South America).

Porichthys plectrodon Jordan, Proc. U. S. Nat. Mus., 1882, 291 (Galveston); Goode & Bean, Proc. U. S. Nat. Mus., 1882, 236 (Gulf of Mexico ; no description); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 307 (Gulf of Mexico ; no description); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 616 (Charleston ; no description); Jordan & Gilbert, Syn. Fish. N. A., 1883, 958 ; Bean, Cat. Fish. Exhibited, London Exhibit, 1883, 47.

Habitat.—Atlantic Coast of North and South America, from Charleston to Rio Janeiro.

We have nothing to add to the very detailed description of this species, given by Jordan and Gilbert under the name of *Porichthys plectrodon.* The single specimen examined by us is from Pensacola.

3. BATRACHUS.

Batrachus Bloch & Schneider, Systema Ichthyol., 1801, 42 (*didactylus*, *tau*, etc.).

In this genus we recognize one American species, with two varieties ; all found in the Atlantic.

Analysis of Species of Batrachus.

Common Characters.—Dorsal spines three; opercle developed as two strong, diverging, subequal spines; subopercle rather well developed; branches of subopercular spine parallel, the lower branch much the shorter. No scales on body. Vertebra **10 + 22**; frontal region not depressed, its median ridge prominent. Interorbital long and narrow with a deep groove. Branchiostegals 6. Teeth conical and blunt; lateral teeth on jaws and palatines in single rows. A large foramen in axil of pectoral fin (in North American species). Head about $2\frac{3}{5}$ in length of body; width of head from 3 to 4 in length of body. D. III–24 to 28; A. 19 to 22.

a. Two indistinct rows of pores on sides of body.

b. A fleshy tentacle between nostrils; color brownish or dusky greenish, mottled with darker and lighter, the dark on sides of body in large irregular blotches extending from base of dorsal to about $\frac{2}{3}$ distance to base of anal, and more or less covered with small pale spots; belly and chin plain white or yellowish. In specimens from shallow water or algæ, the brown becomes nearly black and more extended, the belly and chin spotted with darker, and top of the head has no distinct markings; in specimens from deeper water or from coral sand, the coloration is more brownish or yellowish. Soft dorsal with six to nine oblique light bands; anal with five to nine. Caudal and pectoral fins with five to seven light cross-bands, these formed chiefly from light spots; ventrals with some dark markings. *Tau.* 9.

bb. No fleshy tentacle between nostrils; color whitish or gray, everywhere blotched or spotted with brownish yellow and black, the black spots on top of head smaller and more numerous than on rest of body; a large black blotch at base of spinous dorsal, running up on fin; three black blotches along base of soft dorsal, which do not extend half the distance to base of anal. Pectoral with black spots which do not form cross-bands. Ventrals with more dark markings than in *tau*. Dorsal, anal and caudal marked nearly as in *tau*. *Tau pardus.* 9 *b.*

aa. Two very prominent rows of pores on sides of body; teeth more numerous than in *Batrachus tau*. Cirri above eyes very large (Cuv. and Val.). *Tau cryptocentrus.* 9 *c.*

9 *a*. **Batrachus tau.** Toad-fish; Sapo.

Gadus tau Linnæus, Systema Naturæ, ed. xii, 1766, 439 (Carolina); Schoepf, Beobacht. viii, 1788, 141 (New York); Walbaum, Genera Pisc., 1792, 135 (Eastern America).

Batrachus tau Cuvier & Valenciennes, Hist. Nat. Poiss., xii, 1837, 478 (New York); De Kay, New York Fauna, Fish, 1842, 168, pl. 28, f. 26 (New York); Storer, Syn. Fish. N. A., 1846, 132; Günther, Cat. Fish. Brit. Mus., iii, 1861, 167 (New York; New Orleans); Gill, Cat. Fish. East Coast N. A., 1861 (name only); Poey, Syn. Pisc. Cuba, 1868, 390 (Cuba); Gill, Report U. S. Fish Comm., 1871–72, 798 (New Jersey; Florida; Cuba; no description); Baird, Report U. S. Fish Comm., 1871–72, 824 (Wood's Holl); Poey, Enumeratio Pisc. Cubensium, 1875, 136 (Cuba); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1878, 372 (Beaufort, N. C.; no description); Goode, Proc. U. S. Nat. Mus., 1879, 110 (Mouth of the St. John's River, Fla.; no description); Goode & Bean, Proc. U. S. Nat. Mus., 1879, 127 (Pensacola); Goode & Bean, Proc. U. S. Nat. Mus., 1879, 334 (Pensacola; Beasley's Point, N. J.; Norfolk, Va.; Punta Russa, Fla.; Wood's Holl, Mass.; Indianola, Tex.); Goode, Bull. U. S. Nat. Mus., xiv, 1879, 32 (Wood's Holl; no description); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1880, 83 (Wood's Holl, Mass.; Noank, Conn.); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 291 (Pensacola, Fla.); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 616 (South Carolina; no description); Jordan & Gilbert, Syn. Fish. N. A., 1882, 750; Bean, Cat. Fish. Ex. U. S. Nat. Mus., 1883, 47; Jordan, Proc. U. S. Nat. Mus., 1884, 143 (Key West; no description).

Lophius bufo Mitchill, Trans. Lit. and Phil. Soc., New York, 1815, 463 (New York).

Batrachoides vernullas Le Sueur, "Mem. Mus., v, 1819, 157, pl. 17."

Batrachoides variegatus Le Sueur, Jour. Acad. Nat. Sci. Phila., iii, 1823, 399 and 401 (Egg Harbor, New Jersey).

Batrachus variegatus Cuvier & Valenciennes, Hist. Nat. Poiss., xii, 1837, 484 (copied); Storer, Fish. Mass., 1839, 74 (Holmes' Hole); Storer, Syn. Fish. N. A., 1846, 133 (New York); Gill, Cat. Fish. East Coast N. A., 1861, 43 (Name only).

Batrachus celatus De Kay, New York Fauna, Fish, 1842, 170, pl. 50, f. 161 (New York); Storer, Syn. Fish. N. A., 1846, 133; Gill, Cat. Fish. East Coast N. A., 1861, 43 (Name only).

Habitat.—Atlantic Coast of North America, from Cape Cod to Cuba.

We have examined numerous specimens (from 3 to $9\frac{3}{4}$ inches in length) of this species from Key West, Florida. We find among these apparently the varieties *A* and *B* of Dr. Günther, and also intermediate grades.

In the young specimens the head is more narrow and rounded, and the lower branch of the subopercular spine proportionally larger than in the adult.

The deeper-water specimens are lighter in coloration than those from near the surface, and those from the coral reefs are paler than those from the green algæ and sea-wrack, otherwise no differences seem to exist.

9 *b*. **Batrachus tau pardus.**

Batrachus tau var. *pardus* Goode & Bean, Proc. U. S. Nat. Mus., 1879, 336 (Pensacola, Fla.); Jordan & Gilbert, Syn. Fish. N. A., 1883, 751.

Batrachus pardus Goode & Bean, Proc. U. S. Nat. Mus., 1882, 336 (Gulf of Mexico); Bean, Cat. Fish. London Exhibit., 1883, 47 (Pensacola, Fla.); Jordan, Proc. Acad. Nat. Sci. Phila., 1884, 45 (Egmont Key).

Habitat.—Gulf of Mexico; Egmont Key; Pensacola.

The coloration of *pardus* is very different from that of *tau*. In the specimen (13⅜ inches in length, from Pensacola) which we have examined, the fleshy tentacle between nostrils is wanting, while in all the specimens of *B. tau* this is present.

The former seems to be a deep-water variety or subspecies of the latter. The few specimens of *pardus* known are from considerable depths. The texture of the flesh and the skin is less firm than in *tau*.

9 *c*. **Batrachus tau cryptocentrus.**

Batrachus cryptocentrus Cuvier & Valenciennes, Hist. Nat. Poiss., 1837, 485 (Bahia).

Habitat.—Eastern Coast of South America (Bahia).

This form is known only from the meagre description of Cuvier and Valenciennes. We venture to place it among the varieties of *tau*, as no diagnostic character of importance appears in the description.

4. BATRACHOIDES.

Batrachoides Lacépède, Hist. Nat. Poiss., iii, 1798, 306 (*Batrachoides tau* Lacépède = *Batrachus surinamensis* Bloch).

This genus is closely allied to *Batrachus*, but it seems to be sufficiently distinguished by the scaly body. Two species are found in American waters.

Analysis of Species of Batrachoides.

Common Characters.—Dorsal spines three; opercle developed as two strong diverging spines; subopercle strongly developed; branches of subopercular spine subequal and diverging; body covered with small ctenoid scales; frontal region broad, flat, and slightly depressed, its median ridge rather prominent.

a. Teeth small, about 14 on vomer; anterior teeth on lower jaw in a band; lateral teeth on palatines enlarged and canine-like, irregularly arranged; pectoral without pores on its inner surface. Color grayish, darker on sides and head; base of soft dorsal pale, with a dark irregular line above; upper part of fin lighter; caudal nearly black; anal fin light, with some dark markings. Head $3\frac{1}{4}$ in length of body; depth 6. D. III–29; A. 26. *Surinamensis.* 10.

aa. Teeth larger, about 8 on vomer; anterior teeth on lower jaw in two rows; lateral teeth on lower jaw gradually increasing to middle of jaw, behind which they become abruptly smaller, and then gradually increase to end of jaw; three teeth on middle of palatines enlarged and canine-like, the middle one the smallest; pectoral with a row of pores on inner surface. Color olivaceous brown; some indistinct dark cross-bands on body; dorsal with about seven very irregular oblique dark bars, anal with about five; pectorals and caudal dark, with few light cross-bands. Head 3 in length of body. D. III–26; A. 22. *Pacifici.* 11.

10. Batrachoides surinamensis.

Batrachoides tau Lacépède, Hist. Nat. Poiss., iii, 1798, 306, pl. 12, fig. 1 (not *Gadus tau* L.)

Batrachus surinamensis Bloch & Schneider, Systema Ichthyol., 1801, 43, tab. 7 (Surinam); Cuvier & Valenciennes, Hist. Nat. Poiss., xii, 1837, 488 (Surinam); Günther, Cat. Fish. Brit. Mus., iii, 1861, 174 (Demarara; British Guiana; West Coast Central America).

Habitat.—Atlantic Coast of Tropical America; a specimen recorded by Dr. Günther from the Pacific Coast.

The single specimen of this species examined by us is from Curuca. The record given by Dr. Günther of this species from the Pacific Coast needs verification. It was not found at Panama by Professor Gilbert.

11. Batrachoides pacifici

Batrachus pacifici Günther, Cat. Fish. Brit. Mus., iii, 1861, 173 (Panama); Günther, Fishes Central Amer., 1869, 435 (Panama).
Batrachoides pacifici Gill, Proc. Acad. Nat. Sci. Phila., 1863, 170 (West Coast of Central America); Jordan & Gilbert, Bull. U. S. Fish. Com., 1882, 3 (Panama; no description); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 626 (Panama; no description).

Habitat.—West Coast of Tropical America; Panama.

The single specimen of this species examined by us is from Panama, at which place the species was found to be abundant by Professor Gilbert.

A REVIEW OF THE SPECIES OF THE GENUS PIMEPHALES.

BY WILLIS S. BLATCHLEY.

I have examined numerous specimens of *Pimephales* and *Hyborhynchus* from various parts of the United States, with a view to discrimination of the species.

The genus *Hyborhynchus* is evidently unworthy of retention, and the entire group is, in my opinion, composed of but two species, *Pimephales promelas* and *Pimephales notatus.*

I give the synonymy of each and an analytical key giving the principal characters by which they may be separated.

The specimens examined belong to the Museum of the Indiana University.

a. Body comparatively short and deep, the greatest depth about 4 times in length of body; head short, convex, almost as broad as long in the adult, its length 4 in body; mouth slightly oblique; lateral line of various lengths, sometimes wanting on twenty or more scales; sometimes complete (variety *confertus*); origin of dorsal midway between pupil and base of caudal; ventrals reaching to or beyond first ray of anal; head, dorsal and pectoral fins of breeding males jet black, the snout with a few moderate-sized tubercles; scales 8–47–6. *Promelas.* 1.

aa. Body elongate, rather slender, the greatest depth about $4\frac{3}{4}$ times in length of body; head comparatively long, its length $4\frac{1}{2}$ in body, its surface much depressed above and descending abruptly in front of nostrils; mouth horizontal; lateral line complete; origin of dorsal midway between snout and base of caudal; ventrals not reaching vent; males in spring with 16 large nuptial tubercles, often accompanied by a small protuberance of skin, resembling a barbel, at angle of mouth; scales 6–44–4. *Notatus.* 2.

1. Pimephales promelas Raf.

Pimephales promelas Rafinesque, Ichth. Oh., 1820, 53 (Lexington, Ky.); Kirtland, Rept. Zool. Ohio, 1838, 194; Kirtland, Bost. Jour. Nat. Hist., iii, 1838, 475; Storer, Synopsis, 1846, 418; Agassiz, Amer. Jour. Sci. Arts, 1855, 220; Putnam, Bull. M. C. Z., 1863, 8; Günther, Cat. Fish. Brit. Mus., vii, 1868, 181; Jordan, Ind. Geol. Surv., 1874, 224; Jordan, Bull. Buff. Soc. Nat. Hist., 1876, 94;

Jordan, Man. Vert., 1st ed., 1876, 275; 2d ed., 1878, 288; 3d ed., 1880, 288: Nelson, Bull. Ill. Lab. Nat. Hist., i, 1876, 45 (Bailey's Creek, Ill., Evanston, Ill.); Jordan & Copeland, Check List Fresh Water Fish. N. A., 1876, 146; Jordan, Bull. U. S. Nat. Mus., ix, 1877, 32; Jordan, Annals N. Y. Acad. Sci., 1877, No. 4, 107 (Wisconsin R., Pecatonica R., Ohio R., Kentucky R.); Jordan, Bull. Ill. Lab. Nat. Hist., ii, 1878, 55 (Bailey's Cr.; Rock R., Ill.); Jordan & Brayton, Bull. U. S. Nat. Mus., xii, 1878, 78 (Tributaries Cumberland R.): Jordan, Bull. Hayden's Geol. Surv., iv, 1878, 402, 419 and 783 (Rio Grande); Jordan, Rept. Geol. Surv. Ohio, iv, 1882, 839; Jordan & Gilbert, Synopsis Fish. N. A., 1883, 158; Bean, Cat. Fish. Internat. Fish Exhibition, London, 1883, 95 (Lake Beaver, Petersburgh).

Pimephales maculosus Girard, Proc. Acad. Nat. Sci. Phila., 1856, 180 (Arkansas R.); Girard, Pac. R. R. Surv., x, 1858, 234 (Arkansas R.).

Pimephales fasciatus Girard, Proc. Acad. Nat. Sci. Phila., 1856, 180 (Yellowstone R.; Milk R.); Girard, Pac. R. R. Surv., x, 1858, 234 (Yellowstone R.; Milk R.).

Hyborhynchus confertus Girard, Proc. Acad. Nat. Sci. Phila., 1856, 179 (Pecos R.); Girard, Pac. R. R. Surv., x, 1858, 233 (Pecos R.); Jordan & Gilbert, Synopsis Fish. N. A., 1883, 159.

Plargyrus melanocephalus Abbott, Proc. Acad. Nat. Sci. Phila., 1860, 325 (Lake Whittelsey, Minn.).

Pimephales milesii Cope, Proc. Acad. Nat. Sci. Phila., 1864, 282 (Detroit R.): Günther, Cat. Fish. Brit. Mus., vii, 1868, 181 (copied); Nelson, Bull. Ill. Lab. Nat. Hist., i, 1876, 45; Jordan, Man. Vert., 1st ed., 1876, 276.

Pimephales agassizii Cope, Cyp. Penn., 1866, 394 (Whitewater R., Ind.); Jordan, Ind. Geol. Surv., 1874, 224.

Hyborhynchus nigellus Cope, Zool. Wheeler's Expl. W. 100th Mer., v, 671 (Arkansas R., Pueblo, Col.).

Pimephales nigellus Jordan, Bull. Hayden's Geol. Surv., iv, 1878, 664 Rio Grande R.).

Habitat.—Lake Champlain to the Upper Missouri, south to Tennessee and the Rio Grande. The species *H. confertus* Girard, is, in my opinion, not a distinct species, but only the western form of *promelas*, having the lateral line better developed.

2. **Pimephales notatus.**

Minnilus notatus Rafinesque, Ichth. Oh., 1820, 47 (Ohio R.).

Hyborhynchus notatus Agassiz, Amer. Jour. Sci. Arts, 1855, 222 (Frankfort, Ky.; Scioto R.; Quincy, Ill.; Burlington, Iowa; Lebanon, Tenn.; Natchez, Miss.; Beardstown and La Salle, Ill.; Rome, N. Y.; L. Huron, L. Champlain): Cope, Proc. Acad. Nat. Sci. Phila., 1864, 282; Cope, Jour. Acad. Nat. Sci. Phila., 1868, 235; Günther, Cat.

Fish. Brit. Mus., vii, 1868, 182 (Montreal; Kanawha R.); Cope, Cyp. Penn., 1866, 392; Jordan, Ind. Geol. Surv., 1874, 224 (L. Michigan, Ohio R.); Nelson, Bull. Ill. Lab. Nat. Hist., i. 1876, 45; Jordan, Man. Vert., 1st ed., 1876, 275; 2d ed., 1878. 288; 3d ed., 1880, 288; Jordan, Proc. Acad. Nat. Sci. Phila., 1877, 45 (Lakes, Laporte Co., Ind.; St. Joseph's R., Kankakee R., Tippecanoe R., Lower Wabash R., White R., Ind.); Jordan, Bull. U. S. Nat. Mus., ix, 1877, 27; Jordan, Annals N. Y. Lyc. Nat. Hist., xi, 1877, 373 (Rock Castle R., Ky.); Jordan, Annals N. Y. Acad. Sci., i, 1877, No. 4, 107 (L. Michigan, Fox R., Rock R., Wisconsin R., White R., Ohio R., Salt R., Rock Castle R.); Jordan. Bull. Ill. Lab. Nat. Hist., ii, 1878, 55 (Mackinaw Cr., Woodford Co.: McLean Co.; Rock R. at Oregon; Little Wabash, Effingham Co.; Ill. R., Peoria; Crystal Lake, McHenry Co., Ill.); Forbes, Bull. Ill. Lab. Nat. Hist., ii, 1878, 79 (Food of *Hyborhynchus notatus*): Jordan & Brayton, Bull. U. S. Nat. Mus., xii, 1878, 63 and 78 (Chickamauga R., Cumberland R.): Hay, Proc. U. S. Nat. Mus.. iii, 1880. 502 (Corinth. Miss.: Catawba Cr., Miss.; Noxubee R.); Hay, Bull. U. S. Fish Com., ii, 1882, 67 (Miss. R., Vicksburg; Big Black R., Yalabusha R, Tombigbee R., Chickasawha R.); Jordan, Rep. Geol. Surv. Ohio, 1882, iv, 840; Jordan & Gilbert, Synopsis Fish. N. A., 1883, 159; Bean, Cat. Fish. Internat. Fish Exhibition, London, 1883, 95 (Yellow Cr., Ohio); Jordan & Swain, Proc. U. S. Nat. Mus., 1883, 248 (Cumberland R., Ky.).

Pimephales notatus Gilbert, Proc. U. S. Nat. Mus., 1884, 200 (Salt Cr., Brown Co., Ind.).

Hyborhynchus perspicuus Girard, Proc. Acad. Nat. Sci. Phila., 1856, 179 (Arkansan R.); Girard, Pac. R. R. Surv., x, 1858, 231 (Arkansas R.).

Hybognathus perspicuus Günther, Cat. Fish. Brit. Mus., vii, 1868, 185.

Hyborhynchus tenellus Girard, Proc. Acad. Nat. Sci. Phila., 1856, 179 (Arkansas R.); Girard, Pac. R. R. Surv., x, 1858, 231 (Arkansas R.).

? *Hyborhynchus puniceus* Girard, Proc. Acad. Nat. Sci. Phil., 1856, 179 (Canadian R.); Girard, Pac. R. R. Surv., x, 1858, 232 (Canadian R.).

Hyborhynchus superciliosus Cope, Jour. Acad. Nat. Sci. Phila., 1868, 234 (Kanawha R.); Jordan, Man. Vert., 1st. ed., 1876, 276; 2d ed., 1878; 289; 3d ed., 1880, 289; Jordan, Bull. U. S. Nat. Mus., ix, 1877, 27; Jordan, Bull. Ill. Lab. Nat. Hist., ii, 1878, 56 (Cache R. and Clear Cr., Union Co.; Rock R., Ogle Co., Ill.); Jordan & Gilbert, Synopsis Fish. N. A., 1883, 160; Jordan & Swain, Proc. U. S. Nat. Mus., 1883, 248 (Cumberland R.).

Habitat.—St. Lawrence River to Delaware; Ohio Valley and Great Lake Regions, southward to Tennessee and Mississippi. Very abundant

The nominal species, *H. superciliosus* Cope, is, as has already been noted by Jordan and Swain, but a spring form of the breeding male of *notatus*.

A REVIEW OF THE AMERICAN ELEOTRIDINÆ.

BY CARL H. EIGENMAN AND MORTON W. FORDICE.

We have attempted to give in this paper the synonymy of the genera and species of *Eleotridinæ* found in the waters of America, with analytical keys by which they may be distinguished. All the specimens examined belong to the Museum of the Indiana University, most of them having been collected by Professor Jordan.

All the species are referred by Dr. Günther to a single genus, *Eleotris*. This group, however, seems to us rather of the nature of a subfamily. An examination of the skeletons of some of the species shows important differences, which we must regard as having generic value.

We place the American species in six genera, which may be characterized as follows:—

Analysis of Genera of Eleotridinæ.

Common Characters.—Ventral fins separate, each with one spine and five soft rays; dorsal spines six or seven.

a. Vomer with a broad patch of villiform teeth; isthmus very narrow; gill-openings extending forward below to posterior angle of mouth; teeth villiform, the outer scarcely enlarged; vertebræ, 12 + 13 (*dormitator*); skull above with conspicuous elevated ridges, one of these bounding orbit above; the orbital ridges connected posteriorly above by a strong cross-ridge; a sharp longitudinal ridge on each side of the occipital, the two nearly parallel, the post-temporals being attached to their posterior ends. Insertions of post-temporals widely separated, the distance between them greater than the rather narrow interorbital width; the post-temporal bones little divergent; top of head depressed, both before and behind the cross-ridge between eyes; a flattish triangular area between this and the little elevated supraoccipital region; preopercle without spines; lower pharyngeals with slender depressible teeth, and without lamelliform appendages; scales of moderate size, ctenoid. GOBIOMORUS. 1.

aa. Vomer without teeth; isthmus broad; gill-openings scarcely extending forward below to posterior angle of preopercle; skull without crests.

b. Body and head entirely scaly.

c. Lower pharyngeal teeth setaceous, the bones with an outer series of broad flexible lamelliform appendages or teeth; body short and elevated, cyprinodontiform; teeth slender, those in the outer row scarcely larger, and movable; top of head without raised crests, flattish, its surface uneven; post-temporal bones rather strongly diverging, the distance between their insertions about half the broad flattish interorbital space; no spine on preopercle or branchiostegals; scales large, ctenoid. Species herbivorous. DORMITATOR. 2.

cc. Lower pharyngeals normal, subtriangular, the teeth stiff, villiform, none of them lamelliform; scales of moderate or small size; body oblong or elongate.

d. Body moderately robust, the depth 4–$5\frac{1}{2}$ times in the length to base of caudal; cranium without distinct median keel; a small supraoccipital crest.

e. Post-temporal bones little divergent, not inserted close together, the distance between their insertions greater than the moderate interorbital space, or $3\frac{4}{5}$ in length of head; top of skull little gibbous; interorbital region somewhat concave or channeled; lower pharyngeals narrower than in *Eleotris;* preopercle without spine; scales very small, ctenoid, about 100 in a longitudinal series. Vertebræ, 11 + 13; teeth moderate, the outer series enlarged. GUAVINA. 3.

ee. Post-temporal bones very strongly divergent, their insertions close together, the distance between them about $\frac{2}{3}$ the narrow interorbital space, and less than $\frac{1}{7}$ the length of the head; top of skull somewhat elevated and declivous; interorbital area slightly convex transversely; lower pharyngeals rather broad, the teeth bluntish; preopercle with partly concealed spine directed downward and forward at its angle; scales moderate, ctenoid, 45 to 60 in a longitudinal series. Vertebræ (*pisonis*) 11 + 15; teeth small.[1] ELEOTRIS. 4.

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[1] These characters of the skeleton are taken from *Eleotris pisonis*, and have not been verified on other species.

dd. Body very slender, elongate, the depth about $\frac{1}{9}$ the length to base of caudal; post-temporal bones short, strongly divergent, the distance between their insertions about equal to the narrow interorbital space, or about $\frac{1}{6}$ length of head; top of head with a strong median keel, which is highest on the occipital region; no supraoccipital crest; preopercle without spine; mouth very oblique; the teeth small; scales very small, cycloid. EROTELIS. 5.

bb. Body naked on the anterior part; head naked; lower jaw with four larger recurved teeth. GYMNELEOTRIS. 6.

1. GOBIOMORUS.

Gobiomorus Lacépède, Hist. Nat. Poiss., ii, 599, 1798 (*dormitor*, etc.).
Philypnus Cuvier & Valenciennes, Hist. Nat. Poiss., xii, 255, 1837 (*dormitator*).
Lembus Günther, Cat. Fish. Brit. Mus., i, 505, 1859 (*maculatus*).
Gobiomorus Jordan & Gilbert, Proc. U. S. Nat. Mus , 1882, 571 (restricted to *dormitator*).

This genus is well characterized by the presence of vomerine teeth, and by the narrowness of the isthmus. Equally good characters may be taken from the cranium, which is provided with elevated, longitudinal and transverse ridges, which are not found in any other of our genera of this type. The species reach a larger size than those of our other genera.

The reasons for preferring the name *Gobiomorus* to *Philypnus* have been given in detail by Jordan and Gilbert (*loc. cit.*).

Analysis of Species of Gobiomorus.

Common Characters.—Body elongate; the head somewhat depressed; body compressed behind. Scales ctenoid; 55 to 66 in a longitudinal series. Dorsal with 7 spines and 9 or 10 rays; anal rays I, 9 or 10; lower jaw considerably projecting; teeth in jaw rather small, slender, recurved, the outer scarcely enlarged; teeth on vomer villiform, in a broad crescent-shaped patch; gill-openings extending forward to below posterior angle of mouth, the isthmus being very narrow. No preopercular spine; insertion of post-temporals almost midway between occipital crest and edge of skull; parietals with a crest running from insertion of post-temporal forward to just behind eye, where they are connected by a thin, high, transverse crest; supraocular with a short high crest, extending from above front of eye back to posterior edge of orbit, thence extending outward parallel with the transverse crest, leaving a deep groove between them; bony projections before and behind eye prominent. Vert. 12+13 (*dormitator*); lower pharyngeals triangular, with slender teeth.

a. Scales large, 55 in a longitudinal series; 28 scales on median line between occiput and front of spinous dorsal. Body robust; depth 4 in length; head 2¾. D. VI–1, 9; A. I–10; crests on skull very high. *Lateralis.* 1.

aa. Scales moderate, 57 to 66 in longitudinal series; head 3 to 3½ in length; depth 5 to 6.

- *b.* Scales in median line from occiput to front of spinous dorsal 26; head 3½ in length; transverse frontal crest not continuous. D. VI–1, 9; A. I–10; 57 to 60 scales in a longitudinal series. *Maculatus.* 2.
- *bb.* Scales on median line from occiput to spinous dorsal 35; transverse frontal crest continuous.
  - *c.* Scales medium, 57 to 60 in a longitudinal series; head 3¼ in length; depth 5½. D. VI–1, 9; A. I–9; crests on skull moderate. *Dormitator.* 3.
  - *cc.* Scales smaller, 66 in a longitudinal series; depth 6 in length; head 3. D. VI–1, 10. *Longiceps.* 4.

1. **Gobiomorus lateralis.**

Philypnus lateralis Gill, Proc. Acad. Nat. Sci. Phila., 1860, 123 (Cape San Lucas); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1881, 232 (West Coast Mexico); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 368 (Cape San Lucas); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 372 (Colima); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 377 (Panama); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 380 (San José).

Eleotris lateralis Günther, iii, 122, 1861 (Cape San Lucas).

Habitat.—Pacific Coast of America, from San José to Panama.

This species represents on the Pacific Coast the *G. dormitator* of the Atlantic. It is readily distinguished by its shorter body, larger scales, and by the greater development of its cranial crests.

2. Gobiomorus maculatus.

Lembus maculatus Günther, Cat. Fish. Brit. Mus., i, 505, 1859 (Andes of Ecuador); Günther, Proc. Zool. Soc. Lond., 1860, 236 (Ecuador, Esmeraldas).

Eleotris lembus Günther, Cat. Fish. Brit. Mus., iii, 121, 1861 (Ecuador).

Habitat.—Streams of Ecuador.

This species is known to us only from the descriptions of Dr. Günther.

3. Gobiomorus dormitator.

Guavina Parra, Descr. Dif. Piezas Hist. Nat. Cuba, tab. 39, fig. i, 1787 (Havana; fide Poey).

Gobiomorus dormitor Lacépède, Hist. Nat. Poiss., ii, 599, 1798 (from a drawing by Plumier).

Gobiomorus dormitator Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 572 (name only).

Platycephalus dormitator Bloch, Syst. Ichth., Plate xii, 1790 (Martinique); Bloch & Schneider, Syst. Ichth., 60, 1801.

Eleotris dormitatrix Cuvier, Règne Animal, ed. ii, 1829 (Antilles); Oken, Naturgeschichte, vi, 173, 1836; Günther, iii, 119, 1861 (Barbadoes, Jamaica, Mexico).

Philypnus dormitator Cuvier & Valenciennes, xii, 255, 1837 (Porto Rico, San Domingo, Martinique); Poey, Mem. de Cuba, ii, 381, 1856 (Cuba); Girard, U. S. and Mexican Boundary Survey, 27, plate xii, fig. 13, 1859 (Rio Grande); Poey, Syn. Pisc. Cub., 395, 1868 (Cuba); Poey, Enum. Pisc. Cub., 128, 1875 (Mexico, Rio Grande, San Domingo, Martinique, Jamaica); Goode & Bean, Proc. U. S. Nat. Mus., 1882, 236 (name only); Jordan & Gilbert, Syn. Fish. N. A., 631, 1882.

Batrachus guavina Bloch & Schneider, Syst. Ichth., 44, 1801 (based on *Guavina* of Parra).

Habitat.—Rio Grande to Martinique, in fresh waters.

This species is generally common in the streams of the West Indies and Eastern Mexico. We follow later writers in changing the incorrectly spelled *dormitor* of Lacépède to *dormitator*. According to Poey, the type of Parra's *Guavina*, still preserved in the Museum at Madrid, has teeth on the vomer, and is therefore a *Gobiomorus*, not a *Guavina*. The many specimens examined by us are from Havana.

4. Gobiomorus longiceps.

Eleotris longiceps Günther, Proc. Zoöl. Soc. Lond., 1864, 151; Günther, Fish. Central America, 1869, 440 (Nicaragua).

Habitat.—Lake Nicaragua.

This species is known to us only from Dr. Günther's description.

2. DORMITATOR.

Prochilus Cuvier, Règne Animal, ed. i, 1817 (*mugiloides*), (preoccupied).
Dormitator Gill, Proc. Acad. Nat. Sci. Phila., 1862, 240 (*gundlachi* = *maculatus*).

This genus is not adopted by Dr. Günther, but it seems to us well founded, its peculiarities in dentition being important. The name *Prochilus* at first given to this group is preoccupied by *Prochilus* of Illiger, a genus of mammalia, as well as by the prebinominal *Prochilus* of Klein, which belongs to the Pomacentridæ.

The known species of this type are very closely related and should perhaps be regarded as geographical varieties of a single one.

Analysis of the Species of Dormitator.

Common Characters.—Body short, robust; head broad and flat above; mouth little oblique; maxillary reaching to anterior margin of orbit; lower jaw little projecting; no teeth on vomer; scales large, ctenoid, 30 to 33 in a longitudinal series; skull much as in *Eleotris*, but everywhere broader. D. VII–1, 8; A. I, 9 or 10; no spine on preopercle; post-temporals inserted midway between occipital crest and edge of skull; supraoccipital crest low.

a. Scales large, becoming much smaller on belly; 25 series on a median line from base of ventrals to vent; 18 series across breast from pectoral to pectoral; 18 on a median line from posterior border of orbit to dorsal. Interspace between dorsals equal to orbit. Highest anal ray $1\frac{3}{4}$ in head; highest dorsal ray $1\frac{1}{3}$ in head. 33 scales in a longitudinal series. *Maculatus.* 5.

aa. Scales larger than in *maculatus*, not much smaller on belly; 18 series on a median line from ventrals to vent; 13 series from pectoral to pectoral; 16 on a median line from posterior border of orbit to front of soft dorsal; interspace between dorsals less than diameter of orbit. Highest anal ray $1\frac{1}{5}$ in head; highest dorsal ray equals head. 31 scales in a longitudinal series. *Latifrons.* 6.

5. Dormitator maculatus.

Sciæna maculata Bloch, "Ichth., tab. 299, f. 2," 1790 (West Indies); Bloch & Schneider, Syst. Ichth., 80, 1801 (copied).
Eleotris maculatus Günther, iii, 112, 1861 (West Indies; Trinidad; Demerara); Günther, Fish. Cent. Am., 440, 1869 (Anamahal).

Dormitator maculatus Goode & Bean, Proc. U. S. Nat. Mus., 1882, 236 (Gulf of Mexico).

Eleotris mugiloides Cuvier & Valenciennes, xii, 226, 1837 (Martinique; Surinam).

Eleotris somnolentus Girard, Proc. Acad. Nat. Sci. Phila., 1858, 169 (Rio Grande); Girard, U. S. and Mex. Bound. Survey, 28, pl. 12, f. 1–3, 1859 (Rio Grande); Günther, iii, 557, 1861 (Cordova).

Dormitator somnolenta Poey, "Repert., ii, 168," 1868; Poey, Enum. Pisc. Cuben., 128, 1875 (Cuba).

Eleotris omocyaneus Poey, Memorias, ii, 269, 1860 (Havana).

Dormitator omocyaneus, Poey, Syn. Pisc. Cuben., 296, 1868 (Cuba); Poey, Enumer. Pisc. Cuba, 128, 1875 (Cuba).

Eleotris gundlachi Poey, Mem., ii, 272, 1860 (Cuba).

Dormitator gundlachi Poey, Syn. Pisc. Cuben., 396, 1868 (Cuba); Poey, Enum. Pisc. Cub., 128, 1875 (Cuba).

Dormitator lineatus Gill, Proc. Acad. Nat. Sci. Phila., 1863, 271 (Savannah).

Habitat.—East Coast of America; South Carolina, Texas, Louisiana, south to Surinam; chiefly in fresh water.

As Cuvier and Valenciennes have identified the type of Bloch's *Sciæna maculata* with their *Eleotris mugiloides*, we adopt the latter name for this species. We are unable to distinguish the *somnolentus* of Girard from *maculatus*, and the *omocyaneus* of Poey is certainly the same. Gill's *lineatus* is also, doubtless, a young example of the same type.

We find nothing (unless it be the greater height of the fins) in the description of *Eleotris gundlachi* Poey, by which it can be distinguished from *Dormitator maculatus*. Poey's type was about 8 inches in length, and its large size may account for the slight differences indicated.

The single specimen studied by us is from the West Indies.

6. Dormitator latifrons.

Eleotris latifrons Richards, "Voy. Sulph. Fishes, 57, pl. 35, f. 4–5," 1837 (Pacific Coast Central America).

Eleotris maculata Günther, iii, 112, 1861 (Guayaquil), (not *Sciæna maculata* of Bloch).

Dormitator sp., Bean, Proc. U. S. Nat. Mus., 1880, 83 (Colima).

Dormitator maculatus Jordan & Gilbert, Proc. U. S. Nat. Mus., 1881, 232 (Salina Cruz); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 368 (Cape San Lucas); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 372 (Colima); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 377 (Panama); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 380 (Cape San Lucas); Jordan & Gilbert, Bull. U. S. Fish. Com., 1882, 108 (Mazatlan); Jordan & Gilbert, Syn. Fish. N. A., 1883, 632 (Mazatlan).

Dormitator microphthalmus Gill, Proc. Acad. Nat. Sci., Phila., 1863, 170 (Panama).

Habitat.—Pacific Coast of Central America, from Cape San Lucas southward to Panama.

This species is abundant on the Pacific slope of Mexico and Central America. It differs from *D. maculatus* in few respects, and should, perhaps, be regarded as a variety of the latter. They have, however, not yet been shown to intergrade.

3. GUAVINA.

Guavina Bleeker, Esquisse d'un Syst. Nat. Gobioid., 302, 1874 (*guavina*).

This genus is externally distinguished from *Eleotris* only by the absence of preopercular spine, and by the smaller size of the scales. The skulls in the two genera are, however, strikingly different, and we think that the two groups should be regarded as generically distinct. We know only one species of this genus.

Analysis of Species of Guavina.

a. Body stoutish, oblong; mouth oblique; maxillary reaching opposite middle of eye, its length about $3\frac{1}{2}$ in head. Lower jaw little projecting. Teeth in broad bands, the outer ones enlarged. Scales on head imbedded; those on body very small, ctenoid on sides, cycloid on back and belly, 100 to 110 in a longitudinal series. Isthmus very broad. Pectorals reaching to middle of spinous dorsal. Highest anal ray $1\frac{4}{5}$ in head. Head $3\frac{1}{2}$ in length to base of caudal; depth $4\frac{1}{2}$ to $5\frac{1}{4}$. D. VI, I, 10; A. I, 9 or 10. Posttemporals inserted twice as far from occipital crest as in *Eleotris pisonis.* Parietals ending in a sharp point behind. Preopercular spine none; a broad thin extension on the lower limb of preopercle taking its place. Lower pharyngeals triangular, normal, rather narrow; the teeth small. Vomer without teeth. *Guavina.* 7.

7. Guavina guavina.

Eleotris guavina Cuvier & Valenciennes, xii, 223, 1837 (Martinique); Günther, iii, 124, 1861 (Demarara); Poey, "Repert. i, 337, 1867;" Poey, Syn. Fish. Cuba, 395, 1868 (Cuba); Poey, Enum. Pisc. Cuba, 127, 1875 (Cuba).

Habitat.—East Coast of tropical America, West Indies, south to Surinam, in fresh waters.

This species is abundant in the streams of Cuba. The numerous specimens examined by us were obtained by Prof. Jordan in the Rio Almendares, near Havana. In life this species may be readily distinguished from *Eleotris pisonis*, which abounds in the same waters, by the bright cherry-colored edgings to its ventrals and anal.

4. ELEOTRIS.

Eleotris "Gronow, Mus. Ichthyol., 16," 1757 (Non-binominal).
Eleotris Bloch & Schneider, Syst. Ichth., 65, 1801 (*pisonis*).
Eleotris Cuvier & Valenciennes, xii, 216, pl. 356, 1837 (*gyrinus*).
Culius Bleeker, Esquisse d'un Syst. Nat. des Gobioides, 303, 1874 (*fuscus*).

As *Eleotris pisonis* possesses the preopercular spine assumed to characterize the genus *Culius*, we place the latter name in its synonymy. In large specimens of *Eleotris pisonis*, this spine is somewhat concealed by the flesh, but it may always be found by dissection. The four following species resemble each other very closely, and probably agree in the structure of the skeleton, but in this regard we have been able to examine only *Eleotris pisonis.*

Analysis of Species of Eleotris.

a. Body comparatively robust; head broad, depressed; body compressed; mouth oblique, lower jaw little projecting; maxillary reaching to below eye; scales ctenoid, 46 to 61 in longitudinal series. Dorsal rays, VI–I, 8; anal rays, I, 7 or 8. Vomer without teeth. Gill-openings extending forward below to angle of preopercle; isthmus broad. Preopercle with a spine projecting downward and forward at its angle. Post-temporals slender, widely diverging, inserted very near the scarcely evident occipital crest. Skull highest in the middle, very broad and short; bony projections in front of and behind eye prominent. Vertebræ about 10 + 14 (*pisonis*). Lower pharyngeals subtriangular, rather broad, with comparatively coarse teeth.

b. Scales large, about 48 in longitudinal series; depth $4\frac{1}{3}$ in length to base of caudal; head $3\frac{1}{4}$. D. VI, 9; A. I, 8; teeth rather small, those of the inner series in each jaw largest. *Amblyopsis.* 8.

bb. Scales moderate, about 60 in lateral series. D. VI–I, 8; A. I, 7 or 8.
  - *c.* Body comparatively robust; depth 4 to 5 in length; teeth in jaws all small, subequal. *Pisonis.* 9.
  - *cc.* Body comparatively slender; depth 6 in length; head 3½.
    - *d.* Teeth in jaws all small, subequal. *Æquidens.* 10.
    - *dd.* Teeth in jaws unequal, some of those in the outer row enlarged. *Belizana.* 11.

8. **Eleotris amblyopsis.**

Culius amblyopsis Cope, Proc. Am. Phil. Soc., 1870, 473 (Surinam); Goode & Bean, Proc. U. S. Nat. Mus., 1882, 236 (Gulf of Mexico); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 610 (Charleston); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 619 (Pensacola); Jordan & Gilbert, Syn. Fish. N. A., 1882, 944.

Habitat.—Atlantic coast of America, from Charleston to Surinam.

Only three specimens of this species are yet known. It is well distinguished from its congeners by its larger scales.

9. **Eleotris pisonis.**

Eleotris capite plagioplateo, etc. "Gronow, Mus. Ichth., ii, n. 168," 1757.

Gobius pisonis Gmelin, Syst. Nat. 1206, 1788 (based on *Eleotris* of Gronow).

Eleotris pisonis Bloch & Schneider, Syst. Ichth., 68, 1801 (based on *Eleotris* of Gronow).

Gobius pisonis Turton, Syst. Nat., 751, 1807 (South America).

Gobius amorea Walbaum, Artedi Piscium, iii, 205, 1792 (based on *Eleotris* of Gronow).

Eleotris gyrinus Cuvier & Valenciennes, xii, 220, 1837. Pl. 356 (Martinique, San Domingo, Surinam); Girard, U. S. and Mexican Boundary Survey, 28, Pl. xii, figs. 11–12, 1859 (Rio Grande); Günther, Catalogue Fish. in Brit. Mus., iii, 122, 1861; Poey, "Repert., i, 336," 1867; Poey, Syn. Pisc. Cubens., 395, 1868 (Cuba); Poey, Enumer. Pisc. Cub., 127, 1875 (Cuba); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 571 (name only); Jordan & Gilbert, Syn. Fish. N. A., 631, 1883.

Eleotris picta Kner & Steindachner, Abhandl. bayer. Ak. Wiss., 1864, 18, Pl. 3, fig. 1 (Rio Bayano, near Panama).

Culius perniger Cope, Proc. Am. Phil. Soc., 1870, 473 (St. Martins).

Habitat.—Both coasts of Central America, north to Cuba and Texas, chiefly in fresh waters.

The *Gobius pisonis* of Gmelin and its synonym, *Gobius amorea* of Walbaum, are based on the *Eleotris* of Gronow. This is undoubtedly identical either with *Eleotris gyrinus* or *Guavina guavina.* To us there is little doubt that the former species was the one intended, as the phrase "P. D. prior declinata 6 radiata; secunda equalis, priori vicina" applies well to the *Eleotris gyrinus* and not at all to the *Guavina guavina*, in which species the second dorsal is much larger than the first. We therefore adopt the name *Eleotris pisonis* instead of *Eleotris gyrinus.*

We have examined numerous specimens of this species from the Rio Almendares, near Havana. All these possess the antrorse preopercular spine supposed to distinguish the genus *Culius* from *Eleotris.* In the larger ones it is partly hidden by the encroachment of the skin and from this has arisen the erroneous supposition (of Günther and others) that this species is one in which the spine is wanting.

A comparison of the figure and description of *Eleotris picta*, given by Kner and Steindachner, shows no constant point of difference whatever. We therefore regard *picta* as a synonym of *pisonis.*

The *Culius perniger* of Cope is evidently identical with *pisonis*, Professor Cope being the first describer of the species who did not overlook the preopercular spine.

10. Eleotris æquidens.

Eleotris sp., Bean, Proc. U. S. Nat. Mus., 1880, 83 (name only).
Culius æquidens Jordan & Gilbert, Proc. U. S. Nat. Mus., 1881, 461 (Mazatlan); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 372 (Colima); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 380 (Cape San Lucas, San José); Jordan & Gilbert, Bull. U. S. Fish Com., 1882, 108 (Mazatlan).

Habitat.—Streams about the Gulf of California, south to Colima.

This species is known to us from the original description by Jordan and Gilbert; it is said to be abundant in the streams of Sinaloa and Lower California.

11. Eleotris belizana.

Culius belizanus Sauvage, "Bull. Soc. Philom. Paris, 1879, 16 (reprint)" (Belize); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1881, 462 (foot-note).

Habitat.—Belize.

This species is known to us only from a foot-note by Jordan and Gilbert, referring to the description by M. Sauvage. It is said to differ from *E. æquidens*, by having the teeth of the outer row enlarged.

5. EROTELIS.

Ereotelis Poey, Memorias de Cuba, ii, 273, 1861 (*valenciennesi* = *smaragdus*).

This genus differs from the others in having the scales small, cycloid, the body long, slender, and the tail lanceolate. In form this genus differs strikingly from *Eleotris*, its nearest ally. It presents a strong analogy to *Gobionellus*, differing from *Eleotris* much as the latter does from *Gobius*.

But one species seems to be known.

Unlike the other *Eleotridinæ*, this is strictly marine, inhabiting the coarse algæ on the coral reefs.

Analysis of Species of Erotelis.

a. Body long, slender; depth about $\frac{1}{9}$ the length to base of caudal; head broad, depressed; mouth large, very oblique, the lower jaw projecting. Maxillary reaching to below centre of eye, its length, $2\frac{1}{2}$ in head. Vomer without teeth; teeth on jaws small, equal. Scales small, cycloid, about 100 in a longitudinal series, largest on caudal peduncle. Caudal fin lanceolate; caudal peduncle slender, 3 in length of body. D. VI–1, 9; A. I–9. Gill-openings extending forward to below centre of opercle. Post-temporals diverging, inserted near occipital crest, which is obsolete. Skull uneven and rather thick. Preopercular spine absent. Vertebræ 10+15. Pectorals reaching past middle of first dorsal. Dorsal and anal high; highest anal ray $1\frac{1}{3}$ in head. *Smaragdus.* 12.

12. Erotelis smaragdus.

Eleotris smaragdus Cuvier & Valenciennes, xii, 231, 1837 (Cuba); Guichenot, "Poiss. in Ramon de la Sagra, Hist. Cuba, 130," 1855; Günther, Cat. iii, 123, 1861 (Cuba); Jordan, Proc. U. S. Nat. Mus., 1884, 141 (Key West).

Erotelis valenciennesi Poey, Mem. de Cuba, ii, 173, 1861 (Cuba); Poey, Syn. Pisc. Cub., 396, 1868 (Cuba); Poey, Enum. Pisc. Cub., 127, 1875 (Cuba).

Habitat.—Florida Keys to Cuba; strictly marine, not ascending rivers.

This species is rather abundant on the coast of Cuba. A single specimen was obtained by Professor Jordan at Key West. It reaches a length of about a foot. It is confounded by Cuban fishermen with the Esmeralda (*Gobionellus*), although it lacks the emerald-colored prominences on the tongue. From this confusion the not appropriate name of *smaragdus* has come to be given to this species. This Poey has proposed to change to *Valenciennesi*; but this change the law of priority forbids.

6. GYMNELEOTRIS.

Gymneleotris Bleeker, Esquisse d'un Syst. Nat. des Gobioides, 304, 1874 (*seminuda*).

The distinguishing mark of this genus seems to be the absence of scales on the head and anterior part of the trunk. Nothing is known either of the genus or of its single species, except what is contained in Günther's description of the latter.

Analysis of the Species of Gymneleotris.

a. Head and trunk naked; tail covered with small scales; head $\frac{2}{7}$ of total length; maxillary extending to below anterior margin of orbit. Teeth in upper jaw in a narrow band; the lower has four somewhat larger and recurved teeth in front; palate toothless. Fin-rays not prolonged. Pectorals not quite extending to origin of second dorsal. Ventrals much shorter than pectoral. D. VII, 11; A. 9.
Seminuda. 13.

13. Gymneleotris seminuda.

Eleotris seminuda, Günther, Proc. Zoological Soc., London, 1864, 24, "Plate iv, f. 2, 2 *a*" (Pacific Coast of Panama); Günther, Fish. Central America, 441, 1869.

Gymneleotris seminuda Bleeker, Esquisse d'un Systema Nat. Gobioides, 304, 1874.

This species is known from the description by Dr. Günther of a small specimen in the British Museum.

List of Nominal Species of Eleotridinæ, arranged in Chronological Order, with Identifications.

(Tenable Specific Names are in Italics.)

Nominal Species.	*Date.*	*Identification.*
Gobius *pisonis* Gmelin,	1788,	Eleotris pisonis.
Sciæna *maculata* Bloch,	1790,	Dormitator maculatus.
Gobius amorea Walbaum,	1792,	Eleotris pisonis.
Gobiomorus *dormitor* Lacépède,	1798,	Gobiomorus dormitator.
Platycephalus *dormitator* Bloch & Schneider,	1801,	“ “
Batrachus guavina Bloch & Schneider,	1801,	“ “
Eleotris mugiloides Cuvier & Valenciennes,	1837,	Dormitator maculatus.
Eleotris *guavina* Cuvier & Valenciennes,	1837,	Guavina guavina.
Eleotris gyrinus Cuvier & Valenciennes,	1837,	Eleotris pisonis.
Eleotris *smaragdus* Cuvier & Valenciennes,	1837,	Erotelis smaragdus.
Eleotris *latifrons* Richardson,	1837,	Dormitator latifrons.
Eleotris somnolentus Girard,	1858,	Dormitator maculatus.
Lembus *maculatus* Günther,	1859,	Gobiomorus maculatus.
Philypnus *lateralis*, Gill,	1860,	Gobiomorus lateralis.
Eleotris omocyaneus Poey,	1860,	Dormitator maculatus.
Eleotris gundlachi Poey,	1860,	“ “
Erotelis valenciennesi Poey,	1861,	Erotelis smaragdus.
Dormitator lineatus Gill,	1863,	Dormitator maculatus.
Dormitator microphthalmus Gill,	1863,	Dormitator latifrons.
Eleotris *longiceps* Günther,	1864,	Gobiomorus longiceps.
Eleotris *seminuda* Günther,	1864,	Gymneleotris seminuda.
Eleotris picta, Kner & Steindachner,	1864,	Eleotris pisonis.
Culius *amblyopsis* Cope,	1870,	Eleotris amblyopsis.
Culius perniger, Cope,	1870,	Eleotris pisonis.
Culius *belizanus* Sauvage,	1879,	Eleotris belizana.
Culius *æquidens* Jordan & Gilbert,	1881,	Eleotris æquidens.

Recapitulation.

In this review we have admitted 13 species and 6 genera of *Eleotridinæ* as probably valid. We give here a list of the species. The general distribution of the species is indicated by the letters W. (Western Atlantic, West Indies, etc.); U. (Coast of United States); P. (Eastern Pacific, Mazatlan, Panama, etc.); G. (Western slopes of South America).

Subfamily **Eleotridinæ**.

Genus 1. **GOBIOMORUS** Lacépède.

1. **Gobiomorus lateralis** Gill (P.).
2. **Gobiomorus maculatus** Günther (G.). (Species unknown to us.)
3. **Gobiomorus dormitator** Lacépède (W. U.).
4. **Gobiomorus longiceps** Günther (W.).

Genus 2. **DORMITATOR** Gill.

5. **Dormitator maculatus** Bloch (U. W.). (Possibly more than one species in our synonymy.)
6. **Dormitator latifrons** Richardson (P.). (Possibly a variety of *maculatus*.)

Genus 3. **GUAVINA** Bleeker.

7. **Guavina guavina** Cuvier and Valenciennes (W.).

Genus 4. **ELEOTRIS** (Gronow) Bloch & Schneider.

8. **Eleotris amblyopsis** Cope (U. W.).
9. **Eleotris pisonis** Gmelin (W. P.). (Possibly two species contained in our synonymy.)
10. **Eleotris æquidens** Jordan and Gilbert (P.).
11. **Eleotris belizana** Sauvage (W.). (Unknown to us.)

Genus 5. **EROTELIS** Poey.

12. **Erotelis smaragdus** Cuvier and Valenciennes (U. W.).

Genus 6. **GYMNELEOTRIS** Bleeker.

13. **Gymneleotris seminuda** Günther (P.). (Unknown to us)

ENTOMOLOGIA HONGKONGENSIS.—REPORT ON THE LEPIDOPTERA OF HONGKONG.

BY F. WARRINGTON EASTLAKE.

The province of Kwangtung, to which the island of Hongkong properly belongs, has long been celebrated throughout the Chinese Empire for the beauty and great variety of the insects to be found within its borders. The soil is, in most parts, exceptionally rich, and teems with an ever-busy world of animal life. But, great as is the fecundity of the larger part of the province, there are, here and there, sandy, arid wastes, which even the untiring labor of the native agriculturists fails to make yield more than the scantiest of crops. This is especially the case along the southeastern littoral. Here the formation is igneous and the rocks granitic, as a rule, with occasional intrusive traps and seams of trachytic porphyry. The island of Hongkong, in particular, consists mainly of hornblendic granite, of which silica, alumina, and various oxides of iron are the principal components. The rock is, at the same time, composed throughout of materials unusually susceptible to climatic influences, particularly to the action of heavy rains. The decomposed and disintegrated rock makes an admirably fertile soil, especially in the ravines, valleys, and lowlands; the hills, however, being constantly exposed to all sorts of weather, are signally barren and verdureless. Tufts of "arrow-grass," long, trailing mosses, coarse ferns and hardy flowering-plants are sparsely scattered over the mountain-slopes; pines, firs, and a few other resinous trees cover the less-exposed portions, but the heavy rains annually sweep down quantities of this local vegetation into the sea. In such places insect life is rare. And yet the entomology of Hongkong, although so small an island, is unusually rich and worthy of attention. This is chiefly due to the fact that the island is connected with the famous Lo-fan Shan —a small range of mountains some fifteen miles north of the thriving market-town of *Shek Lung* ("Stone Dragon,") and about seventy miles east of Canton. Starting from the westernmost spur of this range, a limestone formation runs to the north and northwest. Here the flora is both beautiful and luxuriant; flowering plants laden with tempting pollen cover the hillsides, and insects find in the verdant groves a veritable paradise. The Lo-fan Mountains besides this, probably owing to their majestic scenery and rich flora, have for more than ten centuries enjoyed a reputation of great sanctity. In the deep caves and mountain forests of the Lo-fan, hermits, sages and priests have lived and taught their disciples from time immemorial; while, in accordance with both Buddhistic and Taoistic precepts, all animals, birds, reptiles, insects, and even the delicious trout of the mountain-streams have been kept from harm and allowed to breed undisturbed. Passing through the thickly populated districts of Pok-lo and Tong-kun, a low, undulating range of hills connects the Lo-fan with the mountainous country opposite Hongkong. And hence it comes that the entomology of the island is so extensive and varied.

Hongkong lies between 22° 9′ and 22° 1′ north latitude, and 114° 5′ and 114° 18′ east longitude; the island is, therefore, just inside the tropics, but near enough to the boundary to enjoy fine, temperate weather from September to April. To a considerable extent, the insular fauna shows close relationship with the fauna of the tropics; and yet there can be no doubt that some few of the tropical features are not characteristic of Hongkong. To this category belong notably *Python reticulatus*, Gray, the rock python of India, and the venomous cobra, *Naja tripudians*, Merr.; very possibly, also *Macrochlamys superlita*, Morelet—a fine land snail. The Lepidoptera, however, are very distinctly related to the entomic fauna of the Himalayas, East India, and the Malayan Archipelago. During a stay of several years in Hongkong, the writer devoted much time and attention to the study of the insular fauna, and formed large collections of the lepidoptera and terrestrial mollusks. In the spring of 1883, the writer published a work on Hongkong, in which a short list of the diurnal Lepidoptera was given. But this list was necessarily incomplete, as the writer had not enjoyed any opportunity of subjecting his collections to competent scientific inspection and classification. Since then, thanks to several important works which have appeared on the Insect Fauna of various parts of Asia, the writer has been enabled to compile the following list in a far more thorough manner. Outside of Donovan's "Insects of China"—which will be mentioned later on—no work has ever been published on the entomology of China, and, beyond a few chapters in the journals of passing naturalists, the enumeration and description of the Hongkong insects have been entirely neglected. Despite this fact, a rich field there awaits the collector and the scientist, as the beetles, butterflies and moths are often of exceptional size and great beauty. An *Attacus* (male) in the writer's possession measures no less than eleven and one-half inches across the wings. Of beetles alone—according to Frauenfeld—Mr. John Bowring (son of Governor Bowring, of Hongkong), collected more than twelve hundred species, many of which were new to science.

In compiling the following list, the entomology of various other localities throughout the province of Kwangtung has been taken into special consideration. Notably that of the other islands in the Ladrones group of the Lo-fan Mountains—where some time was spent in collecting—and of Macao. In the latter port the writer passed several months, and succeeded in making valuable collections, thanks to the courtesy of Governor da Graça, who did everything in his power to facilitate the work. A complete catalogue and description of the collections then made have since been embodied in a work entitled "Fauna Macanensis," recently forwarded to the Portuguese Government. It is somewhat difficult to keep the entomology of Hongkong entirely distinct from that of adjacent islands and mainland. As has already been stated, the hills opposite Hongkong practically introduce the insect fauna of the entire Kwangtung Province. At times, months or even years may pass before the reappearance of a certain species; and then a favorable wind may waft it unexpectedly into the flower-gardens of Victoria, there, mayhap, to completely puzzle the brains of some ardent entomologist. In the following list, however, all doubtful species have been so far as possible excluded, and only such admitted as have been identified by scientists of acknowledged ability.

Reference has been made to the following works:—

Donovan, A. The Insects of China, 2d ed., 1842 (Westwood).

Frauenfeld. Die Novara Expedition, Sitzungsber. d. mathem. naturw. Cl. K. K. Acad. d. Wissensch., Wien, xxxv, 1859, 10.

Butler, A. Lepidoptera Heterocera in the British Museum, Pts. ii, iii, 1878.

Elwes, H. J. Butterflies of Amurland, North China and Japan. Proc. Zoolog. Soc. London, 1881.

Distant, W. L. Rhopalocera Malayana, Pts. i–v, London and Penang, 1882.

Pryer, H. A Catalogue of the Insects of Japan, Trans. Asiatic Soc. of Japan, 1883.

Donovan's "Insects of China" is a mere primer on the vast subject included in its title, and very incorrect at that. Since his day, entomological nomenclature has undergone many changes, and even the classification of genera and species has not been left undisturbed. For the sake of completeness, however, it is perhaps advisable to append the meagre list of Lepidoptera, which Donovan notes as coming from Hongkong. It includes but fifteen butterflies and four moths:—

Papilio paris, Linn.
Papilio agenor, Linn.
Papilio agamemnon, Linn.
Papilio epius, Jones.
Papilio demetrius, Linn.
Pieris hyparete, Linn.
Pieris (*Iphias*) *glaucippe*, Linn.
Pieris (*Thestias*) *pyrene*, Linn.
Argynnis eurymanthus, Drury.
Cynthia orithya, Linn.
Cynthia œnone, Linn.
Cynthia almana, Linn.
Limenitis leucothoe, Linn.
Limenitis eurynome, Linn.
Thecla mæcenas, Jones.

Sesia hylas, Linn.
Glaucopis polymena, Linn.
Phalæna attacus.
Saturnia atlas, Linn.
(*Eusemia lectrix*, Linn., doubtful.)

In Mr. H. J. Elwes' list I find further one butterfly mentioned as coming from Southern China, which I have never met with in Hongkong. This is *Thaumantis howqua*, Westwood, named probably after that rich Cantonese merchant so well known twenty or thirty years ago. Those marked with an asterisk (*) in the following list are contained in the writer's collection, but several others in this collection have still to be identified.

***Papilio xuthus**, Linn. (*xuthulus*, Linn.).

This insect occasionally finds its way to Hongkong, but is tolerably numerous around Canton and further north, and abundant in Japan. The imago invariably appears under the xuthulus form in the spring. The female is dimorphic, it feeds on various kinds of *Citrus*, especially *C. trifoliata*.

***Papilio maackii**, Men. (*Dehaani*, Feld.).

Very frequent in the Lo-fan Mountains; less so in Hongkong. Found also in North China and Japan.

***Papilio helenus**, Linn.

Rare; has been taken also in Shanghai and Nagasaki.

***Papilio pamnon**, Linn.

This gorgeous butterfly is not uncommon about May, and continues to visit the island from time to time until September.

***Papilio memnon**, Linn.

This is one of the largest of the Hongkong Lepidoptera. The markings of the female are totally different from those of the male, which is altogether a smaller insect. Also Southern Japan.

***Papilio sarpedon**, Linn.

Quite common throughout the year. North China and Japan.

***Papilio demetrius**, Cramer.

Occasionally seen in autumn. Common in Japan.

***Papilio paris**, Linn.

Abundant. A beautiful insect, always to be found near *Hyliscus rosa sinensis*.

Papilio clytia, Linn. (var. *dissimilis*, Swainson).
***Papilio panope**, Linn.
Papilio polytes, Linn.
***Papilio agenor**, Linn. (var. *alcanor*, Cramer).
***Papilio bianor**, Cramer.
***Pieris rapæ**, Linn. (*crucivora*, Butler).

One of the commonest butterflies; found all the year round. In markings and size it is very variable. As a rule, it feeds on cultivated *Cruciferæ*.

***Pieris napi**, Linn. (*megamera*, Butler; *melete*, Men.),
Pieris canidia, Sparrm.
***Tereias multiformis**, H. Pryer (*Hecabe*, Linn.; *mandarina*, De l'Orza; *hecabeoides*, Men.; *sinensis*, Sue; *Mariesi*, Butler; *anemone*, Felder; *connexiva*, Butler; *asiope*, Mon.; *sari*, Horsfield).

Thanks to the scientific investigation of Mr. H. Pryer, it is now demonstrated that this butterfly is found in nearly every country, and that the long list of varieties do not constitute special species, as most of them interbreed without difficulty. It is abundant throughout China and Japan.

Eurema blanda, Boisduval.
***Delias pasithoe**, Linn.
***Delias hierte**, Hübner.
***Lycæna bætica**, Linn.
***Lycæna lysimon**, Hübner.

Both of these are common throughout the greater part of the year.

***Neptis aceris**, Lep. (*intermedia*, Pryer).

Abundant, and very variable in size.

Vanessa charonia, Drury.
***Vanessa callirhoe**, Fabricius.

Quite common, but a very beautiful insect. Feeds on several *Urticaceæ*.

***Vanessa cardui**, Linn.

This butterfly has a very wide spread, and comes early in spring and stays throughout the summer. It is quite as abundant as the foregoing.

***Argynnis niphe**, Linn.

Not uncommon, but very local.

***Argynnis eurymanthus**, Drury.
***Melanitis leda**, Linn.
***Mycalesis gotama**, Moore.
***Mycalesis perseus**, Fabricius.
Mycalesis perseus, var. *visala*, Moore.
***Mycalesis igoleta**, Felder.
***Mycalesis medus**, Fabricius.
***Mycalesis mineus**, Linn.
***Ypthima baldus**, Fabricius.
***Ypthima asterope**, Klug.
Ypthima philomela, Joh.

The first of these three is very abundant, but varies remarkably in size, markings and colorations. I am inclined to believe that the latter two are one and the same species.

Discophora celinde, Stoll.
***Junonia lemonias**, Linn.
***Junonia laomedia**, Linn.
***Junonia Wallacei**.
***Junonia hierta**, Fabricius.
Junonia hierta, var. *cebrene*, Trim.
Junonia orithya, Linn.
***Junonia asterie**, Linn.
***Junonia almana**, Linn.
***Precis iphita**.

***Ergolis ariadne,** Linn.
***Athyma perius,** Linn.
Athyma leucothoe, Linn.
Athyma sulpitia, Cram.
***Athyma kasa,** Moore.
***Euthalia puseda.**
***Lethe Europa,** Fabricius.
***Danais genutia,** Cramer.
***Danais tytia,** Gray.

This and the foregoing insects attain unusual dimensions in the warm climate of Hongkong. The latter is found also in Japan, but is invariably smaller in size.

***Danais limniace,** Cramer.
Danais similis, Linn.
***Danais plexippus,** Linn.
***Catopsilia philippina,** Cramer.
Catopsilia pyranthe, Linn.
***Hebomoia glaucippe,** Linn.
Hebomoia crocale, Cramer.
Ixias pyrene, Linn.
***Miletus chinensis,** Felder.

This pretty member of the *Lycænidæ* is said to be confined to Hongkong, but I have taken it in several places on the mainland.

***Euplœa superbus,** Herbst.
***Euplœa midamus,** Linn.

The latter is much more frequent than the former. It varies remarkably in size; more so, perhaps, than any other butterfly haunting the gardens of Hongkong.

***Hesperia flava,** Murray.

Common throughout China and Japan.

***Pamphila mathias,** Fabr.
Pamphila maro, Fabr.
Plesioneura folus, Cramer.
Hipparchia eumea, Drury.

I have, in the foregoing list, not made any attempt at correct classification. The field, so far as the province of Kwangtung, or indeed southern China, is concerned, is a virgin one. Much remains still to be done, as the greater part of those who collect, or have collected, in Southern China, have neglected to give careful data as to the localities, seasons, etc. By far the most important part of the little work hitherto done is thus untrustworthy or often downright misleading.

The following list of moths includes merely the most important species; from personal observation I believe that more than three hundred species can be identified as coming from Hongkong:—

Chærocampa suffusa, Walker.
**Chærocampa pallicosta*, Walker.
**Acherontia medusa*, Butler.
Diludia discistriga, Walker.
**Diludia increta*, Walker.
Northia tenuis, Butler.
**Phissama vacillans*, Walker.
Spilarctia subcarnea, Walker.
**Lælia sinensis*, Walker.
Pantana ampla, Walker.
**Acontia bimacula*, Walker.
(Acontia maculosa ?)
**Boarmia repulsaria*, Walker.

**Ophiusa arctotænia*.
**Tropæa artemis*, Butler.

In conclusion, it is necessary to state that the list of butterflies is by no means exhaustive. There are some five or six doubtful species which the writer has thought best not to include; and, besides these, there are one or two others that may, very probably, turn out to be *species novæ*.

MARCH 31.

Mr. GEORGE W. TRYON, Jr., in the chair.

Thirty-four persons present.

The following was presented for publication:—

"Remarks on Lanius robustus Baird, based on an examination of the type specimen," by Leonhard Stejneger.

The following were ordered to be printed:—

DESCRIPTION OF A NEW SPECIES OF THE GENUS CYANOCORAX.

BY ALAN F. GENTRY.

Cyanocorax Heilprini, n. sp.

Sp. Char.—Above light brown, with decided purplish shade. Front of head from a line directly back of eye, sides of head and neck, together with the throat, black; frontal plumes bristly and recurved; spot of purplish-blue at base of lower mandible. Crown, occiput and hind-neck lilac or light violet. Breast and abdomen brown, with deeper purplish reflections than on the rest of the body, and becoming lighter towards the vent. Tail concolorous with back above, brownish underneath, and broadly tipped with white; under tail-coverts white. Tibiæ ashy; bill and legs black. Length, 14·25; wing, 6·75; tail, 6·37; tarsus, 2·75; bill, 1·50.

Habitat.—Rio Negro. A single specimen, marked ♂, and part of the T. B. Wilson Collection of the Academy of Natural Sciences.

Mr. R. B. Sharpe, in his Catalogue of the Birds of the British Museum, vol. iii, divides the genus into two sections, which are respectively characterized by the presence or absence of white tips to the tail-feathers. While properly coming under the first division by reason of the existence of tips, it differs very markedly from the species therein included, the breast and abdomen being purplish brown and dusky instead of white, and the blue or white spot above, as well as below the eye, being wanting. But in the close resemblance which obtains between the upper and lower surfaces of the body, there is a manifest relationship to the group with uniform tail-feathers.

The species is dedicated to my friend, Prof. Angelo Heilprin, of Philadelphia, in recognition of his services to science.

REMARKS ON LANIUS ROBUSTUS (Baird), BASED UPON AN EXAMINATION OF THE TYPE SPECIMEN.

BY LEONHARD STEJNEGER.

In April, 1843, there was referred to the Academy, for publication, a paper by Dr. William Gambel, entitled "Descriptions of some New and Rare Birds of the Rocky Mountains and California," where he had been traveling at the instance of Mr. Nuttall. The Committee on Publication, of which Mr. Cassin was a member, recommended it, and consequently it was printed in the Proceedings of that year (vol. i, pp. 259–262).

We make at once the remark, that the Academy at that time had not received specimens, as will appear from the note on page 258. On the contrary, the transfer of Gambel's collection was not made before 1847 (*cf.* Proc. Phila. Acad., iii, p. 346). During that very year several large collections were also received and arranged for exhibition by Cassin and Gambel, viz.: the Rivoli collection, Boucier's collection, Wilson's collection, Cassin's collection of West African birds, altogether nearly 18,500 specimens!

The history of the specimen of *Lanius*, which afterwards became the type of Cassin's *elegans* and Baird's *robustus* cannot (from the catalogues and records of the Academy, as I am kindly informed by Prof. A. Heilprin) be traced further back than 1857, when it was described by Cassin in the Proceedings as *L. elegans.*

It will be remarked, however, that Gambel already, in his paper mentioned above, enumerates *L. elegans* as a bird observed by him in California. But it is evident that he does not refer to any particular specimen, and that the birds referred to *elegans* were nothing but *L. excubitorides.* He says: "This species, of which but a single specimen is known to ornithologists [viz., the type in the British Museum], I found abundant in California . . . . . in the adults the breast is pure white; in the young blended with dark brown, like our common species, except the throat and vent, which are white." In his later, more elaborate paper, published in the same year as his collection was turned over to the Academy, Gambel realizes the fact, and simply calls the species met by him *L. ludovicianus* with which he identifies *excubitorides* (Proc.

Phila. Acad., iii, 1846–47, p. 200). Nor is mention made in this paper of any particular specimen.

In his special report upon the increase of the ornithological collection during 1847, Cassin, while mentioning the incorporations of the collection made by Gambel in California, enumerates *Lanius elegans* as among the species "especially interesting," but no allusion to any specimen is made.

It is not before ten years later that we encounter a description and special notice referable to the specimen in question, when Cassin in his "Notes on the North American species of Archibuteo and Lanius" (Proc. Phila. Acad., ix, 1857,[1] p. 213), gives the characters of *Lanius elegans* Swainson, which evidently are taken from the bird now before me. Regarding the distribution of this species, he says: "This appears to be exclusively a western and northern species, the only specimens of which that we have ever seen are in the Museum of the Philadelphia Academy. Our specimen was brought from California by Dr. Gambel." It will be noted that he speaks of several specimens in the Academy's Museum.

Prof. Baird, in the "Birds of North America," page 327, simultaneously describes the same specimen under the heading of *Collyrio excubitoroides.* He refers to it as "Collected in California by Dr. Gambel," and remarks: "This bird has been referred to *L. elegans* of Swainson, but seems to differ in some appreciable points."

The specimen was figured on plate lxxv.

A more detailed description of the specimen is given by the same author in his "Review of American Birds," page 444 (1866), but he seems to have become doubtful as to the origin of the specimen, since the locality is given as "California?" and in the text he says that it is "labeled as having been collected in California by Dr. Gambel." Though "by no means satisfied that the bird is the true *Lanius elegans* of Swainson," the author introduces it under the heading *Collurio elegans.* It may be remarked that no mention is made of other specimens.

Next we find the specimen mentioned in Cooper's "Ornithology of California," edited by Prof. Baird. On page 140 is

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[1] Published in 1858; the paper was recommended for publication at the meeting, Dec. 29, 1857, *cf.* p. 210.

given a woodcut representing the head and one of the secondaries. Of the locality is said: "*Hab.*—Of original specimen, uncertain, but somewhere in western North America."

In Dr. Coues' "Key" (1872), for the first time is seriously doubted the North American origin of the specimen. He says (page 125): "To this species [*C. ludovicianus*] I must also refer the *C. elegans* of Baird, considering that the single specimen upon which it was based represents an individual peculiarity in the size of the bill. This specimen is supposed to be from California, but some of Dr. Gambel's, to which the same locality is assigned, were certainly procured elsewhere, and it may not be a North American bird at all."

The "History of North American Birds," by Baird, Brewer and Ridgway, contains little additional information, except that the bird here is made the type of the new name *Collurio ludovicianus*, var. *robustus*, since it had been shown by Sharpe and Dresser that the type of *L. elegans* Sw. was referable to some Old World species, erroneously said to have come from the "Fur-countries." The authors also assert that they "have no reason to discredit the alleged locality of the specimen."

Not being able to reconcile the statement of Prof. Baird, that the specimen in question "is very decidedly different from any of the recognized North American species," with the reduction of it to a variety under *ludovicianus*, I, in 1878, named the bird *Lanius bairdi* (Arch. Math. Naturv., iii, p. 330), a synonym which, together with many others, Dr. Gadow has seen fit to entirely ignore in the eighth volume of the "Catalogue of the Birds in the British Museum" (1883).

Finally, we have to mention the position taken by Dr. Coues, who, in his "Birds of the Colorado Valley" (p. 546) "under the circumstances, declines to take further notice of the supposed species in the present work." "The circumstances" alluded to seem to be the doubt as to the correctness of the locality attributed to Gambel's specimen, as expressed already in his "Key." We are compelled, however, to take exception to a statement contained in the sentence commencing his account, though, as will be found later on, we agree with him as to the result. He says: "But Dr. Gambel, in 1843 (Proc. Phila. Acad., 1843, 261), described a shrike, *supposed to be* from 'California,' which he identified with Swainson's bird, and called *L. elegans*." The fact is, however, that the species which Gambel, in 1843, described *l. c.*, not only was supposed to be, but also really was, from "California," being *excubitorides*, collected there by himself, and the statement should correctly read thus: "But Cassin and Baird, in 1858, described a shrike, *supposed to be* from 'California,'" etc.

The latest account of the bird is found in the eighth volume of the "Catalogue of Birds in the British Museum" (1883), p. 243, by Dr. Gadow, solely based on Baird, Brewer, and Ridgway's work. The name is given as *Lanius robustus*, and the habitat, California, is not questioned.

This finishes the literary history of the specimen, which may be tabulated thus:—

1858. *Lanius elegans* Cassin, Pr. Phila. Acad., ix, 1857, p. 213 (nec Swains., 1831).
1858. *Collyrio excubitoroides* Baird, B. North Am., p. 327 (part).
1858. *Collyrio elegans* Baird, B. North Am., pl. lxxv, fig. 1.
1866. *Collurio elegans* Baird, Rev. Am. B., p. 444; Baird and Cooper, Orn. Californ., i, p. 140 (1870).
1872. *Collurio ludovicianus* Coues, Key, p. 125.
1873. *Collurio ludovicianus* var. *robustus* Baird, Am. Natural., vii, 1873 (p. 608); B., Br. and Ridgw., Hist. N. Am. B., i, p. 420 (1874).
1878. ——— ——— Coues, B. Color. Vall., i. p. 545.
1878. *Lanius bairdi* Stejneger, Archiv Math. Naturv., iii, 1878, pp. 326, 330; *Id.*, *ibid.*, iv, 1879, p. 263.
1880. *Lanius ludovicianus robustus* Ridgw., Pr. U. S. Nat. Mus., 1880, p. 175; *Id.*, Bull. U. S. Nat. Mus., No. 21, p. 20 (1881).
1883. *Lanius robustus* Gadow, Cat. B. Brit. Mus., viii, p. 243.

We shall now examine the specimen itself, which, by the courtesy of the authorities of the Academy, I have before me. It is mounted and in a state of preservation which, though not very good, still makes it sufficient for all practical purposes. No label is attached to it, but on the underside of the stand is written in Cassin's handwriting:—

Dr. Gambel
Lanius elegans
Sw. Faun. Bor. Am.
p. 122
☞ Observe larger bill
J. C.

No number or reference to a catalogue is found anywhere, nor does the Academy seem to possess any special record of the specimen. The inscription is in ink, except the name, which is written with a lead-pencil.

It will be seen that the locality is not inscribed on the stand, and that now, at least, the specimen is not "labeled as having been collected in California."

The U. S. National Museum possesses a very rich collection of North American Shrikes, and the Old World forms are also tolerably well represented, partly due to the incorporation of my own collection of Shrikes, of which formerly I made a specialty. I have compared the type of *L. robustus* with these, the result being as follows:—

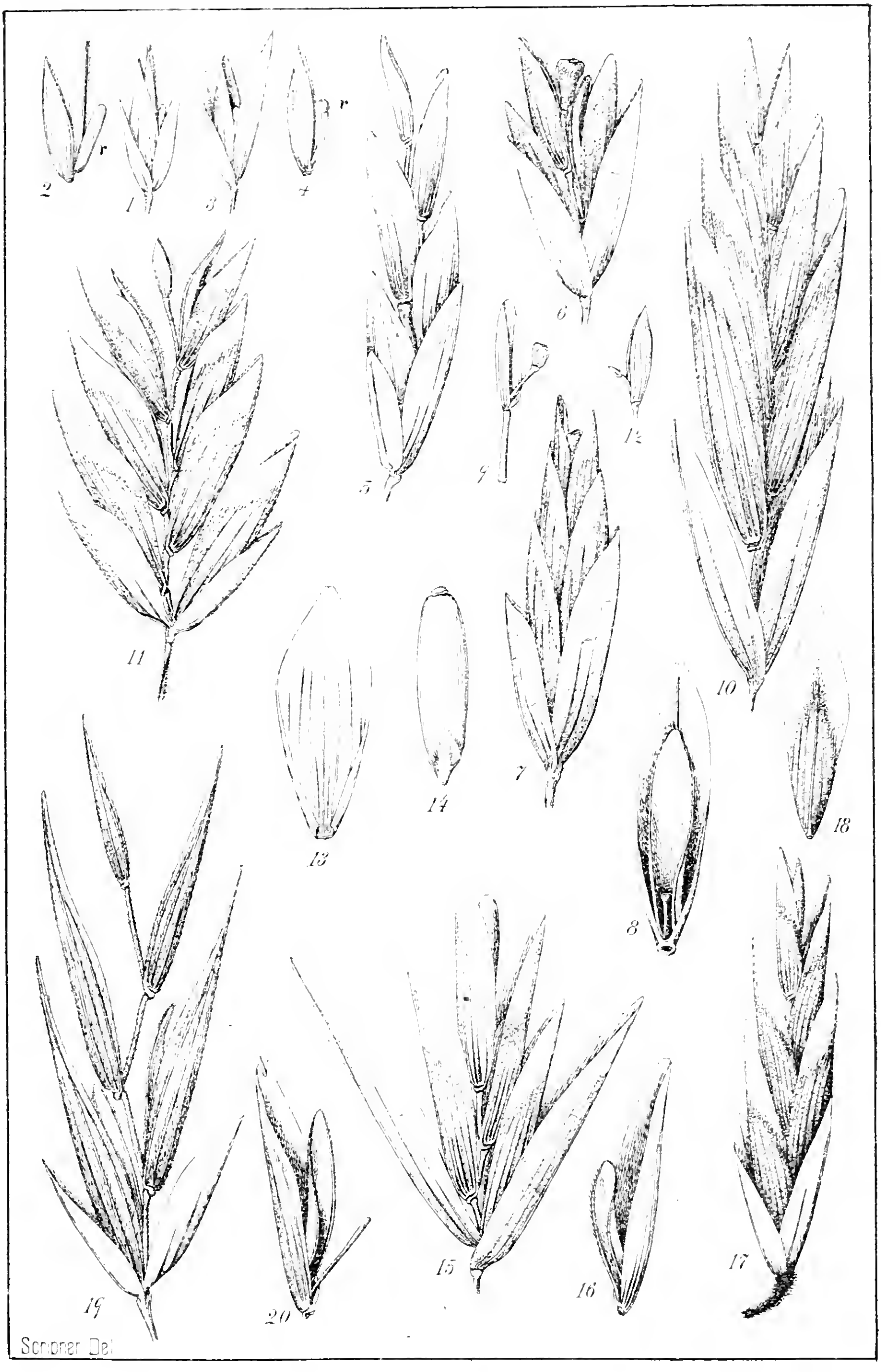
The statement of Professor Baird, that it is "very decidedly different from any of the recognized North American species," is eminently confirmed. The material in the Museum has been doubled many times during the twenty years since he wrote the above, but still the type remains unique in its peculiar characters. I need not repeat here his excellent description, but think it proper to sum up the most diagnostic features of the bird, mainly to counteract any erroneous impression that might arise, caused by the quotation above from Dr. Coues' "Key," in which it is asserted "that the single specimen represents an individual peculiarity in the size of the bill." *Lanius robustus* is not only remarkable for its large bill, but also for its general dark color, total absence of light superciliary stripe, the ashy wash of the lower parts, the gray loral spot, the restriction of the white on the tail-feathers, particularly at the base, and the peculiar distribution of black and white on the secondaries, so well illustrated by the figure in Cooper and Baird's Californian Ornithology quoted above.

Of all the Old World members of the restricted subgenus *Lanius*, the present bird only needs comparison with a few dark-colored species. In many respects it resembles *L. algeriensis* Less., particularly in the shade of the gray on the back, the absence of a white superciliary stripe, the ashy under surface; but the wing speculum is much larger, the secondaries differently colored, and the tail with less white, not to speak of the difference in the size of the bill. In the latter respect our bird agrees rather closely with a specimen of a *Lanius* collected by H. B. Tristram at Gennesareth, March, 9, 1864, but it is darker both above and beneath, and the pattern of secondaries and tail is different. This specimen from Palestine seems referable to the form which Gadow says is "intermediate between *L. fallax* and

L. uncinatus," the latter being a big-billed island form from Socotra, off the coast of Eastern Africa, and, judging from his remarks (Cat. B. Brit. Mus., viii, p. 248) some of the specimens from that region east of the Mediterranean may be even more like the type of *robustus*. The conclusion of my comparison is that the latter is more closely allied to some of the forms inhabiting the regions south and east of the Mediterranean, than to any of the known Nearctic species, but that it is entirely distinct from any other species known.

We shall now shortly review the evidence bearing upon the origin of the type: 1. Gambel himself nowhere directly and particularly refers to the specimen in question; 2. His collection was turned over to the Academy four years after his original paper was published; 3. During the same year the Academy received more than 18,000 specimens, a great many of which were from the Old World; 4. Not before ten years after is any direct allusion made to the specimen by Cassin; 5. No indication of it having been collected in California, can now be found attached to the bird or the stand; 6. We have Dr. Coues' testimony that "some specimens of Dr. Gambel's, to which the same locality (California) is assigned, were certainly procured elsewhere"; 7. So far as the evidence goes, the bird is nearer related to some Old World forms than to those from North America. The sum of all this would indicate that the specimen in all probability is not North American, and enough reasons are given to explain how the mistake may have easily originated. It would not be human, if in receiving and putting on exhibition more than 18,000 specimens in one year some such mistakes did not happen. I therefore think we would be fully justified in excluding *Lanius robustus* from the list of North American birds.

But it should always be borne in mind, that notwithstanding the apparent conclusiveness of the above remarks, the question is not fully solved before we have pointed out where the species really occurs, since there is a bare possibility that some day it may be discovered not far from its alleged habitat in spite of all our arguments. *L. robustus* is very distinct from the other American Shrikes, but not so much so, that its eventual discovery in any part of the Nearctic region would cause a great surprise as far as this point is concerned. The large bill and the dark color suggest some southern island, and explorers of islands off our southwest coast should be on the look-out.



SCRIBNER ON MELICAE.

April 7.

The President, Dr. Leidy, in the chair.

Twenty persons present.

The Primary Conditions of Fossilization.—Mr. Charles Morris made a communication in answer to the query: "Why are there no fossil forms found in the strata preceding the Cambrian?" In mineral conditions there is little difference between the two sets of strata. Yet the Cambrian contain numerous fossils, while the preceding strata are barren in this respect. This Cambrian life, however, does not come in the succession we might naturally expect, and it may be desirable to consider the succession which actually occurs.

Of Protozoa there is not a trace, if we reject the doubtful Eozoön. Yet vast numbers of Protozoa must have existed, and if there were any calcareous- or siliceous-shelled forms, as at present, they must have left some indication in the rocks. The Metazoa do not begin with the lowest forms, but the different orders make their appearance in very odd conjunction. Thus, at the very beginning, we have a great variety of trilobites, in conjunction with a much smaller variety of annelides and mollusks, while there are very scanty traces of sponges, echinoderms and the lower crustaceans. The most advanced form of these animals, the trilobite, greatly outnumbers all its contemporaries.

At a considerably later date two widely separated forms come together into existence. The low order of Hydrozoa makes its first appearance as the Graptolite, and at a closely related date appear Cephalopods, the highest order of Mollusks. The Silurian era opens with an abundance of Graptolites and a considerable increase of Cephalopods. It is much later ere any clear trace of Vertebrates appears, and this in what is certainly not their lowest form.

The appearance of land animals presents a somewhat similar phenomenon. No land Vertebrates appear below the Carboniferous rocks, yet it is now known that insects existed well down in the Silurian, proving that the conditions necessary for land life had very long prevailed ere Vertebrates left the sea for the land.

It is impossible to believe that these fossils represent truly either the beginning or the actual succession of life upon the earth. Such an idea would be utterly inconsistent with the development theory, and even under the creation hypothesis it is incredible that life could have begun with such a confused mixture of high and low. No one, for instance, can accept what the rocks seem to teach, that advanced forms of Mollusks and Crustaceans came into existence before the Cœlenterata. It may be taken for granted that we have but fragments of the primeval life, and these fragments associated in a manner that cannot indicate the actual life conditions.

These earliest animals are mainly burrowing, crawling, or stationary forms. There is very little indication of the abundance of swimming life which now crowds the ocean and must have then done so. We find only minute swimmers, such as Pteropods and Phyllopods, while if the Trilobites were able to swim it must have been but a sluggish movement. There is no indication of the existence of rapid and powerful swimmers.

Yet there are several reasons for believing that swimming animals existed in abundance. The rapid swimmer has an advantage in food-getting and in escape from danger over the slow-moving surface animals. Natural selection, therefore, must have tended to produce swimming forms.

The facts of embryology yield evidence to the same effect. Nearly or quite all ocean animals begin life as swimmers. The stationary forms become fixed only after their larval period is passed. This fact indicates that at some early period the ancestors of our present fixed forms were free swimmers.

But a stronger proof of this is found in the condition of the animals whose fossil forms we possess. They are all covered with protective armor. It is, indeed, to the preservation of this armor that we owe our knowledge of their existence. We find no weapons of offense. Everything is defensive. Even the trilobite, which had nothing to fear from the other known forms, was clothed in a strong coat of mail, and had acquired the habit of rolling himself into an impenetrable ball. There can be no question that he had foes, stronger than himself, against whom he found defense only in his chitinous armor. Yet of these predatory foes we know nothing.

All other preserved forms tell the same story. We would know nothing of them but for their hard parts, and these hard parts are all protective. The soft-bodied annelid saved itself by burrowing in the mud. The mollusk clothed itself in a firm limy covering. Of the remaining forms each wore some kind of defensive armor. Many of them doubtless needed defense against the trilobites, but the foes of the trilobite are missing.

If we ascend higher in the rocks, the same tale is told. The Hydrozoa, which had probably swum the earlier seas in forms allied to our soft-bodied Medusæ, become stationary and protected as Graptolites. And simultaneously the powerful Cephalopods make their appearance as surface forms, clothed in a heavy and cumbrous defensive armor. If they formerly had mastery of the seas, as we may conjecture, they had been driven from it by some more powerful and rapid foe.

In fact all the preserved forms may be looked upon as to some extent degenerated types of life. They very probably represent earlier free-moving forms, which have been driven to wear heavy armor for protection from stronger foes, and have been forced by the weight and the character of this armor to take up a life on the ocean bottom, either as stationary, crawling, or sluggishly swimming forms.

Where are the foes who have forced these forms of life into degenerated conditions? They are indicated in the rocks by no hard parts, either offensive or defensive. They probably needed no protective armor, they had no internal hard skeletons, and the only trace of early offensive weapons are found in the dubious Conodonts, of the lower Silurian strata. Not until undoubted fish teeth appear do we find unquestionable weapons of offense. And there is no indication of active predatory swimmers until we find the earliest fish remains. We may conceive that fishes had so increased as to sweep the seas of any overabundance of food forms, and had begun to actively prey upon each other. Then they developed the protective armor to which they had previously driven their prey. And this armor increased in thickness and strength until the remarkable bony plates of the Devonian fishes were produced. But in all probability several successive types of life obtained mastership of the ocean, each superior form driving all earlier forms to seek protection. Of these the fish was the last and most powerful, and it cleared the open seas of all competitors.

Only from some such cause as this can we understand the sudden appearance of the Cambrian Orthoceratites, with their bulky and clumsy shells, which certainly would never have been developed except through pressure of sheer necessity. This armor must have greatly diminished the motor powers of the cephalopod; it was solely protective in character, and it is impossible to impute it to any cause save that of defense from a powerful predacious foe. All the early lords of the ocean had successively to clothe themselves in strong armor, or to vanish from existence as more powerful forms appeared.

There are strong indications, therefore, that in addition to the armored forms preserved in the rocks, there was abundance of naked forms of life, mainly swimmers, and pursuing a predatory mode of life. If we pass backward through the succession of fossil forms, it is to find the armored types decreasing in numbers and variety. We seem to gradually approach a period in which the naked swimming forms were greatly in excess. This may have been preceded by a period in which there were no armored forms. In such a case, though life may have been as abundant as now, it could not have been fossilized. Such may possibly have been the pre-Cambrian life condition.

There could have been no era of life, indeed, in which predatory forms did not exist. But there may have been a long period during which animals were incapable of secreting armor. The organic functions are certainly not all of primitive origin. Many of them may have been the product of ages of slow development. Such may have been the case with the development of glands suitable for the secretion of chitin, carbonate of lime, and the other protective substances. We know that it was at a late date in the history of life when animals first began to secrete an internal hard skeleton. The need of protection undoubtedly caused a more rapid evolution of the power to secrete an external hard covering, and yet life may have long prevailed before this adaptation was gained. The mantle of the bivalve mollusks, for instance, with its glands for the secretion of a limy shell, cannot have been a primitive feature of molluscan life. So the chitin-forming glands of the crustaceans may have been a late product of evolution. It is possible that, in the early days of life, all the mineral ingredients of food were directly excreted. It is equally possible that the power of transforming food elements into hard substances did not exist. The development of dermal glands, necessary to the secretion of external skeletons, teeth, etc., must have occupied a considerable time, and its completion may have taken place but shortly before the opening of the Cambrian period.

If such was the case, the preceding life must have been of a low order, and of small dimensions. Animals might have grown to considerable size with cartilaginous skeletons, but scarcely without teeth or other hard weapons of offense, of which no trace remains. It may be that the earlier forms of life were in great part swimming animals, that they waged constant war upon each other, and that in time, through the action of natural selection, the power of secreting defensive armor was evolved.. As this armor grew denser and heavier the swimming powers became abridged, and the armored animals were successively carried to the bottom, and forced into slow-moving or stationary habits of life.

In corroboration of this idea is the fact that the power of secreting an internal skeleton appeared only at a much later date. It has never been developed in the Invertebrates, except in late cephalopods, and in all these animals the external armor has necessarily been utilized for muscular attachment. The superiority of the vertebrates is largely due to the fact that their muscular attachment has always been internal, a method which gives much greater flexibility and power of movement. Yet for a long period after the appearance of vertebrate life the basis of muscular attachment was merely a rod of cartilage. Even the great Devonian fishes, with their dense epidermal plates, were destitute of internal bone, except that in a few cases they possessed ossified vertebral arches. The next evidence of power to secrete internal bone is found in certain Carboniferous Ganoids, which possessed a mere ring of bone in the external portion of their vertebræ. It cannot reasonably be argued that bony skeletons would have been of no use to these ancient swimmers. The possession of bony skeletons by all the Teleostei shows that this adaptation is a valuable one. Modern Sharks and Ganoids, while often cartilaginous, frequently possess completely ossified vertebræ. Thus we have reason to believe that the absence of internal bone in the most ancient fishes came from the fact that the conditions for the secretion of such bone had not yet been developed.

This leads to one further conclusion. Though a cartilaginous basis of muscular attachment might suffice for large swimming animals, it would not answer for large forms of terrestrial life. In these a greater rigidity was necessary. Therefore land vertebrates of large size could not appear until after the power of forming a bony skeleton had been attained. And it is significant that shortly after the appearance of bone in fish skeletons the Batrachians make their appearance in the rocks. We know that the land had been adapted for animal life for long ages before, and peopled by insects and scorpions, and possibly by forms of life of which we have no comprehension. It is very probable that fishes had long used the land as a temporary place of residence and feeding-ground. This we may safely infer from the existence of fossil Dipnoi, with their powers of breathing air or water at will. Yet it was impossible that large land vertebrates could appear until the bone-making power was fully developed. *Archægosaurus* one of the earliest air-breathers, possessed but a ring of bone in its vertebræ, like the Carboniferous Ganoids. But in all the remaining Carboniferous Batrachians a fully ossified skeleton appears, and this has been ever since an absolute requisite of all land vertebral life, and of all ocean vertebrates except a few survivals of the antique types.

Thus we reach the general conclusions that fossilization of animal forms was not possible until, after a long period of evolution, the power of secreting hard external coverings was gained; and that the existence of large land vertebrates was not possible until, after a still longer period of evolution, the power of secreting internal bony skeletons was developed. If these conclusions be well founded, many of the conditions of early life must remain forever unknown to us, and we cannot hope to recover more than a fragment of the antique fauna.

April 14.

The President, Dr. Leidy, in the chair.

Thirty-one persons present.

A paper entitled "Notes on Mesozoic Cockroaches," by Samuel H. Scudder, was presented for publication.

Hibernation and Winter Habits of Spiders.—The Rev. Dr. McCook remarked that the effect of a low temperature upon spiders was observed in the cases of several young specimens of *Theridion tepedariorum.* They hung on a few short lines to the plastered wall of a brick out-building, the plaster being laid directly on the brick, forming a very cold surface. The spiders were protected from the wind and snow, but wholly exposed to the frost. January 14 (1885), with thermometer ranging from 20° to 25 above zero (Fahrenheit), the spiders were hanging motionless. When touched by the tip of a pencil they dropped down in the usual manner of their kind, holding on by the outspun threads which reached a length of over one foot. They ascended to their perch afterward, and crawled over the roof a little ways.

At a temperature of 18·6° they again were able to drop from the perch. January 19, with thermometer ranging from 17·5° to 20°, they seemed less active—one, when touched, dropping about one inch, another six inches. Four hours thereafter they were suspended in the same position. As the natural habit of the creature is to ascend in a moment or two after disturbance, this shows that the frost had somewhat affected the normal energy. But one of them, being gently lifted on the finger, moved its legs and very slowly began to ascend. Five hours thereafter it was at its perch against the roof. These spiders, at this temperature, with some variations (January 21), moved their position, one passing along the angle of the roof, a distance of four feet. This change of site was probably caused by the annoyance which the experiments produced.

February 11, the thermometer stood at zero at the City Signal Service Office; in West Philadelphia, where his observations were made, the temperature was lower. On the 12th, the Signal Service reported 1° above zero; at his house it was below zero. On this day he removed from its position one of the specimens, a young female about two-thirds grown, and placed it in his library where the temperature was summer heat. She was laid upon the table in the sun. The legs were drawn up around the cephalothorax in the usual "hunched" way when torpid or feigning death. There was a slight and regular pulsation of the feet. In less than ten minutes, upon being touched, she stretched forth her legs and began to move slowly over the paper upon which she had been placed. When touched, her motion was much accelerated, and she began vigorously to perambulate her bounds, anchored to and pulling out after her the usual drag-line. When lifted up on the tip of a pencil she spun out a long thread, to the end of which she hung in the little basket-like structure of silken cords which he had elsewhere described. Indeed, her action was in every respect normal, and showed a remarkably sudden and complete revival of activity after so long an exposure to such extreme cold.

February 26, a younger specimen, about one-third grown, hanging in a crevice in the site above described, when touched and lightly pressed down, slowly moved its legs and began to struggle back to its perch. The thermometer ranged from 20° to 25°; on the day before the range was from 21° at 7 A. M., to 28° at 11 A. M.

During the six weeks over which these observations extended, the temperature was unusually low for this vicinity; for a great part of the time, the thermometer stood below freezing point, and several times reached zero. The month of March following was unusually severe, the thermometer frequently reaching winter temperature. On the first of April, however, the above-named spiders, and others of a younger brood, were in their webs hale and active, drawn out by the first soft days of spring. It would seem, therefore, that the hibernation of spiders (of this species, at least), is not accompanied with a great degree of torpidity; that they preserve their activity and spinning habit while exposed to cold ranging from freezing point to zero (Fahrenheit); that after long and severe exposure, the recovery of complete activity when brought into a warm temperature is very rapid, almost immediate; and that on the return of spring, even after a prolonged and severe winter, they at once resume the habits of their kind.

In all the above specimens the abdomens were full, indicating perfect health. Other spiders hung upon their webs with shriveled abdomens, quite dead, among them one of his specimens, a male, who died during the course of the observations. A *Pholcus phalangioides* hung thus dried up, holding with a death-grip to her web by the two fore-pairs of legs which supported the cephalothorax in a position parallel to the plane of the horizon, while the long abdomen hung down at right-angles thereto, and the third and fourth pairs of legs were drooped downward and backward. He could not determine that these and other spiders perished by the cold. The living individuals were all characterized by the plump abdomen, as though there had been little or no absorption of tissues for nourishment of life. There appeared to be no growth during hibernation.

The same facts hold good as to the winter habits of Orb-weavers. The young survive the winter in the admirably arranged cocoons provided by maternal instinct. But early in the spring many adults of both sexes are found nearly full-grown, who have also safely weathered the cold months. He had, at various times in midwinter, collected examples of *Epeira strix*, and had found the species adult in spring. Specimens of Strix may be frequently taken during the winter months from rolled leaves, within which they have weathered our hard frosts. These rolled leaves also serve for nests during summer. Dr. Geo. Marx had informed him that, on the capacious Government grounds in

Washington city, he often sees such curled leaves suspended conspicuously amid the verdureless branches, and had learned to recognize them easily as the winter-quarters of this species. It of course follows that, either from purpose or by the accidental unwrapping of the threads during continual journeys back and forth trailing her drag-line behind her, the spider prevents the leaf from falling.

A vast colony of *Epeira vulgaris* inhabits the boat-houses grouped around the inlet wharf at Atlantic City. Dr. McCook stated that he had once visited this colony, May 22, 1882. The season had been a remarkably backward one, cold, and very rainy. The trees on the island had not yet leaved; insect life had scarcely appeared; in short the season had advanced little further than the first of May in ordinary years. The inlet colony, however, had already appeared in large numbers, and had swung their orbs between the timbers of the houses and the piles which supported them. These were of various sizes, full-grown, half-grown, and young several weeks out of the cocoons. All the cocoons—which were thickly laid along the angles of the joists and cornices—were empty. The number of young spiders was, however, remarkably small, a fact which he could account for only on the supposition that in the absence of the usual insect food supply, the adults had been driven to prey upon the young and the young upon each other to an unusual degree. Many of the spiders were hanging in the centre of their round snares. Others—the greater part, indeed—were sheltered within a thick tubular or arched screen, open at both ends, which was bent in the angles of the woodwork, or beneath an irregular rectangular silken patch stretched across a corner.

Many others were burrowed behind cocoons, quite covered up by the thick flossy fibre of which these are composed. In this condition they had undoubtedly spent the winter. He had found examples of *E. strix* blanketed in precisely the same way during the winter months. Unfortunately he had never been able to make a mid-winter journey to this favorite spider-haunt, in order to see the araneads in extreme hibernation; but he asked some of the young boatmen what the spiders did in winter-time. "They crawl into their bags," one answered, referring to the screens and tubes above described, "and stay there. They came out about a month ago (the last of April), and then 'shed.' A couple of weeks ago the sides of the houses were all covered with these 'sheds'"—by which, of course, the young man meant their moults.

The following was ordered to be printed:—

NOTES ON MESOZOIC COCKROACHES.

BY SAMUEL H. SCUDDER.

I. *Pterinoblattina, a remarkable type of Palæoblattariæ.*

Among the many fossil cockroaches figured by Westwood thirty years ago, was one which Giebel afterwards named *Blatta pluma*, on account of the resemblance of its neuration to the barbs of a feather, where the shaft is on one side. Several species are now known, and on account of this curious arrangement of the veins, the generic name,

PTERINOBLATTINA (*πτέρινος*)

is proposed. The wings were very broad, expanding considerably beyond the base, broadest beyond the middle, and filled with an abundance of branching veins. The mediastinal, scapular, and externomedian veins ran close together, side by side, in a perfectly straight course (the shaft of the feather), from near the middle of the base of the wing toward and nearly to a point on the costal margin a little within the apex of the wing, and the superior mediastinal and inferior externomedian branches, crowded closely together, parted from this apparently common stem at nearly similar angles on either side of it. The complete independence of the mediastinal, scapular, and externomedian veins shows that the genus falls in the Palæoblattariæ. The species are all small.

Pterinoblattina pluma.

Blatta pluma Gieb., Ins. der Vorw., 322. Figured by Westw., Quart. Journ. Geol. Soc. Lond., x, pl. 15, fig, 14†.

The specimen, the original of which I have had the privilege of studying, by the favor of my kind friend Rev. P. B. Brodie, is rather imperfect, and a little deceptive from the fact that just that portion of the tip is missing which contains the scapular branches; it is probable, however, from the longitudinal character of the apical externomedian offshoots that the species more closely resembles *P. chrysea* than *P. intermixta*. All the mediastinal branches are simple, parallel, equidistant, almost straight, closely crowded, and part from the main stem at an angle of about 45°. The externomedian branches, the only others preserved, part at a less angle, gradually become quite horizontal apically, are nearly as close at base as the scapular branches, and as most of them fork and even re-fork, though with entire irregularity, become excessively crowded toward the margin. The length of the fragment is 9 mm., its breadth 5 mm. Probably the wing was 12 mm. long, and 5·5 mm. broad.

It was found in the Corbula or Pecten beds of the Dorset Purbecks of England.

Pterinoblattina penna, sp. nov.

The single specimen of this species at hand is preserved in much the same manner as the last, but shows a fragment of the internomedian region. The three principal veins approach each other very gradually so as to give them the appearance of a tapering rod. The mediastinal branches part from the stem at nearly a right-angle near the base of the wing, gradually increasing in obliquity distally, until they form an angle of 45° with it; they are slightly curved, the concavity outward, very closely crowded, and about every third one forked near the middle, but with no regularity. The scapular branches are not preserved, but as in *P. pluma*, and for the same reason, they probably resemble *P. chrysea* rather than *P. intermixta*. The externomedian branches are very closely crowded, generally straight, part from the stem at an angle of 45° next the base, and become almost wholly longitudinal at the apex; they fork about as frequently as, and more irregularly than, the mediastinal branches. The internomedian area extends far out on the wing, and its branches (what few can be seen) resemble those of the preceding area, and at its extremity are parallel to them. Length of fragment, 13 mm.; width, 9 mm. Probable length of wing, 15 mm.; probable width, 9 mm.

Described from a specimen from the English Purbecks sent me for examination by Rev. P. B. Brodie.

It is not impossible that the fragment of a larger wing figured by Westwood (Quart. Journ. Geol. Soc. Lond., 1854, pl. 17, fig. 7), from the Lower Purbecks of Durdlestone Bay may be a species very close to this.

Pterinoblattina chrysea.

Blattina chrysea E. Geinitz, Zeitschr. Deutsch. Geol. Gesellsch., 1880, 520, pl. 32, fig. 2.

In this case we have a more perfect wing, the tip being almost completely preserved. The mediastinal vein terminates before the middle of the outer half of the costal border, and is furnished with simple, straight, oblique branches, not so numerous as in the other species, to judge by the figure, though they are spoken of by Geinitz as " very numerous and closely crowded." Just before the scapular reaches the tip of the mediastinal, it turns parallel to the costal margin, runs to the upper tip of the wing, and emits branches similar to those of the mediastinal, but of course of equal length. All the externomedian branches run almost longitudinally, are straight, sometimes forked, and appear from the figure to be less crowded than the mediastinal branches, though they are compared by Geinitz to the barbs of a feather. The internomedian runs to just beyond the broadest part of the wing, being thus longer than the mediastinal, and sends less crowded, gently curved, usually forked, rather short branches to the border. The few anal branches curve and strike the inner margin. Length, 5 mm.; breadth about 2·25 mm.

From the Lias of Dobbertin, Germany. The description is drawn up from the data given by Geinitz.

Pterinoblattina intermixta, sp. nov.

A nearly complete wing of this species has almost the same shape as *P. chrysea*, but the upper part of the apex is more produced. The mediastinal vein terminates before the middle of the outer half of the wing, and the area narrows more gradually than in any of the others; its branches are gently curved, and often forked, but not excessively crowded. Just before reaching the tip of the mediastinal, the scapular vein suddenly bends toward the apex, running subparallel to, but away from the costal margin, terminating at the tip and emitting a crowd of curved and forked branches. The closely crowded externomedian branches part at an angle of 45° with the stem, are straight, and fork only just before the tip, forming a tolerably regular belt of crowded veinlets along the margin. The basal branches, however, are interfered with and affected by the internomedian vein, which is nearly straight, at first running plump against the externomedian branches, curves then downward parallel to these and terminates a little before the mediastinal; it is furnished abundantly with branches curving like its extremity and branching next the border like the externomedian branches, but where it abuts against these latter they simulate the appearance of the internomedian branches so as to appear as if a part of the internomedian area, and thus give the latter the appearance of extending out beyond the broadest part of the wing. The anal appears to be insignificant, reaching less than a third the distance from the base and resembling a narrower and smaller internomedian area. Length of fragment, 10·5 mm., probable length of wing 12 mm.

Received from Rev. P. B. Brodie, as coming from the Upper Lias of Alderton, Gloucestershire, England.

Pterinoblattina hospes.

Ricania hospes Germ., Acta Acad. Leop. Carol., xix, 220–21, Pl. 23, fig. 18.

Germar took this for one of the Fulgorina, in the neighborhood of *Ricania* and *Pœciloptera*. It is pretty plain, however, that it belongs here, though the figure given by Germar is not sufficiently clear to enable one to formulate any characteristics. Assmann thought it a Neuropteron, falling in the neighborhood of *Drepanopteryx*.

It comes from the Oolite of Solenhofen.

Pterinoblattina gigas.

Ricania gigas Weyenb., Arch. Mus. Teyl., ii, 270–71, pl. 35, fig. 23.

Following Germar, Weyenbergh placed this enormous species in *Ricania*, but it as evidently falls here and bears a close general resemblance, excepting in size, to *P. penna* of the Purbecks. *Ricania fulgens* Gieb. (Brodie, Pl. 4, fig. 12), from the Vale of Wardour, has nothing to do with *Pterinoblattina*.

This gigantic form also come from the Oolite of Solenhofen.

II. *Triassic Blattariæ from Colorado.*

In a recent paper I described some of the Triassic Palæoblattariæ, which I mentioned as interesting on account of their special relation to the Blattariæ of the same formation. Brief diagnoses of these latter forms will therefore have some interest, and I mention them in the order of their relation to the Palæoblattariæ.

NEORTHROBLATTINA (*νέος, ὄρθρος*), gen. nov.

In this genus the wings are about two and a half times longer than broad, with fairly well rounded apices, the mediastinal and scapular veins amalgamated into a single vein, which extends nearly to the tip and in the middle of the wing occupies nearly one-half its width. The internomedian vein is of varying importance, and in the large anal area the veinlets terminate on the margin; the anal furrow is strongly arcuate, and deeply impressed.

Neorthroblattina albolineata, sp. nov.

The single wing has lost the tip, but all the essential features are preserved, excepting the form of the tip. The wing is very dark colored, and the veins appear as very pale lines upon it. The costal margin is gently and equably arched, while the inner margin is perfectly straight. The externomedian vein is little developed, first forking and then not widely in the middle of the wing, its fuller development being prevented by the ample and unrestricted development of the internomedian vein, which runs in a full rounded course nearly to the tip of the wing. The anal area is interesting because the veins of the upper half run close to, but do not impinge upon the anal furrow, curving downward just before reaching it, and either running into the next vein below and terminating there, or continuing parallel to the furrow and terminating on the inner border. Length of fragment, 7 mm.; probable length of wing, 9 mm.; breadth of wing, 3·5 mm.

Triassic beds near Fairplay, Colorado.

Neorthroblattina Lakesii, sp. nov.

Several specimens of this species were found. The costal margin is arched as in the last species, and the inner margin has an almost equal opposite curvature. The externomedian vein has a very sinuous course, and forks before the middle of the wing with abundant neuration, occupying on the margin the entire tip of the wing, and almost the outer half of the lower margin, while the internomedian is reduced to an arching vein, extending but little beyond the anal furrow, and with only two or three branches; the anal veins are all parallel to the anal furrow and simple. Length of wing, 9 mm.; breadth, 3·5 mm.

Triassic beds near Fairplay, Colorado. This species is named after Prof. Arthur Lakes, of the School of Mines, in Golden, Colorado, who first made known these beds; this species being one of the first discovered by him.

Neorthroblattina rotundata, sp. nov.

The costal margin in this species is very strongly arched, while the inner margin is straight, giving a very different aspect to the wing. It closely resembles the preceding species in the mediastino-scapular, and anal areas, and also in the peculiarities of the externomedian vein, excepting that the latter does not encroach to so large a degree upon the internomedian, the terminal offshoot of which creeps along the border so as to limit the marginal extent of the externomedian area almost as much below as above, although the branching of the externomedian vein is scarcely lessened. Length of wing, 8·5 mm.; breadth, 3·3 mm.

Triassic beds near Fairplay, Colorado.

Neorthroblattina attenuata, sp. nov.

This species departs from the typical forms in its slenderness and pointed apex, but it agrees so fairly in general structure that it would best be placed here. The costal margin is not regularly arched, being flattened mesially, while the whole wing tapers beyond the basal third; the inner margin is also arcuate, and the tip bluntly pointed. The mediastino-scapular vein terminates considerably before the apex, and the oppositely arcuate internomedian reaches almost as far out, the branches of both nearly always simple. The anal veins are only slightly irregular. Length of wing, 15 mm.; breadth, 4 mm.

Triassic beds near Fairplay, Colorado.

SCUTINOBLATTINA (*σκύτινος*), gen. nov.

In this genus, composed of small species, the front wings are decidedly more coriaceous than the hind wings, so that the neuration is often more or less obscured by it. The wing itself is convex, as in the modern *Phoraspis*, and subtriangular in form, its greatest width being near the base, while the tip is bluntly pointed. The mediastinal and scapular veins are again blended into one, which, instead of having a sinuous course, is nearly or quite straight, and terminates below the apex of the wing, while the externomedian vein follows closely parallel to it, and the oblique veins of this and the internomedian veins follow each other so as to make it difficult to tell where the line of demarkation may lie. The anal veins sometimes fall on the margin and sometimes on the anal furrow.

Scutinoblattina Brongniarti, sp. nov.

In this interesting species the wings are very strongly convex at the base, and the whole surface is flecked with dark spots. The branches part from the main veins at a similar angle on either side of the middle of the wing. The anal area extends nearly to the middle of the wing, where it is marked by a considerable emargination, and its veins are frequent, oblique, mostly simple, and terminate on the margin. Length of wing, 7 mm.; breadth, 3 mm.

Triassic beds near Fairplay, Colorado. Named after Mr. Chas. Brongniart, of Paris, well known for his remarkable discoveries among the older fossil insects.

Scutinoblattina intermedia, sp. nov.

This species resembles the last, but is not marked by any dots, and the anal area, while shorter, shows no emargination of the border at its extremity; the anal veins are very close, parallel to the inner margin, and terminate not on the margin, but on the anal furrow. It further differs in that the externomedian branches are considerably more longitudinal than those terminating on the costal margin. Length of wing, 7 mm.; breadth, 2·75 mm.

Triassic beds near Fairplay, Colorado.

Scutinoblattina recta, sp. nov.

This species, the smallest and most abundant of all in the Triassic rocks, is rather slenderer than the others, and has the surface finely reticulated. The mediastino-scapular and externomedian veins run side by side in perfectly straight lines from the middle of the base to the middle of the tip, the branches, very few in number, parting similarly on the two sides. The costal is more arched than the inner margin, and where they can be made out, the one or two anal veins seem to run to the margin, but all the veins on the wing are exceedingly obscure. Length of wing, 6·3 mm.; breadth, 2·4 mm.

Triassic beds near Fairplay, Colorado.

III. *On the Genera hitherto proposed for Mesozoic Blattariæ.*

Brodie, in 1845, published figures of a considerable number of mesozoic cockroaches, but named only one, which he referred to the genus *Blatta*. In 1852 Heer figured and named another under the equally broad generic name *Blattina*. Westwood, in publishing in 1854 a considerable addition to our knowledge of the cockroaches of the English mesozoic rocks, separated four somewhat peculiar forms under the generic term *Blattidium*; the rest were unnamed. Giebel two years later named a considerable proportion of Brodie's and Westwood's species; while placing a considerable number under *Blatta* and *Blattina*, he divided the rest under three new genera, *Rithma*, *Elisama* and *Nethania*, the last including the only one of Westwood's species of *Blattidium* which was noticed. On the other hand, Heer, in 1864, divided all the mesozoic species between *Blattina* and *Blattidium*, placing in the latter all of Westwood's species, together with all those referred to new genera by Giebel. Finally, a few years ago E. Geinitz proposed for a triassic species described by him, and one previously published by Heer, the new generic term *Mesoblattina.*

There is no question that the forms described by Westwood, after eliminating the one separated by Giebel, under the name of *Nethania*, form a very distinct group; but none of the species since added to it belong here, so that

BLATTIDIUM

should stand much as first limited (though not described) by Westwood. Probably, however, it should be still further restricted by the elimination of *B. Achelous* Westwood. The wings are exceedingly long and slender, particularly in *B. Symyrus* Westw.—which may be taken as the type—with nearly or quite parallel sides. The mediastinal vein terminates not far from the middle of the wing, and sends out a multitude of crowded offshoots to the margin. The scapular vein unites in the basal third of the wing with the externomedian, and throws off rather distant oblique veins, first to the mediastinal, and afterwards to the border. The externomedian and internomedian veins have together several more or less forked, very longitudinal branches, all of which appear to terminate on the apical margin, while the main anal vein, longitudinally oblique, extends nearly as far as the mediastinal, and the outer half of the inner margin of the wing seems to have no veins falling upon it; the veins of the anal area run obliquely from the margin upward and outward to the main anal vein.

As to the genera of Giebel, six species are placed by him in *Rithma*, two in *Elisama* and one in *Nethania*. The species of *Nethania* is rather too uncertainly figured to determine by the illustration alone where it belongs. The two species of

ELISAMA

figured by Brodie certainly belong together, and seem to constitute a natural genus. By the kindness of Rev. Mr. Brodie, I have seen the original of his pl. v, fig. 1 (*Elisama Kneri* of Giebel) and another specimen which seems to belong to *E. minor*, so that I can more fully characterize this genus. The mediastinal and scapular veins appear here to constitute one vein, and to occupy almost the entire upper half of the wing. The externomedian and internomedian veins fill the lower half between them with parallel veins, which at their origin curve at once strongly downward, and then run longitudinally to the apical margin, leaving only the meagrest possible space to the anal area, which is indeed broken off from the two specimens I have seen, and does not appear in the figures published by Brodie. In addition, in both the species, there is an abundant, but imperfect, cross-venation at the base of the externomedian and internomedian areas, and on the latter a large discolored spot, which may of course be confined to these two species only.

RITHMA

contains more incongruous material. I have myself recognized in the English species I have examined autoptically only one of the species referred to it, named *R. Murchisoni* by Giebel, and this is certainly to be referred to *Mesoblattina* Geinitz. *R. ramificata* is quite too imperfect to be considered until better specimens occur. It is probable that *R. antiqua* should be separated from the others, and the same may be true of *R. Westwoodi*. This leaves two species, *R. purbeccensis* and *R. Morrisi*, which agree well together, and represent a group which seems to have flourished in mesozoic times, as I have seen a number of species from the English Lias belonging with them, and *Blattina formosa* Heer from Schambelen, and *Blattina liasina* Gieb., figured by Brodie, also belong here. These wings are rounded wedge-shaped, with the amalgamated mediastinal and scapular area so large as to occupy about half of the wing, the vein running in a slightly sinuous course to, or even below, the tip. The anal area is generally pretty large, convex, and filled with parallel veins, which terminate on the margin. The space between is divided about equally between the externomedian and internomedian veins, which generally take a somewhat sinuous course, and fork with tolerable abundance, filling the space with graceful lines, spreading like (sinuous) rays of a fan. The genus is closely related to *Neorthroblattina* of the American Trias, but differs from it in the much greater area covered by the amalgamated mediastinal and scapular veins.

The following described species may be referred to it:—

Rithma purbeccensis Gieb., Faun. d. Vorw., iii, 319. Figured by Westw., Quart. Journ. Geol. Soc. Lond., x, Pl. 18. fig. 32. Lower Purbecks, Durdlestone Bay, England.

Rithma Morrisi Gieb., Faun. d. Vorw., iii, 319. Figured by Westw., Quart. Journ. Geol. Soc. Lond., x, Pl. 18, fig. 34. Lower Purbecks, Durdlestone Bay, England.

Rithma formosa.

Blattina formosa Heer, Lias Ins. Aarg., 15, Pl. II, figs. 41, 42; Heer, Urw. Schweiz, Pl. 7. figs. 1, 1 *b*,: Lias, Schambelen, Switzerland.

Rithma liasina.

Blattina liasina Gieb., Faun. d. Vorw., iii, 317. Figured by Brodie, Foss. Ins. Engl., Pl. 8, fig. 12; Lower Lias of Wainlode, Strensham, England.

MESOBLATTINA,

proposed by E. Geinitz, as stated, for two Liassic species of continental Europe, is a most prolific type, a considerable number of English mesozoic forms falling here, and among others, as remarked above, those figured by Westwood and described by Giebel under the names of *Rithma Murchisoni* and *R. antiqua*. The former of these, as well as a considerable number of new species have been sent to me by Mr. Brodie. In this genus the basal sweep of the externomedian and internomedian veins is very noticeable, following as they do the curve of the anal furrow before branching to fill the lower half of the wing. In this respect they remind one strongly of Elisama, but the wings are much slenderer than there, and what is of more importance the anal area is of the normal size, while next the humeral angle is seen a flat unveined field, so frequent in modern cockroaches. To this belong among others the following species:—

Mesoblattina protypa Gein., Zeitschr. Deutsch. Geol. Gesellsch., 1880, 519–20, Pl. 22, fig. 1. Lias of Dobbertin, Germany.

Mesoblattina angustata Gein., *ib.*, 519–20.

Blattina angustata Heer, Viert. naturf. Gesell. Zurich, ix, 288, 299–300, Pl. fig. 6. Lias of Schambelen, Switzerland.

Mesoblatina dobbertinensis Gein., Zeitschr. Deutsch. Geol. Gesellsch., 1884, 570, Pl. 13, fig. 1. Lias of Dobbertin, England.

Mesoblattina Murchisoni.

Rithma Murchisoni Gieb., Ins. d. Vorw., 319. Figured by Westw., Quart. Journ. Geol. Soc. Lond., x, Pl. 18, fig. 43. Lower Purbecks of Durdlestone Bay, England.

Mesoblattina antiqua.

Rithma antiqua Gieb., Ins. d. Vorw., 319. Figured by Westw., Quart. Journ. Geol. Soc. Lond., x, Pl. 17, fig. 10. Lower Purbecks of Durdlestone Bay, England.

Mesoblattina elongata.

Blatta elongata Gieb., Ins. d. Vorw., 322. Figured by Westw., Quart. Journ. Geol. Soc. Lond., x, Pl. 15, fig. 23. Middle Purbecks of Durdlestone Bay, England.

APRIL 21.

Mr. THOMAS MEEHAN, Vice-President, in the chair.

Twenty-seven persons present.

Persistence in Variations Suddenly Introduced.—Mr. THOMAS MEEHAN remarked that some public notice had been given to his observations on *Cypripedium insigne* (see page 30 of the Proceedings, 1885), and hence correspondents had written to him of similar behavior in this plant. A correspondent at Lee, Mass., had plants that had subspicate flowers last year; and one from Sharon, Western Pennsylvania, wrote that Mr. O'Brien of that place had a plant that produced such flowers four years ago, and the same plant had produced them annually ever since. There could be very little of what is understood by the term environment to so affect one plant that it should change in this manner any more than other plants growing under the same conditions of environment; and when we found the same species producing identical variations in localities two or three hundred miles apart, the application of the term environment had absolutely no meaning at all. We must still continue to search for some power that gave law to the production of variation—in other words, we had yet no comprehensible theory of the origin of species. That new species owed allegiance to the power of variation must be admitted, for these variations were species. The subspicate inflorescence and accompanying changes in the forms of the flower, were specific characters. We had no right to undervalue the characters because we happened to know the parentage. The form once produced had the hereditary character of a species. It had endured for four years. By analogy with similar changes in other plants, we were justified in assuming that it would reproduce itself indefinitely from seeds, as it had done by offsets; and again we had the recognized character of a species.

The most interesting deduction, however, from the facts now presented, was that it is not necessary to assume that every species sprang from one parent form, and from this one centre of origin spread by long lapses of time over a wide extent of country. We see that identical forms may appear simultaneously in localities widely separated; and, the circles meeting, cover a district in a comparatively short time. There would, of course, still have to be explained how the original forms from which these modern variations sprung, first had such a wide distribution, but that was a question which must wait for its own facts to properly solve. This difficulty could not invalidate what we saw must be a truth, that in these modern times new and identical forms do appear simultaneously in widely separated localities.

Influence of Temperature on the Separate Sexes of Flowers.—Mr. **Meehan** referred to his former observation, recorded in the Proceedings, that the male flowers in *Amentaceæ*, and other diœcious plants would grow, become perfectly developed, and mature the pollen under a temperature wholly insufficient to excite the growth of the female flower, which would remain undeveloped until a warmer temperature ensued. He had shown that the infertility of hickories, oaks, walnuts, hazelnuts, and other plants, a complaint common among orchardists in our country, arose from this fact, there being very little or often no pollen to fertilize the flowers in seasons when a few moderately warm days in winter would bring the aments to perfection a month or even months before the female flowers grew. This season we had no warm winter days, and at this time, middle of April, the aments in the hazelnuts and the female flowers were maturing together.

Mr. Meehan added that when he first reported these observations to the Academy he believed them wholly original, but he had since noted that similar observations had been communicated to the Horticultural Society of London, on the 18th of February, 1823, by Rev. George Swayne. "I entertain," says he, "a strong suspicion that the very frequent failures of the filbert crop (Mr. Williamson tells us that they totally fail three years out of five) are in great measure occasioned by a deficiency either in number or in power of the male blossom." He remedied this by experiment, by getting aments from other trees and hanging them in the trees that had lost them. This gentleman, however, did not apparently perceive the underlying principle that it took less heat to perfect the male flowers than the female flowers of the same species. It was quite possible this generalization might be carried out of the region of amentaceous or allied plants, and carried to a wide range of vegetable species, or even into zoology.

April 28.

Mr. Edw. Potts in the chair.

Fourteen persons present.

A paper entitled "On the genus Aphredoderus," by Willis S. Blatchley, was presented for publication.

Mr. Philip Laurent and the Rev. J. R. Danforth, D. D., were elected members.

Elasticity in the Fruit of Cactaceæ.—At the last meeting of the Botanical Section, Mr. **Thomas Meehan** exhibited fruit of *Mamillaria Heyderi*, and remarked on the elastic characters of this and other species. This *Mamillaria*, under culture, flowers in April or May, and, after flowering there is no sign of any development in the fruit. The ovarium is, indeed, buried between the closely appressed walls of the bases of the mammæ. Here they remain, undiscernible, till just before the next flowering season, when they suddenly emerge, and in a single night apparently stretch out to their full length. All attempts, however, to get at the exact time of development had failed, for the fruit was always of full length when first observed. In this species, the fruit is about two inches in length, clavate and incurved, and, as they are bright red, and more than double the length of the mammæ, and produced in considerable numbers, the effect on a plant where they were wholly absent a few days before, is very striking. This same sudden appearance of the fruit a year after the ovaria had been fertilized, has been noticed in *Mamillaria Nuttalliana*, and some Mexican allied species. That the sudden development is the result of an elastic projection, and not of a proper growth, is manifest from the fact that the fruit is mature from its first appearance, has its dark red color, and succulence, and the seeds are perfect in color and size. Growth has to finish, in all fruits, before maturity is reached. A related form of elasticity has already been recorded by him in the *Botanical Gazette*. He has noted that after the maturity of the fruit of *Opuntia Bigelovii* the seeds are projected from the apex, and run down the sides of the fruit like lava from a burning mountain. In a letter to the speaker, Dr. Engelmann a short time before his death, referred to this observation as a matter of great importance as explaining a fact for which he had never been able to account, that fruit evidently seed-bearing, had generally been found by him to have no seed when cut open.

Mr. Meehan remarked that cases where ovaria, though fertilized, would remain a year without signs of growth, were not unknown. Indeed, large numbers of Coniferæ, and species of *Quercus* or oak had especially this peculiarity. There was often little or no growth in the fertilized fruit till the second year.

He knew of no author who had made any mention of this sudden and elastic development in the fruit of the Cacti, though the fact must surely have come within the view of some observers. Pfeiffer, Decandolle, Zuccarini, and other leading writers on Cactaceæ, seldom make any reference at all to the fruit, while Dr. Engelmann, who, of all others, has given us the most of what we do know in reference to this interesting part of the history of this plant, simply says in a few instances that the "fruit matures about the same time with the opening of the flowers." He had however, nearly perceived the fact in one instance. He notices in *Planta Lindheimeriana* that in this very species (he then regarded it as *M. applanata*) "the scarlet fruit is still persistent, and forms an outer circle," while the new flowers are opening; and in the Botany of the Mexican Boundary, p. 9, referring to a closely allied species, *M. micrantha*, he says: "Fruit ripening the second spring and summer, till then hidden between the bases of the surrounding tubercles, and for the greater part buried in the tissues of the plant; in spring the young fruit suddenly (in one or two weeks) grows to its full size, 9–12 or even 15 lines long, protruding far above the tubercles, and forming an interior (exterior?) scarlet circle, around the inner circle of rose-colored flowers." He did not perceive that the development of the fruit was not a growth, but the emergence and stretching out of structure the actual growth of which had already been matured; that it was an elastic and not a growing fruit.

MAY 5.

Mr. JOHN H. REDFIELD in the chair.

Twenty-one persons present.

The following papers were presented for publication:—

"On the Air-bladder of Fishes," by Charles Morris.

"A Review of the Genus Phrynosoma," by Alan F. Gentry.

Spawning of Fulgur perversus.—Mr. JOS. WILLCOX remarked that during the month of March, 1884, and recently, during the past March, in Clearwater Harbor and Sarasota Bay, in Florida, he observed many egg-cases (more than a hundred) of *Fulgur perversus*, both recently completed and during the process of their formation.

When completed, one end of the string of egg-cases floats freely in the water, while the small end is fastened to a shell under the sand. Being thus anchored it is not liable to be removed from its original position by the force of the tide. Whenever both ends of the egg-case are found to be under the sand, the middle portion being above the surface in the form of a loop, the parent conch will always be attached to one of the ends, but invisible to the beholder. All the processes connected with the subject of the reproduction of this species are performed under the sand, until the egg-cases are completed. When about to spawn, a place is selected where the sand is not packed hard. At that time a disposition is manifested to assemble in communities, usually upon a sand-flat where the water is never deep, and where the receding tide leaves the egg-cases dry and exposed to the warm rays of the sun during a portion of each day. Many egg cases, however, are to be seen, which are always submerged. In such instances the eggs may require a longer time for their development. Although, during the early part of April, many egg-cases were observed that were completed, in no instance were the young shells found to be developed in them.

When the mollusk is about to spawn, it first descends into the sand deeply, and attaches the egg-case to a bivalve shell. As the process of extrusion permits, it ascends until the small end of its shell or siphon reaches the surface of the sand, so that it may respire the water freely. In this position it remains until the spawning is completed, during which process the body is protruded from its shell to a great extent. Only four or five of the cells or capsules were observed to exist in the body of the female at one time, which were closely compacted there, occupying little space; but, after extrusion, each cell becomes enlarged in thickness, being swollen by the introduction of water. During the process of formation, the egg-case is forced upward, appearing in the form of a loop above the sand, though no portion of the parent is then visible.

This species commences to spawn early in life. One egg-case was observed, the cells of which were about a half inch in diameter, the shell of the parent being only three and a half inches long. If handled gently, when dug from the sand, the conch does not withdraw its body into its shell; but, if it is injured, it will quickly eject all the egg-cells from its body, and close its operculum. As only four or five of the egg-cells are found in the body at one time, in the process of formation, it is presumed that the whole series of cases require a long time in their development.

May 12.

Mr. Thomas Meehan, Vice-President, in the chair.

Twenty-four persons present.

The manuscript diary of Wm. Bartram was presented to the library by Mr. Meehan. It covers the period from 1802 to 1822, and contains notes on meteorology and natural history, especially ornithology.

A paper entitled "A Review of the American Genera and Species of Mullidæ," by Edw. A. Hall and J. Z. McCaughan, was presented for publication.

May 19.

Mr. Edw. Potts in the chair.

Fifteen persons present.

Erythrite, Genthite and Cuprite from near Philadelphia.—Prof. H. Carvill Lewis stated that during the Saturday excursions of his class in mineralogy, a number of new mineral localities had been discovered, three of which were of sufficient interest to be recorded.

Erythrite.—Erythrite, the beautiful and rare arsenate of cobalt, not heretofore recorded as occurring in North America, was found at the Wheatley lead mines, south of Phœnixville. It occurs here in veins and incrustations of a beautiful rose-pink color. Under the microscope these incrustations are shown to be for the most part composed of minute globular rosettes of crystals, while earthy and fibrous masses also occur. The mineral was found to fuse easily in the flame of a Bunsen burner, coloring the flame pale grayish blue, the color of burning arsenic. A borax bead was colored deep blue, proving the presence of cobalt. The erythrite was associated with fluorite and blende. The specimens were collected by Mr. L. Woolman.

GENTHITE.—Genthite, a hydrous silicate of nickel and magnesia, was discovered in emerald-green coatings on the Schuylkill Valley Railroad, about a hundred feet north of the steatite quarry at Lafayette, just outside the city limits. It occurs on an actinolite rock in thin coatings, which, under the microscope, show the mammillary and stalactitic structure characteristic of genthite. Fused with borax, it gives a bead which is violet-brown in the oxidizing flame, and in the reducing flame is reduced to gray metallic particles, these reactions being characteristic of nickel. The genthite is associated with the numerous magnesian minerals which have made the steatite quarry so well known. Efflorescences of epsomite and veins of asbestos were found within a few feet of the genthite.

The discovery of genthite has a geological interest in demonstrating the presence of nickel in the serpentine belt which here crosses the Schuylkill. Some years ago Mr. T. D. Rand[1] had found a single specimen of millerite, another nickel mineral, in capillary crystals in the dolomite at the same locality. With this exception, nickel had not been known in this serpentine belt. Chromic iron and other chromium minerals are, however known to occur in several localities in the same zone of serpentine, and the association of chromium and nickel is well known. The serpentines of Cornwall, the Alps, the Vosges, and of hundreds of other localities, contain both chromium and nickel. Dr. T. Sterry Hunt states[2] that the serpentines of his third (Green Mountain) series, which he refers to the lower Silurian age, are "marked by the almost constant presence of small portions of the oxides of chrome and nickel," a character which distinguishes them from the serpentines of the Laurentian series, which are usually free from these metals. Dr. Hunt, however, fails to identify the serpentine and steatite of Lafayette with his Green Mountain series, but supposes it to belong to another horizon,[3] refusing to believe that it was derived from an eruptive rock.

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[1] Proc. Min. and Geol. Sec. Acad. Nat. Sci. Phila., 1877.

[2] Chemical and Geological Essays, 1875, p. 32.

[3] The Geological History of Serpentines. Trans. Roy. Soc. Canada, 1883, i, p. 171.

Yet the presence of chromium and nickel in serpentine are facts in favor of its eruptive origin. For very many serpentines are derived from peridotite, as has been clearly shown by recent work in microscopic lithology. Most peridotites, whether meteoric or terrestrial, as the numerous analyses collected by Dr. M. E. Wadsworth[1] demonstrate, contain chromium and nickel. Most stony meteorites contain these same elements, and even the iron meteorites, in which the presence of nickel is so characteristic, frequently contain chromium. The late Dr. Lawrence Smith has described[2] nodules of chromite in meteoric iron, and has described a new sulphide of chromium and iron, under the name of Daubréelite,[3] peculiar to meteorites, and, as he believes, almost constantly present.[4] Chromite is well known to occur in terrestrial eruptive rocks. The association of nickel and chrome has previously been noticed in Pennsylvania at Wood's Chrome Mine, Lancaster County, where genthite[5] (described as nickelgymnite) was originally found. Genthite is associated with chromite also at Webster, Jackson County, North Carolina, where it forms handsome apple-green specimens incrusting chromite, and it is said to have a similar association at Malaga, Spain. Zaratite, a carbonate of nickel, occurs with chromite in West Nottingham, Chester County. Genthite has also been found at two other chrome-ore mines in Lancaster County,[6] but until now not elsewhere in this State.

CUPRITE.—Bright vermilion-red earthy incrustations of cuprite, were noticed at Frankford, Philadelphia, in the quarries of hornblendic gneiss, so well known to mineralogists. This red oxide of copper here sometimes forms a coating on bornite, which latter is a beautiful, and somewhat abundant, mineral, at these quarries. The cuprite has in this association a peculiarly resinous lustre, and the specimens collected closely resemble red sealing-wax.

Bothriocephalus in a Trout.—Prof. LEIDY remarked that through Dr. B. H. Warren he had recently received from the Smithsonian Institution, several vials with tape-worms, obtained by Mr. L. M. Turner, from a trout, *Salvelinus* ——?, at Ft. Chimo, Ungava. One of the vials contained eight worms ranging from 3 to 8 inches long, together with fragments of others; and was labeled, "Passed from a Trout, caught in the river, August 14, 1882." The worms belong to a species of *Bothriocephalus* or *Dibothrium*, apparently different from either the *D. infundibuliforme* or *D. proboscideum*, found in *Salmo salvelinus*, *S. salar*,

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[1] Mem. Mus. Comp. Zool. Cambr., xi, 1. Lithological studies, tables.

[2] Amer. Jour. Science, xxi, 1881, p. 461.

[3] Amer. Jour. Science, xii, 1876, p. 107, and xvi, 1878, p. 270.

[4] Original Researches, 1884, p. 513.

[5] Keller-Tiedemann, Nordam. Monatsbericht, iii, 188.

[6] Report B. Second Geolog. Survey of Penna., p. 118.

S. trutta, and other fishes of the kind. The specimens are all mature; the segments from near the head throughout being distended with brownish eggs. The characters of the worm are as follow:—Body linear, band-like, widest just behind the head, and gradually narrowing to the posterior extremity, thickened along the middle and to a less degree along the lateral borders, which are narrowly obtuse at the free edge, apparently continuous but irregularly crenulate; the broad surfaces transversely wrinkled, with the lateral borders defined from the middle by longitudinal striæ; anterior extremity wider and transversely convex; posterior extremity obtusely rounded. Head small, oval, equitant across the anterior border of the body, with an oval bothria fore and aft, directed obliquely from the broad surfaces of the body. No distinct neck. Segments of the body commencing immediately after the head, wider than long, indistinctly defined at the lateral margins and most marked transversely along the middle of the body, becoming narrower and slightly longer at the posterior part of the latter, fertile throughout, and furnished on one side of the body, in the median line, with a prominent penal papilla and just behind with a genital pore. Animal whitish with a median chain of brownish spots due to the ova-distended uteri.

In a specimen of eight inches in length, the anterior extremity of the body is 3 mm. wide; at the middle 2 mm.; and at the posterior extremity 1·5 mm. The head measures 0·16 mm. transversely and 0·18 mm. deep or long on the broad aspect of the worm. The segments generally measure about 0·625 mm. long. The ova are brownish, oval, and 0·04 mm. long by 0·024 broad.

The second vial contains a single worm, and is labeled, "Taken from the intestine of a Trout, Aug. 29, 1882." This worm I suspect to represent an immature stage of the former. It is 30 mm. long, and in shape resembles a fluke-worm or a leech. It is elongated elliptical, flat, widest in front, with the lateral margins apparently entire, the broad surfaces transversely striated, and longitudinally divided in three bands, with the median band indistinctly divided into segments, on one surface in the median line provided each with a minute pore. Head oval, situated fore and aft across the anterior transversely convex border of the body; with a minute oval bothria fore and aft. Caudal extremity narrowest, transversely convex at the end, and emarginate or with a pore. Breadth at fore-part 3 mm.; at back part 2 mm. The species may be named *Bothriocephalus* (*Dibothrium*) *cestus*.

The following were ordered to be printed:—

ON THE AIR-BLADDER OF FISHES.

BY CHARLES MORRIS.

The generally accepted explanation of the use of this singular organ, that it serves to enable the fish to readily rise and sink in the water, while it is in all probability true in a measure, has undoubtedly been too greatly extended. It is usually offered as applying generally to fishes with an air-bladder, with little regard to the fact that in many cases the air-bladder is too small to serve any useful purpose as a gravity organ. This being the case, some further examination into its functions and organic relations seems not amiss.

Cuvier tells us that "the most obvious use of the swim-bladder is to keep the animal in equilibrium with the water, or to increase or reduce its relative weight, and thereby cause it to ascend or sink, in proportion as that organ is dilated or compressed. For this purpose, the fish contracts the ribs or allows them to expand." This is, however, not always the case, for in many cases the bladder is provided with compressing muscles, and, as Van Der Hoeven says: "In many fishes it is difficult to show how they are in a condition to expand the bladder and to rarefy the air." Cuvier says further: "With regard to the presumed assistance which the swim-bladder affords in respiration, it is a fact that, when a fish is deprived of that organ, the product of carbonic acid by the branchiæ is very trifling; but there is no sufficient foundation for assuming that it offers any analogy to the lungs." This is no doubt true as regards the usual condition of the organ. It may perform some function in facilitating the exchange of gases in the blood, but this is not a direct respiratory function. In some cases, however, its function is directly respiratory, and in a few instances it constitutes an actual lung, closely approaching the Batrachian lung in organization.

A similar view is offered by the latest writers. Günther, in his "Study of Fishes," remarks that "this organ serves to regulate the specific gravity of the fish, to aid it in maintaining a particular level in the water, in rising or sinking, in raising the front part of its body or depressing it as occasion may require." This theory is based on hypothesis, since it would be no easy matter to prove or disprove it by experiment. As above said, however, it is in consonance with physical laws in certain cases, and in such cases it very probably gives a correct view of the function of the organ. Yet there are many cases in which the small size of the organ must render it nearly or quite useless for any such purpose, while its entire absence in very many instances of active species of fish, shows that this function is of no special value to the fish tribe as at present constituted, and suggests that the original purpose of the air-bladder must have been very different from that here surmised. A general examination of the subject may aid us in gaining some definite conception of the character of this original function.

The air-bladder of fishes is an internal sac, occupying usually the dorsal aspect of the body, and in some cases connected with the intestinal canal by a pneumatic duct, though in the great majority of cases this duct is wanting, or its cavity is closed. Thus, most generally, the bladder is a closed sac, containing gas which could only have come from the blood-vessels, with which it is abundantly provided in the form of *retia mirabilia.* This gas, in fresh-water fishes, is nearly pure nitrogen. In ocean fishes, particularly the deeper swimmers, oxygen is in excess, and has been found in some instances to constitute as much as 87 per cent. of the contents. Some naturalists advance the singular theory that the absolute weight of the fish may be increased or diminished by compression or dilation of this gas, as if the same quantity of gas could change its weight by a variation in its density. But that the relative weight of the fish, or its displacement of water, might be changed by a variation of its body-volume, through a variation in the state of compression of the air-bladder, is unquestionable, though in those numerous cases where the bladder is very small its influence must be of very little aid in the movements of the fish.

In addition to its use in aiding the fish to ascend or descend in the water, its dorsal position must also act to keep the back of the fish uppermost. In certain cases it also doubtless subserves another gravitative purpose—that of elevating or depressing the anterior region of the body, at the will of the fish. This is possible in those cases in which the bladder has a considerable longitudinal extension. In some cases, it is prolonged into the tail of the fish. In others, it sends processes into the head. And in certain instances, the ductless bladder is divided by constrictions into two or three compartments, in the longitudinal direction. In these cases, the fish may have the power to shift the gaseous contents of the bladder forward or backward at will, and thus, by a variation in the weight of the different regions of the body, to change its line of motion from a horizontal to a more or less inclined direction. Yet such a function cannot be of any absolute importance to the fish, or preparation for it would be far more general than we find it.

If we consider the conditions under which the air-bladder exists in fishes, it becomes exceedingly doubtful that it was originally evolved as a gravity-organ. In one important order of fishes, the Elasmobranchs, it does not exist. No shark or ray possesses this organ. In the main body of the fish tribe, the Teleostean, its occurrence and character are very irregular. In those which possess it, it exhibits an extraordinary variation in shape, size and relations to the body, and this sometimes between closely related genera and species. With some Teleosteans the air-bladder has an open pneumatic duct, connecting with the œsophagus, or in a few cases with the stomach. With others this duct exists, but its cavity is closed. In some cases it is reduced to a fine ligament. In many others no trace of it exists. The air-bladder itself is a hollow sac, composed usually of two tunics, and compressible, in whole or in part, by the aid of muscles on its external surface, or by other means. It is situated in the abdominal cavity, above the intestinal canal, and outside the peritoneal sac, its ventral surface being invested by a fold of the peritoneum. In some fishes it is almost loose in the abdominal cavity. In others it is intimately adherent to the vertebral column and the abdominal tissues. In many cases it is enclosed in osseous capsules formed by the vertebræ, which seem capable of exerting a pressure upon it. In addition to the cases of its longitudinal division into chambers, it is sometimes composed of two lateral divisions, and in some families there is an extraordinary development of lateral appendages.

Its occurrence is as irregular as its shape and relation to the body. In this respect, it varies remarkably in species of the same genus. Thus the mackerel has no air-bladder; yet one exists in *Scomber pneumatophorus*, a species which in every other respect very closely resembles the mackerel. So *Polynemus* *paradiseus* is without an air-bladder, while all other species of the genus have one. The same condition occurs in related genera. Thus in the species of *Sebastes* the air-bladder is very large, while in the next genus of the family it is scarcely the size of a pea.

These examples will serve to show the great diversity in the shape, size and condition of this organ. And it may be said here that these variations have no appreciable effect upon the velocity and activity of the fish. Those that have no air-bladder seem in no respect at a disadvantage, as compared with those that have one. Again, it may be said that no animal organ whose function is of known importance presents such extraordinary modifications. In the heart, lungs, brain, etc., there is one shape, position and condition of greatest efficiency, and throughout the lower forms we find a steady and undeviating advance towards this condition. There is in all these organs a persistent movement towards homogeneity; not towards heterogeneity, such as we find in the air-bladder. The natural conclusion from this would be that the air-bladder is not an organ of functional importance, while its absence from many fish, and great diversity in others, indicates that it is of minor value to the fish tribe. If it is of absolute necessity to any fish as a gravitating organ, why is it not necessary to all, and why has it not developed into some shape and condition of greatest efficiency? The existence of the air-bladder is proof that it has had, at some time, a function of considerable importance; but its many variations go to prove that it has ceased to perform any essential function, and is on the road towards extinction. On no other theory can we explain its great diversity in nearly related species.

That the air-bladder is degenerating we have evidence in cases like that above mentioned, where it is no larger than a pea. It is difficult to imagine that this minute organ is of any use to the animal. But no process of evolution can take place, except the organ is of use at every stage of its development. The natural conclusion is that the air-bladder evolved long ago, under some influence not now active, and is now on the road towards extinction, being retained only in those forms where it serves some minor purpose, but being nearly or quite obliterated in forms in which it is put to no practical use. This secondary use of degenerating organs is not uncommon. We have one instance in point in the adaptation of the embryonal gill-arches of mammals to other uses. Of these secondary employments of the air-bladder one seems to have some connection with the organ of hearing. Another seems to be to change the direction of the fish-body from the horizontal towards the vertical line. As a general rule, when present, it may fix the special buoyancy of the fish-body, and, by its situation near the back of the fish, may aid to keep the dorsal surface upward in the water. This may be the purpose of its lateral appendages, as the former is of its longitudinal extension. Yet the fishes which have no air-bladder seem none the worse off in any of these particulars. It is impossible that such an organ could have developed to perform functions which were satisfactorily performed without it, and it seems more probable that it is an organ arrested at various points in its process of degeneration, as it proved serviceable in some minor function.

If, then, we may look upon the air-bladder as an organ which has partly or wholly lost its original function, the question follows, what was that function? There are certain good reasons for believing that the breathing of air was the original purpose of this organ. In mature Teleosteans this is occasionally indicated by the existence of a pneumatic duct connecting with the œsophagus. It is true that this duct is usually of no functional use, and varies from partial to complete disappearance. But the fact is, that all fishes with an air-bladder possess a duct in the early stage of embryological development. In the mature stage it is lost by all Teleosteans except the Physostomes.

Thus embryological evidence indicates that one original function of the air-bladder was the introduction of external air into the body, a function which has now lost its importance. And the apparatus for compressing and dilating the bladder may have been originally developed as an aid in this function. Also the extraordinary development of *retia mirabilia*, in the inner tunic of many air-bladders, now used only to secrete gas into the interior, may be a survival of ancient pulmonary capillaries, which have changed their character with their function.

There are other reasons beyond those here given that the air-bladder was originally an air-breathing organ. Embryology points back to the condition of the primal fishes. But of these antique vertebrates we have existing representatives in the Ganoids and the Elasmobranchs, and it is of interest to find that in these modern survivals of the ancient fish life, the Elasmobranchs are entirely destitute of air-bladders, both in the mature and the larval stage, while all Ganoids possess an air-bladder, which retains a fully developed pneumatic duct in the mature stage. And in the suborder of Dipnoi, the air-bladder is functionally active as a lung. It is well-known that counterparts of the modern Dipnoi existed in the Devonian age, and it is highly probable that they breathed air then as they do now. In fact, we have some warrant for the belief that the antique fishes were divided into two orders, as clearly by their breathing habits as by other characteristics, the Elasmobranchs breathing by gills only, while the Ganoids had developed a supplementary organ for an occasional breathing of the air.

If we compare the air-bladder with the lungs of the higher vertebrates, we find that its general condition in the Ganoids is that of a single cavity, with an effective duct opening into the dorsal side of the œsophagus. But there is an exception to this in the Dipnoi, and in *Polypterus*. In these, the duct connects with the ventral side of the œsophagus, as in the lungs of higher animals. Wilder shows that there is a series of forms, mostly Ganoids, leading from *Amia* and *Lepidosteus*, with the pneumatic duct entering the throat on the dorsal side, to *Lepidosiren*, in which it enters on the ventral side, as in lung-breathing animals.

In all the fishes just named the air-bladder functions as a lung. In *Polyterus* it has lateral divisions, and is probably used in air breathing, while in the Dipnoi it becomes a functional lung. In *Lepidosteus*, the American Gar-Pike, the air-bladder becomes cellular and lung-like. This fish keeps near the surface, and may be seen to emit air-bubbles. It apparently takes in a fresh supply. The American Bow Fin or mud-fish (*Amia*) has a bladder of the same lung-like character, and it has been seen by Wilder to come to the surface, open its jaws widely, and apparently swallow a large quantity of air. Wilder remarks that "so far as the experiments go it seems probable that, with both *Amia* and *Lepidosteus*, there occurs an inhalation as well as exhalation of air at pretty regular intervals, the whole process resembling that of the *Menobranchus* and other salamanders, and the tadpoles, which, as the gills shrink and the lungs increase, come more frequently to the surface for air."[1]

The Dipnoi have the air-bladder developed into a true lung. Of these the Australian lung fish (*Ceratodus*), has but a single air-bladder, but this is provided with breathing pouches that possess a symmetrical lateral arrangement. It has no pulmonary artery, but receives branches from the *Arteria cœliaca.* It is supposed that this fish ordinarily breathes with the gills, but uses its lungs when the water has become thick and muddy, or is charged with gases from decomposing organic matter. Finally *Lepidosiren* and *Protopterus* have completely formed lungs, divided into two lateral chambers, and provided with a pulmonary artery. Their cellular structure nearly approaches that of the batrachian lung.

The facts here cited certainly seem to lead to the conclusion that the air-bladder was originally developed as an air-breathing organ, and only became adapted to other purposes when it had become no longer of value in this direction. We may find evidence in favor of this conclusion in the condition of the fishes which still use it as a breathing organ. With them the gill is the ordinary breathing apparatus. The lung is not called into use except when the water becomes foul or unaerated. It is a supplementary organ, which could be easily dispensed with if the fish should gain the habit of swimming in search of better aerated water. It is impossible to imagine that the air-bladder developed into a lung under the force of such a minor necessity as this. It is very much more probable that it was once an important breathing organ with these fishes, and has retained its functional value from its occasional use, but has become of minor importance, and has been largely superseded by the gill.

If now we ask, what were the conditions of life under which this organ was developed, and what were the later conditions which rendered it in great measure or entirely useless, some definite answer may be given. The question takes us back to the Devonian and Silurian geological periods, during which it is probable that its original development took place. In this era the seas were thronged with fishes of two distinct orders, the Elasmobranchs and the Ganoids, the former without, the latter with,

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[1] For other instances of the same character, see Semper's "Animal Life," Note 75.

an air-bladder. This difference in organization was probably the result of some marked difference in their life habits. The Ganoids may, in their original state, have inhabited poorly aerated waters or waters otherwise ill-adapted to breathing, while the Elasmobranchs may have had their primordial habitat in clearer and purer waters.

But there were other conditions which may have been the main influencing causes in the development of an organ for air-breathing. We know that the land was habitable during long ages ere it gained any vertebrate inhabitants. The presence of insects in Devonian and Silurian strata proves this. It must have possessed much food material, both vegetable and animal, and it is hardly probable that the active fish forms of the early seas made no effort to obtain a share of this food. Long ages passed during which we have no evidence of land animals higher than insects or snails. It is highly probable that many fishes gained the habit of leaving the water temporarily for the land in search of food during this period. We know that many fishes do so now, and that some even climb trees, in spite of the many dangerous foes that now exist on land. In the era referred to there were no such dangerous foes. Such fishes as left the sea for the land would find only food to repay their enterprise. Thus there must have been a powerful inducement for fishes to assume this habit.

The indications, however, do not lead to the idea that the original development of an air-breathing organ was due to occasional visits from sea to shore. Such an organ must have slowly developed under the pressure of less extreme changes of conditions. It probably arose through the effect of such influences as still act upon fish, and force them to occasionally breathe air; such as foul or muddy water, or a lack of proper aeration arising from any cause. Another important influence is the drying-out of pools, by which fish are left in the moist mud until the recurrence of rains, or are even buried in the dried mud for the six months of the dry season. Such is the case with *Lepidosiren*, which uses its lungs during this period. In certain other fresh-water fishes, of the family Ophiocephalidæ, air is breathed while the mud continues soft enough for the fish to come to the surface, but during the remainder of the dry period it remains in a torpid state. In these fishes the air is breathed into a simple cavity in the pharynx, whose opening is partly closed by a fold of the mucous membrane. In the family Labyrinthici the accessory breathing cavity becomes an organ, with thin laminæ or plates, which undoubtedly perform an oxygenating function. This organ is greatly developed in *Anabas scandens*, the Climbing Perch. In addition to these there are cases in which fish leave drying pools, and migrate for a considerable distance overland in search of water, with no breathing organ but the gills.

If even now, when the land is everywhere occupied with active and dangerous foes, so many fish find occasion to venture on shore, it is quite probable that in the early period, when it could be visited without danger, very many fishes may have paid temporary visits to the land. And if now, under this influence, and that of drying pools and stagnant water, many fish have acquired a partial air-breathing habit, this was far more likely to take place under the more favorable conditions of ancient times. It seems quite possible that the development of the air-bladder was due to influences of this character. The occasional habit of breathing air is quite common with fish, especially of fresh-water species. Cuvier remarks that air is perhaps necessary to every kind of fish; and that, particularly when the atmosphere is warm, most of our lacustrine species sport on the surface for no other purpose.

It may be even possible to draw a hypothetical scheme of the original process of development of the air-bladder as a breathing organ. Embryology indicates that its existence began in an eversion of the intestinal canal, in its œsophageal portion, and that this gradually became an air-bladder with its pneumatic duct. It may have had its primal form in a simple pharyngeal cavity, like that of the Ophiocephalidæ, partly closed off from the food-passage by a fold of the mucous membrane. A step further would reduce this membraneous fold to a narrow opening, leading to an inner pouch. From such a condition the development of the Ganoid air-bladder, with its pneumatic duct of greater or less length, is a probable and natural one, and is sustained by embryological evidence. Though we do not possess the intermediate steps, and the breathing organ of the Labyrinthici is a specialized apparatus aside from this line of progress, yet the breathing pouch of the Ophiocephalidæ is in the direct line of development of the Ganoid air-bladder. We can scarcely look upon it as in any sense a survival of the archaic air-breathing organ. It is more probably a modern reproduction from the action of similar causes, of the first existing stage of an air-breathing apparatus. And though it is hardly probable that the reproduction is an exact one, yet it may not be very divergent from the original organ. Thus from a simple pouch in the wall of the œsophagus may have arisen, by successive steps, the air-bladder, with its pneumatic duct, its compressing muscle and its plexus of blood capillaries. And this may have unfolded, through further successive steps, several of which yet exist, into a lung like that of *Lepidosiren*. Thus we seem to possess existing representatives of every important phase in lung development, from that in which the simple wall of the intestine performed an air-breathing function, to the lung of the batrachian.

In this view of the case, the original lung was a simple, smooth-walled bladder, provided with abundant vessels to subserve blood-aeration, with muscles to aid in inhalation and exhalation, and with an air-duct opening into the œsophagus on its dorsal aspect. This dorsal connection may have arisen from the upward pressure of the air in the swimming fish, which would tend to give this position to the original intestinal pouch. But when any fish came to frequently visit the shore two new influences necessarily came into play. The effect of gravity on the growing organ would tend to drag it and its duct from the dorsal to the ventral position. And the increased use of the bladder in breathing must have required a more extended surface. It first grew cellular, then the cells became laterally-arranged pouches. Finally a constriction of the wall separated these lateral pouches, and two chambers were produced. Of every stage of this process instances still exist, and there is much reason to believe that the development of the lung followed the path here pointed out.

At the opening of the Carboniferous era there may have been many lung- and gill-breathing Dipnoi, finned Batrachians as we may call them, who spent much of their life on shore. And their habit of land-life would naturally be attended by a gradual change of the fins into better walking organs, from which by a long continued process of evolution, may have arisen the leg and foot of the primordial batrachian. For this purpose to become fully achieved, however, the development of an internal bony skeleton was necessary, and with the completion of this step of evolution the lung-breathing fish probably directly unfolded into the batrachian. But from that time forward the dominion of the fish on the land must have steadily decreased. The fin could not compete with the leg and foot as an organ of land motion, and the Dipnoid fishes were probably driven back to the water. As a result of this change of condition a retrogressive evolution took place in the air-breathing organ. Some fishes continued to use it occasionally as a lung, of which we have instances in the modern Dipnoi. Yet with the Ganoids, as a rule, it probably never attained a lung-like development, and was used only for temporary breathing purposes. This is its condition in most of the few existing Ganoids. But with their successors, the Teleosteans, it has lost all air-breathing capabilities, and has passed through every stage of degeneration, from a condition closely resembling that of the Ganoids to complete extinction. And in this process of degeneration it has been, in certain cases, adapted to minor uses, some of the most probable of which have been above enumerated, while there may be others as yet unknown to us.

A consideration of the gaseous contents of the air-bladder may lead to a conception of one such possible use. It is somewhat remarkable that it contains nearly pure nitrogen in fresh-water forms, while in the deep-swimming sea fish oxygen forms its main contents, often to a very large percentage. There must be some sufficient cause of this difference of contents. It is not due to any difference in the gases contained in water at various depths, for the percentage of nitrogen is closely the same at all depths, while oxygen diminishes in quantity from the surface downward. Thus, if its contents depended on the relative quantity of gases present, nitrogen should predominate below as well as above. It is probable, however, that the presence of oxygen in the bladder of deep-sea fishes is really due to the smaller quantity of oxygen there present in the water. The bladder may serve as a complementary aerating apparatus, as suggested by Semper, a reservoir of oxygen for the use of the fish during sleep, or when, from any cause, not actively breathing, or in poorly aerated water. Such a function would be of little or no importance to surface fish, which can readily obtain water rich in oxygen. And these fish, for this reason, may secrete only the useless nitrogen into the air-bladder. But for deep-water fishes this function may be highly necessary. When actively breathing they probably obtain little more oxygen than is required for immediate use. And the small excess gained may be secreted into the air-bladder as a reservoir, to be taken up again by the blood during inactivity of the breathing function. This seems probable from what Cuvier tells us, that when a fish is deprived of the swim-bladder, the product of carbonic acid by the branchiæ is very trifling. We cannot imagine such a result unless the bladder in some way supplies oxygen to the blood. If this be the case, the air-bladder still performs, in an indirect manner, its probable original function of a breathing organ.

If the hypothesis here offered be a well-founded one, an interesting conclusion as to the process of organic evolution involved may be taken. For we would have the air-breathing function at first performed by the unchanged walls of the œsophagus. Then this became pouched. Then the pouch became constricted off, with a duct of connection. Then the duct disappeared, as the original function vanished, and what was originally a portion of the wall of the intestinal canal, became a separate internal sac. Then this sac decreased in size, until in some instances it became a closed internal bladder, of the size of a pea, far removed from and utterly disconnected with its place of origin. Finally it completely vanished. This process, if correctly drawn, certainly forms a very remarkable organic cycle of development and degeneration, which probably has no counterpart of a similarly striking character in the whole circle of organic life.

ON THE GENUS APHREDODERUS.

BY WILLIS S. BLATCHLEY.

With a view to ascertaining whether more than one species of Pirate Perch (*Aphredoderus* Le Sueur) exists in our waters, I have compared numerous specimens from various localities of the United States, in the Museum of the Indiana University.

I find individual variations, but no constant differences distinguishing Eastern, Western or Southern forms of this species from one another.

Since the variation in the position of the vent, upon which the nominal genus *Sternotremia* Nelson was based, has been shown by Profs. Forbes and Jordan to depend upon the age of the fish, there is, in my estimation, but one species, *Aphredoderus sayanus*, belonging to the genus.

The following is the synonymy of the genus and species:—

Aphredoderus (Le Sueur) Cuv. & Val., Hist. Nat. des Poiss., ix, 1833, 145 (*gibbosus*).

Aphredodirus Cope, Proc. Amer. Phil. Soc., 1870, 455 (emended orthography).

Sternotremia Nelson, Bull. Ill. Lab. Nat. Hist., i, 1876, 39 (*isolepis*).

Aphododerus Jordan, Annals N. Y. Acad. Sci., i, 1877, No. 4, 101 (emended orthography).

Asternotremia (Nelson), Jordan, Bull U. S. Nat. Mus., x, 1877, 51 (*isolepis*: emended meaning).

Aphrodedirus Jordan, Proc. Acad. Nat. Sci. Phil., 1877, 60 (emended orthography).

Aphredoderus sayanus.

Scolopsis sayanus Gilliams, Jour. Acad. Nat. Sci. Phila., iv, 1824, 81 (Harrowgate, Pa.).

Aphredoderus sayanus De Kay, N. Y. Fauna, Fishes, 1842, 35; Baird, Ninth Smithson. Rept., 1855, 326 (Cedar Swamp Cr., Cape May Co., N. J.): Günther, Cat. Fish. Brit. Mus., i, 1859, 271; Abbott, Proc. Acad. Nat. Sci. Phila., 1861, 95 (Camden, N. J., Habits of *A. sayanus*); Cope, Proc. Acad. Nat. Sci. Phila., 1865, 274 (Streams of Lowlands of N. J. and Del.): Putnam, Amer. Nat., Jan., 1872, 35; Jordan & Copeland, Check List, 1876, 139; Hay, Proc. U. S. Nat. Mus., iii, 1880, 501, 515 (Noxubee R.): Jordan, Geol. Rept. Ohio, iv, 1882, 920; Hay, Bull. U. S. Fish. Com., ii, 1882, 64, 74 (R. at Vicksburg and Memphis, Big Black R., Pearl R., Tombigbee R., Chickasawha R.): Jordan & Gilbert, Synopsis Fish. N. A., 1882, 160; Bean, Cat. Fish. International Fish Exhibition, London, 1883, 82 (Vaughan's, Miss.); Forbes, Studies of Food of Fishes, Ill. Lab. Nat. Hist., 1883, 66

(Anatomy and food of *A. sayanus*); Gilbert, Proc. U. S. Nat. Mus., 1884, 204 (Salt Creek, Brown Co., Ind.).

Aphredodirus sayanus Cope, Proc. Amer. Phil. Soc., 1870, 455 (Tributaries Neuse R., Wake Co. N. C.).

Aphododerus sayanus Jordan, Annals N. Y. Acad. Sci., i, 1877, No. 4, 101 (Delaware R., Neuse R., Miss. R. in Louisiana, Flint R.); Jordan, Annals N. Y. Lyc. Nat. Hist., xi, 1877, 368 (Coosa R.): Jordan, Amer. Nat., Oct., 1877, 613: Jordan, Man. Vert., 2d ed., 1878, 249; 3d ed., 1880, 249; Jordan & Brayton, Bull. U. S. Nat. Mus., xii, 1878, 41, 47, 89 (Neuse R., Chattahoochee R., Alabama R.): Jordan, Bull. Hayden's Geol. Surv., iv, 1878, 434.

Aphredoderus gibbosus (Le Sueur), Cuv. & Val., Hist. Nat. des Poiss., ix, 1833, 448 (Lake Pontchartrain).

Sternotremia isolepis Nelson, Bull. Ill. Lab. Nat. Hist., i, 1876, 39 (Calumet R., Ill.); Jordan & Copeland, Check List, 1876, 139; Jordan, Proc. Acad. Nat. Sci. Phila., 1877, 61.

Asternotremia isolepis (Nelson), Jordan, Bull. U. S. Nat. Mus., x, 1877, 51 (Tributaries Ohio R.).

Aphododerus isolepis Jordan, Annals N. Y. Acad. Sci., i, 1877, No. 4, 101 (Wabash R., Maumee R., Calumet R., Streams of S. Ill., Arkansas R.): Jordan, Bull. Ill. Lab. Nat. Hist., ii, 1878, 48 (Calumet R., Wabash R. at Mt. Carmel, Streams of S. Ill.; Variation in position of vent); Forbes, Bull. Ill. Lab. Nat. Hist., ii, 1878, 77, 84 (Food of *A. isolepis*, and account of change in position of vent); Jordan, Man. Vert., 2d ed, 1878, 249; Jordan, Bull. Hayden's Geol. Surv., iv, 1878, 434.

Aphrodedirus cookianus Jordan, Proc. Acad. Nat. Sci. Phila., 1877, 60 (Sawyer's Cr., Kendallville, Ind.).

Aphododerus cookianus Jordan, Bull. U. S. Nat. Mus., ix, 1877, 49 (Wabash R.); Jordan, Bull. U. S. Nat. Mus., x, 1877, 52.

Asternotremia mesotrema, Jordan, Bull. U. S. Nat. Mus., x, 1877, 52 (Little Red R., Arkansas).

A REVIEW OF THE GENUS PHRYNOSOMA.

BY ALAN F. GENTRY.

Phrynosoma Wiegmann, in Oken, Isis, xxi, 1828, p. 367: Wagler, Naturl. Syst. Amph., 1830, p. 145: Gray, Cat. Liz. Brit. Mus., 1845, p. 227: Dumeril & Bibron, Erpet. gener., iv, 1837, p. 311: Holbrook, N. A. Herp., ii, 1842, p. 85: Fitzinger, Syst. Rept., 1843, p. 78: A. Dumeril, Cat. Meth. Rept., i, 1851, p. 78: Girard, Stans. Expl. Vall. Gt. Salt Lake, 1852, p. 351: Girard, Herp. U. S. Expl. Exped., 1858, p. 388: Dumeril & Bocourt, Miss. Sci. au Mex. et Am. Cent., 1870, p. 217: Cope, Check List N. A. Batrach and Rept., 1875, p. 49.

Anota Hallowell, Proc. Acad. Nat. Sci. Phila., 1852, p. 182.

Gen. Char.—Head short, cordiform, elevated at the vertex, and armed behind and on the sides with strong spines, variable in length and number. Cephalic plates small, rugose and polygonal. Palatine teeth wanting. Gular fold present. Auricular aperture inconspicuous in certain species, or entirely absent. Body short, rounded, depressed, and ordinarily fringed. Dorsal and caudal crests lacking. Limbs short, digits moderately developed. Tail comparatively short. Femoral pores present, but anal wanting.

This genus, which is probably the best defined and the most strikingly distinct of its family, is wholly restricted to North America. Its northernmost range, so far as has been determined, is the boundary line between the United States and the British possessions, Dr. Coues having met with it in the region of the Milk River during the summer of 1874, while its southern limit is the scope of country that occupies the terminus of Mexico. Montana, Dakota, Nebraska, Kansas, Indian Territory, Texas, and the countries stretching thence to the Pacific, are the only portions of the Union, as far as are known, that have yielded evidences of its existence. Of the many species which have been described from this area, but twelve seem to me as valid, seven being denizens of the United States, and the residue of the table-lands of Mexico.

While differing from previous writers in an estimate of the number of species, I am constrained to disallow any separation of the genus into subgenera, as has been done by Girard, and by Dumeril and Bocourt, since the characters upon which they are founded are not sufficiently strong to warrant such a division. The interests of science are doubtless best subserved by considering but a single undivided genus, whose species-representatives, with their most salient marks of distinction, I shall now proceed to tabulate.

Synopsis of Species.

I. Nostrils lateral; opening on the anterior extremity of the superciliary ridge.

  A. A single row of pyramidal scales at the periphery of the abdomen; gular scales subequal; abdominal scales smooth.

    1. Cephalic spines very short and tubercular; occipitals less prolonged than the longest of the temporals, posteriorly; head broader than long. *Douglassi.* 1.

    2. Cephalic spines of medium length; occipital spines directed obliquely upwards, and a little less prolonged than the longest of the temporals, posteriorly; head broader than long. *Boucardi.* 2.

    3. Cephalic spines of medium length; occipital spines horizontal, more prolonged than the longest of the temporals, posteriorly; head as broad as long. *orbiculare.* 3.

  B. Two rows of pyramidal scales at the periphery of the abdomen; three or four rows of enlarged pointed gular scales upon each side of the median line.

    1. Abdominal scales smooth; cephalic spines to the number of twelve or thirteen; occipital spines horizontal or nearly so. *coronatum.* 4.

    2. Abdominal scales carinated; cephalic spines eight in number; occipital spines vertical. *asio.* 5.

II. Nostrils anterior; situated within the superciliary ridge; two rows of enlarged gular scales, one row on each side of, and distant from, the median line.

  A. Two rows of pyramidal scales at the periphery of the abdomen; auricular opening conspicuous.

    1. Abdominal scales carinated, sometimes smooth or nearly so; occipital spines directed obliquely backward, much longer than the longest of the temporals, from which they are separated by one or two flattened scales. *cornutum.* 6.

    2. Abdominal scales carinated; cephalic spines forming with the inframaxillary plates a continuous circular series; occipital spines projecting posteriorly as far as, and not separated from, the longest of the temporals. *regale.* 7.

B. One row of pyramidal scales at the periphery of the abdomen; auditory aperture conspicuous.

a. Abdominal scales carinated; tail very short, not equal in length to the femur.

1. One temporal on each side strongly developed and conical, very much more prolonged posteriorly than the occipitals, which are small. *taurus.* 8.
2. Temporal spines moderate, flattened, four or five on each side, scarcely projecting beyond the occipitals, posteriorly. *Braconnieri.* 9.

b. Abdominal scales smooth; tail of ordinary length; occipital spines projecting beyond the longest of the temporals, posteriorly. *platyrhinos.* 10.

C. No pyramidal scales at the periphery of the abdomen; auditory aperture sometimes absent on one or both sides in *modestum;* always absent in *Maccalli;* abdominal scales smooth.

1. Occipital spines short, projecting about as far as the longest temporal, posteriorly; one row of enlarged gular scales next to the inframaxillary plates. *modestum.* 11.
2. Occipital spines very long and recurved, projecting much farther than the longest temporal, posteriorly; one row of enlarged gular scales on each side, distant from the inframaxillary plate. *Maccalli.* 12.

1. **Phrynosoma Douglassi.**

Agama Douglassi Bell, Trans. Linn. Soc. Lond., xvi, 1828, p. 105, pl. x; Harlan, Med. and Phys. Researches, 1835, p. 141.

Phrynosoma Douglassi Wagler, Naturl. Syst. Amph., 1830, p. 146; Gray, Griff. Anim. King., ix, 1831, p. 14; Wiegmann, Herp. Mex., 1834, p. 54; Dumeril & Bibron, Erpet. gener., iv, 1837, p. 323; Holbrook, N. Am. Herp., ii, 1842, p. 101, pl. xiv; Dekay, Zool. New York, iii, 1842, p. 31; Fitzinger, Syst. Rept., i, 1843, p. 78; Gray, Cat. Liz. Brit. Mus., 1845, p. 227; Aug. Dumeril, Cat. Meth. Coll. Rept. Mus. Paris, 1851, p. 78; Girard, Stans. Expl. Vall. Gt. Salt Lake, 1852, p. 362, pl. vii, figs. 6-9; Aug. Dumeril, Arch. Mus. Hist. Nat., viii, 1856, p. 551; Cope, Proc. Acad. Nat. Sci. Phila., 1866, p. 302; Allen, Proc. Bost. Soc. Nat. Hist., xvii, 1874, p. 69; Cope, Am. Nat., xii, 1879, p. 135.

Phrynosoma orbiculare Hallowell, Sitgreaves' Expl. Zuni and Col. Riv., 1853, p. 125, pl. viii and ix.

Tapaya Douglassi Girard. Herp. U. S. Expl. Exped., 1858, p. 398, pl. xxi. fig. 1–5; Baird, P. R. R. Rep., x. 1859, Gunnison & Beckwith's Route, Rept., p. 18: *Id.*, Williamson & Abbott's Route, Rept., p. 9; Cooper & Suckley. Nat. Hist. Wash. Terr., 1860, p. 294; Dumeril & Bocourt. Miss. Sci. au Mex. et Am. Cent. Rept., 1870. p. 226. pl. xi, fig. 5.

Tapaya brevirostre Girard, Herp. U. S. Expl. Exped., 1858, p. 397; Cope, Proc. Acad. Nat. Sci. Phila., 1866, p. 302.

Tapaya Hernandezi Girard, Herp. U. S. Expl. Exped., 1858. p. 395; Baird, U. S. and Mex. Bound. Surv., ii, pt. ii. 1859, p. 8.

Tapaya ornatissima Girard, Herp. U. S. Expl. Exped., 1858, p. 396; Baird. U. S. and Mex. Bound. Surv., ii. pt. ii. 1859, p. 9; Baird. P. R. R. Rep., x. 1859. Whipple's Route, Rept., p. 38; Demeril & Bocourt, Miss. Sci. au Mex. et Am. Cent. Rept., 1870. p. 227, pl. xi, fig. 6.

Phrynosoma Douglassi, subsp. *Douglassi* Cope. Check List N. A. Batrach. and Rept., 1875. p. 49: Yarrow, U. S. Geol. Surv. west of the 100th Meridian, v. 1875, p. 580: Coues. *op. cit.*, p. 590: Coues & Yarrow. Bull. U. S. Geol. Surv. of Terr., iv. 1878. p. 285.

Phrynosoma Douglassi, subsp. *ornatissima* Cope, Check List N. Am. Batrach. and Rept., 1878, p. 49: Yarrow, U. S. Geol. Surv. west of 100th Meridian. v. 1875, p. 581; Coues, *op. cit.*, p. 591; Coues & Yarrow, Bull. U. S. Geol. Surv. of Terr., iv. 1878. p. 286.

Phrynosoma Douglassi pygmæa Yarrow. Bull. U. S. Nat. Mus., v. 1882, p. 443.

Head broader than long; nostrils lateral, opening upon the anterior extremity of the superciliary ridge; cephalic spines small and tuberculous; occipital spines more prolonged than the longest temporal, posteriorly; last three or four sublabial scales on each side, enlarged and pointed; submaxillary plates small and subequal, about the size of the posterior sublabials; a conical scale at the angle of the mouth; gular scales nearly equal, the row next to the inframaxillary plates slightly largest; one row of pyramidal scales at the periphery of the abdomen; abdominal scales smooth; back armed with several rows of spiny scales; tail of medium length, similar to back above, smooth beneath, and fringed laterally with conical spines.

Habitat.—Washington Territory, Oregon, California, Montana, Dakota, Nebraska, Kansas, Indian Territory, Texas, Wyoming, Colorado, Utah, and New Mexico.

A careful study of *Douglassi*, and an institution of comparison between its characters and those of *Hernandezi*. convince me that the two are identical. The row of enlarged gular scales next to the inframaxillary plates, as given by Girard as a mark of distinction, is also found in *Douglassi*. The abdominal scales are spoken of as being acuminate, and such is the case with those of the upper portion of the belly in *Douglassi*, although lower down they are somewhat obtuse.

Between *Douglassi* and the subspecies *ornatissima* and *pygmæa*, of some authors, I can perceive no differences. Examinations of numerous specimens in the collection of the Academy of Natural Sciences of Philadelphia, from all parts of its extended habitat, convince me that there are no fixed discriminating characters, not even of size, as the smaller northern forms are found to grade imperceptibly into their larger southern neighbors. And, as *pygmæa* was described from the region of the Columbia River, and *ornatissima* from New Mexico, the former as small and the latter as large, and corresponding otherwise as they do with *Douglassi*, there is good reason for considering them only as extreme forms of this species.

2. **Phrynosoma Boucardi**

Tapaya Boucardi Dumeril & Bocourt, Miss. Sci. au Mex. et Am. Cent. Rept., 1870, p. 225, pl. xi, fig. 4.

Head broader than long; cephalic spines of medium length; occipital spines directed nearly vertically upwards, not prolonged as far posteriorly as the longest temporal; sublabials small, increasing in size posteriorly; inframaxillary plates somewhat smaller than the posterior sublabials; no enlarged pointed gular scales; one row of pyramidal scales at the periphery of the abdomen; abdominal scales smooth; back with numerous spinous scales; tail of ordinary length, similar to the body, with but few spines along the margin.

Habitat.—Plateau of Mexico.

This species is very easily separated from its nearest allies, *Douglassi* and *orbicularis*, by the character of the occipital spines. In the two latter these spines are directed nearly horizontally backward, while in the present species they project nearly vertically upward.

3. **Phrynosoma orbicularis.**

Lacertus orbicularis Hernandez, Nov. Plant. Anim. Min. Mex., xvi, 1651, p. 327, fig; Linnaeus, Syst. Nat., 1789, p. 1061; Cuvier, Regn. Anim., ii, 1817, p. 35; *Id.*, 2d ed., ii, 1819, p. 37, *Agama orbicularis* Daudin, Hist. Nat. Rept., iii, 1805, p. 406; Voigt, Uebers. Thierr. Cuv., ii, 1831, p. 54.

Phrynosoma orbiculare Wiegmann, in Oken., Isis, xxi, 1828, p. 367; Wagler, Naturl. Syst. Amph., 1830, p. 146; Gray, Griff. Anim. King., ix, 1831, p. 45; Wagler, Descr. and Icon. Amph., 1833, pl. xxiii, figs. 1 and 2; Schinz, Naturg. und Abild. der Rept., 1833, p. 88, pl. xxvii, fig. 2; Gravenhorst, Act. Acad. Caes. Leop. Carol. Nat. Cur., xvi. pt. ii, 1833, p. 912, pl. lxiii; Wiegmann, Herp. Mex., 1834, p. 53; Dumeril & Bibron, Erpet. gener., iv, 1837, p. 321; Gray, Cat. Liz. Brit. Mus., 1845, p. 228; Aug. Dumeril, Cat. Meth. Coll. Rep. Mus. Paris, 1851, p. 78; Girard, Stans. Expl. Vall. Gt. Salt Lake, 1852, p. 359; Sumichrast, Ann. and Mag. Nat. Hist., xiii, 1864, p. 507; Peters, Berlin Monatsb., 1869, p. 875; Müller, Verh. Natur. Gesell., Basel, 1878, p. 634; Weidersheim, Zool. Anz., i, 1878, p. 105.

Phrynosoma Wiegmanni Gray, Beechey's Voy. Pacif. Zool., 1839, p. 96.

Tapaya orbicularis Girard, Herp. U. S. Expl. Exped., 1858, p. 394; Dumeril & Bocourt, Miss. Sci. au Mex. et Am. Cent. Rept., 1870, p. 221, pl. xi, fig. 1.

Tapaya orbicularis, var. *Cortezi* Dumeril & Bocourt, Miss. Sci. au Mex. et Amer. Cent. Rept., 1870, p. 223, pl. xi. fig. 2.

Tapaya orbicularis, var. *Dugesi* Dumeril & Bocourt, Miss. Sci. au Mex. et Am. Cent. Rept., 1870, p. 224, pl. xi, fig. 3.

Head as broad as long; cephalic spines moderately developed; occipital spines equal to, or a little more prolonged than, the longest of the temporals, posteriorly; sublabial plates very small; a large conical scale at the angle of the mouth; inframaxillary plates small, equal in size to the posterior sublabials; one row of pyramidal scales at the periphery of the abdomen; abdominal scales smooth; back spinous; tail of ordinary length, similar to the body, and sparsely fringed with conical scales.

Habitat.—The plateaus of Mexico.

4. Phrynosoma coronatum.

Phrynosoma coronatum Blainville, Nouv. Ann. Hist. Nat., iv, 1835, p. 284, pl. xxv, fig. 1 *a* and 6 *c*; Dumeril & Bibron, Erpet. gener., iv, 1837, p. 318; Holbrook, N. A. Herp., ii, 1842, p. 97, pl. xiii; Dekay, Zool. New York, iii, 1842, p. 31; Aug. Dumeril, Cat. Meth. Coll. Rept. Mus. Paris, 1851, p. 78; Girard, Stans. Expl. Vall. Gt. Salt Lake, 1852, p. 360, pl. viii, figs. 7–12; Hallowell, Sitgreaves' Exped. Zuni and Colorado Riv., 1853, p. 122; Sanders, Proc. Zool. Soc. Lond., 1874, p. 71–78 (Myology); Cope, Check List of N. A. Batrach. and Rept., 1875, p. 50; Lockington, Am. Nat., xiv, 1880, p. 295.

Phrynosoma Blainvillei Gray, Beechey's Voy. Pacif. Zool., 1839, p. 96, pl. xxix, fig. 1; Gray, Cat. Liz. Brit. Mus., 1845, p. 228; Cope, Check List N. A. Batrach. and Rept., 1875, p. 49; Yarrow, U. S. Geol. Surv. west of 100 Meridian, v, 1875, p. 582.

Batrachosoma coronatum Fitzinger, Syst. Rept., i, 1843, p. 79; Girard, Herp. U. S. Expl. Exped., 1858, p. 400, pl. xx, figs. 10–13; Dumeril & Bocourt, Miss. Sci. au Mex. et Am. Cent., 1870, p. 239, pl. xii, fig. 10.

Head large; nostrils lateral; cephalic spines strongly developed; occipital spines separated from each other by a single plate or small spine, directed horizontally backward, beyond the longest temporals; sublabial plates small; a large flattened scale at the angle of the mouth; inframaxillary plates beneath it very small, the others large and sharp-edged; three or four rows of enlarged pointed gular scales upon each side of, and separated by, the median line; two rows of pyramidal scales at the periphery of the abdomen; abdominal scales smooth; back spinous; tail of ordinary length, similar to the body, fringed with conical spines.

Habitat.—Oregon and California.

In *coronatum* the plate or scale that separates the two occipital spines shows intermediate gradations between a nearly flattened and a tubercular and even spiny surface. Therefore, the possession of a flattened scale by a specimen, which was the leading character upon which *Blainvillei* was established, loses its importance and necessitates its incorporation with the species under consideration.

5. **Phrynosoma asio.**

Phrynosoma asio Cope, Proc. Acad. Nat. Sci. Phila., 1864, p. 178; Sumichrast, Bibl. Univers. et Rev. Suisse, 1873, p. 258; Sumichrast, Bull. Soc. Zool. Fr., 1880, p. 177.

Phrynosoma spinimentum Peters, Berlin Monatsb., 1873, p. 742.

Batrachosoma asio Dumeril & Bocourt, Miss. Sci. au Mex. et Am. Cent., 1870, p. 241, pl. xvii, fig. 9.

Head large; nostrils lateral; cephalic spines well developed; occipital spines vertical, separated from each other by four or five small plates; temporal spines separated from the occipitals, and directed horizontally backward; sublabials small; inframaxillary plates increasing in size posteriorly; three or four rows of enlarged pointed subgular scales on each side of, and separated by, the median line; two rows of pyramidal scales at the periphery of the abdomen; abdominal scales carinated; back spinous; tail of medium length, similar to the body, and margined with conical scales.

Habitat.—Tehuantepec, Mexico.

This large and beautiful species is most nearly allied to *coronatum*, from which it is separated by the character of the cephalic spines, and also that of the abdominal scales. It is also closely related to the succeeding species, differing, however, in the position of the nostrils, and in the number and position of the rows of enlarged gular scales.

6. **Phrynosoma cornutum.**

Agama cornuta Harlan, Journal Acad. Nat. Sci. Phila., iv, 1825, p. 299, pl. xx.

Lacerta cornuta Cuv., Regn. Anim., 2d edit., ii, 1819, p. 37.

Phrynosoma cornutum Gray, Griff. Anim. King., ix, 1831, p. 45; Holbrook, N. Am. Herp., ii, 1842, p. 87, pl. xi; Dekay, Zool. New York, iii, 1842, p. 31; Gray, Cat. Liz. Brit. Mus., 1845, p. 229; Girard, Stans. Expl. Vall. Gt. Salt Lake, 1852, p. 360, pl. viii, figs. 1-6; Blanchard, Organ. Regn. Anim., 1852, pt. v, pl. xii; Hallowell, Sitgreaves' Exped. Zuni and Col. Rivers, 1853, p. 119; Girard, Herp. U. S. Expl. Exped., 1858, p. 403, pl. xxi, figs. 6–9; Baird, U. S. and Mex. Bound. Surv., pt. ii, 1859, p. 9; Dumeril & Bocourt, Miss. Sci. au Mex. et Am. Cent., Rept., 1870, p. 236, pl. xii, fig. 9; Cope, Check List N. A. Batrach. and Rept., 1875, p. 49; Yarrow, U. S. Geol. Surv. west of 100th Meridian, v, 1875, p. 579; Müller, Verh. Nat. Gesell., Basel, 1878, p. 634; Cope, Proc. Am. Phil. Soc., 1879, p. 261; Cope, Bull. U. S. Nat. Mus., No. 17, 1880, p. 17.

Phrynosoma Harlani Wiegmann, Herp. Mex., i, 1834, p. 54; Dumeril & Bibron, Erpet. gener., iv, 1837, p. 314; Spring & Lacordaire, Bull. Acad. Roy. Brussels, 1842, pt. ii, p. 192, fig. 2; Aug. Dumeril, Cat. Meth. Coll. Rept. Mus. Paris, 1851, p. 28.

Tropidogaster cornutus Fitzinger, Sys. Rept., i, 1843, p. 79.

Phrynosoma planiceps Hallowell, Proc. Acad. Nat. Sci. Phila., 1852, p. 178; Hallowell, Sitgreaves' Exped. Zuni and Col. Rivers, 1853, p. 124, pl. vii; Dumeril, Arch. Mus. Hist. Nat., viii, 1855, p. 552; Dumeril & Bocourt, Miss. Sci. au Mex. et Am. Cent., 1870, p. 238, pl. xii, fig. 11; Copé, Check List N. A. Batrach. and Rept., 1875, p. 49; Yarrow, U. S. Geol. Surv. west of 100th Meridian, v, 1875, p. 579, pl. xxiv, fig. 1; Coues, in the above, p. 593.

Head broad; nostrils anterior, placed within the superciliary ridges; cephalic spines strongly developed; occipital spines long, directed obliquely upward, a smaller spine between the two; posterior inframaxillary plates largest; one row of enlarged pointed gular scales on each side, distant from the median line; two rows of pyramidal scales at the periphery of the abdomen; abdominal scales carinated, occasionally smooth or nearly so; back with several rows of spiny scales; tail of ordinary length, similar to the body, and fringed with conical scales.

Habitat.—Kansas, Indian Territory, Texas, and New Mexico. Possibly from Arkansas and Louisiana.

The only difference between *cornutum* and the supposed species *planiceps*, was in the character of the abdominal scales, the former being carinated, and the latter smooth. Prof. Cope, however, after examining numbers of specimens, finds that the above forms grade into each other, and, consequently, considers them but one species.

7. Phrynosoma regale.

Phrynosoma regale Girard, Herp. U. S. Expl. Exped., 1858, p. 406; Baird, U. S. and Mex. Bound. Surv., 1859, pt. ii, p. 9, pl. xxviii, fig. 1–3; Cope, Proc. Acad. Nat. Sci. Phila., 1866, p. 310; Dumeril & Bocourt, Miss. Sci. au Mex. et Am. Cent. Rept., 1870, p. 235, pl. xii, fig. 12; Cope, Check List N. A. Batrach. and Rept., 1875, p. 49; Yarrow, U. S. Geol. Surv. west of the 100th Meridian, v, 1875, p. 578; Coues, in the above work, p. 593; Müller, Verh. Nat. Gesell., Basel, 1878, p. 634; Lockington, Am. Nat., 1880, p. 295.

"*Phrynosoma solaris* Gray, Cat. Liz. Brit. Mus., 1845, p. 229?"

Head large; nostrils anterior; cephalic spines strongly developed, directed backwards; the longest two of the temporals being in the same plane as, and touching, the occipitals, all four being subequal; no plate or scale separating the occipital spines; two rows of enlarged pointed gular scales, one on each side of, and distant from, the median line; last inframaxillary plate smaller than the preceding; two rows of pyramidal scales at the periphery of the abdomen, lower one very small; abdominal scales carinated; back spinous; tail of medium length, similar to the body, and fringed with conical scales.

Habitat.—Valleys of the Gila and Colorado Rivers.

8. Phrynosoma taurus.

Phrynosoma taurus Dugès MSS., 1868; Dugès, Cat. Vert. Mex., 1869; Dumerii & Bocourt, Miss. Sci. au Mex. et Am. Cent. Rept., 1870, p. 234, pl. xii, fig. 8; Dugès, La Naturaleza, ii, 1871–73, p. 302, fig.

Head broad; nostrils anterior; occipital spines small and conical; temporals strongly developed, conical, projecting very much farther posteriorly than the occipitals; inframaxillary plates nearly equal; one row of enlarged pointed gular scales upon each side of, and distant from, the median line; a single row of pyramidal scales at the periphery of the abdomen; abdominal scales carinated; back spinous; tail very short, about as long as the femur, and with very few conical scales along the margins.

Habitat.—Puebla, Southern Mexico.

9. **Phrynosoma Braconnieri.**

Phrynosoma Braconnieri Dumeril & Bocourt, Miss. Sci. au Mex. et Am. Cent. Rept., 1870, p. 233, pl. xii, fig. 7.

Head as broad as long; nostrils anterior; cephalic spines of medium size; occipital spines somewhat less prolonged posteriorly than the longest of the temporals; four or five temporal spines upon each side; one row of enlarged pointed gular scales upon each side of, and distant from, the median line; inframaxillary plates nearly equal; a single row of pyramidal scales at the periphery of the abdomen; abdominal scales carinated; tail very short, little more than half as long as the femur.

Habitat.—Oaxaca, Southern Mexico.

10. **Phrynosoma platyrhinos.**

Phrynosoma platyrhinos Girard, Stans. Expl. Vall. Gt. Salt Lake, 1852, p. 361, pl. vii, fig. 1-5; Cope, Proc. Acad. Nat. Sci. Phila., 1866, p. 302; Dumeril & Bocourt, Miss. Sci. au Mex. et Am. Cent. Rept., 1870, p. 232; Cope, Check List N. A. Batrach. and Rept., 1875, p. 49; Yarrow, U. S. Geol. Surv. west of the 100th Meridian, v, 1875, p. 577; Coues, in the above work, p. 594.

Doliosaurus platyrhinos Girard, Herp. U. S. Expl. Exped., 1858, p. 409; Baird, P. R. R. Rept., Gunnison & Beckwith's Route, Rept., 1859, p. 18.

Head small; nostrils anterior; cephalic spines of medium size; occipital spines produced further than the longest of the temporals, posteriorly; sublabial plates nearly equal; inframaxillary plates becoming larger posteriorly; one row of enlarged gular scales on each side of, and distant from, the median line; one row of pyramidal scales at the periphery of the abdomen; abdominal scales smooth; back with several rows of spinous scales; tail of medium length, fringed with conical scales.

Habitat.—Utah, Nevada, New Mexico, Arizona and California.

11. Phrynosoma modestum.

Phrynosoma modestum Girard, Stans. Expl. Vall. Gt. Salt Lake, 1852, p. 361, pl. vi, fig. 4–8; Cope, Proc. Acad. Nat. Sci. Phila., 1866, p. 302; Dumeril & Bocourt, Miss. Sci. au Mex. et Am. Cent., Rept., 1870, p. 232; Cope, Check List N. A. Batrach. and Rept., 1875, p. 49; Yarrow, U. S. Geol. Surv. west of 100th Meridian, v, 1875, p. 577; Coues, in the above work, p. 594.

Doliosaurus modestus Girard, Herp. U. S. Expl. Exped., 1858, p. 409; Baird, U. S. and Mex. Bound. Surv., ii, pt. ii, 1859, p. 10; Baird, P. R. R. Rept., x, 1859, Whipple's Route, Rept., p. 38.

Head broader than long; nostrils anterior; cephalic spines small; occipital spines extending as far as the longest of the temporals, posteriorly; auricular aperture sometimes wanting on one or both sides, but when present, small and granular; sublabial plates small and nearly equal; inframaxillary plates broad and pointed; gular scales next to the inframaxillary plates slightly larger than the others; no pyramidal scales at the periphery of the abdomen; abdominal scales smooth; back nearly smooth, devoid of conical scales; tail nearly equal in length to the body, a few conical scales along the basal margin.

Habitat.—Western Texas, Utah, New Mexico and Arizona.

12. Phrynosoma Maccalli.

Anota Maccalli Hallowell, Proc. Acad. Nat. Sci. Phila., 1852, p. 122; Hallowell, Sitgreaves' Exped. Zuni and Col. Rivers, 1853, p. 127, pl. x, figs. 1, 2; Dumeril & Bocourt, Miss. Sci. au Mex. et Am. Cent. Rept., 1870, p. 230.

Doliosaurus Maccalli Girard, Herp. U. S. Expl. Exped., 1858, p. 408; Baird, U. S. and Mex. Bound. Surv., ii, pt. ii, 1859, p. 9, pl. xxviii, figs. 4–6.

Phrynosoma Maccalli Cope, Proc. Acad. Nat. Sci. Phila., 1866, p. 310; Cope, Check List N. A. Batrach. & Rept., 1875, p. 49; Coues, U. S. Geol. Surv. west of 100th Meridian, v, 1875, p. 593.

Head small; snout truncated; nostrils anterior; cephalic spines long, strongly developed; occipital spines slightly recurved; middle inframaxillary spines broadest and longest; one row of enlarged gular scales upon each side of, and distant from, the median line; auricular apertures always wanting; no pyramidal scales at the periphery of the abdomen; abdominal scales smooth; back smooth as in *modestum;* tail as long as the body, margined with conical scales.

Habitat.—Deserts of the Gila and Colorada Rivers.

A REVIEW OF THE AMERICAN GENERA AND SPECIES OF MULLIDÆ.

BY EDWARD A. HALL AND J. Z. A. McCAUGHAN.

In the present paper we have attempted to collect the synonymy of all the American genera and species of the family of Mullidæ. All the specimens examined by us belong to the Museum of the Indiana University.

Analysis of American Genera of Mullidæ.

a. Teeth on lower jaw, vomer and palatines; upper jaw toothless; caudal lobes equal. Vertebræ 9 + 14; the nasal bone, which forms a downward hook over maxillary, strongly developed; interorbital space flat and wide; opercle without spine. D. VII–I, 8; A. II, 6. MULLUS. 1.

aa. Teeth on both jaws; vomer and palatines toothless. Vertebræ 9 + 14; the nasal bone, which forms a downward hook over the maxillary, moderately developed; interorbital space concave and narrow; opercle ending in a single spine. UPENEUS. 2.

1. MULLUS.

Mullus Linnæus, Syst. Nat., 1758, ed. 10, 299 (*barbatus; surmuletus*).

The species of this genus, two or three in number, are very closely related. They are chiefly confined to the waters of Europe.

Analysis of Species of Mullus.

a. Depth less than 4 in length; maxillary scarcely reaching front of orbit; eye much larger than in *M. surmuletus*, less than 5 in head; barbels scarcely reaching to lower angle of preopercle, more than $1\frac{1}{3}$ in head. Scales more deciduous than in *M. surmuletus*. (*Vinciguerra.*) *barbatus.*[1]

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[1] For purposes of comparison we insert the characters of this European species as given by Vinciguerra. We have examined no specimens of it. The descriptions given by Günther and others, of *M. surmuletus* and *M. barbatus*, are said to show a confusion of the two forms.

aa. Length of head greater than depth of body, $3\frac{1}{4}$ in length of body; depth 4 in length; snout $7\frac{1}{7}$ in length of body; maxillary not quite reaching the vertical from front of eye; eye 5 in head; interorbital space $12\frac{1}{2}$ in length of body; barbels reaching to a point half-way between angle of preopercle and extremity of opercle, $1\frac{1}{3}$ in head. Sides of body with three yellow longitudinal stripes; first dorsal barred with light and black. *surmuletus.* 1.

aaa. Length of head about equal to depth of body, about $3\frac{3}{4}$ in length of body; snout $7\frac{6}{10}$ in length of body; maxillary just reaching vertical from front of eye; eye 4 in head; interorbital space $14\frac{7}{8}$ in length of body; barbels reaching to extremity of opercle, $1\frac{1}{3}$ in head; scales in lateral line 32. Sides of body with two yellow longitudinal stripes; first dorsal with an orange band at base and a yellow one higher up; second dorsal mottled with scarlet and pale; no black on dorsals. *surmuletus auratus.* 1 (*b*).

1. **Mullus surmuletus.**

(*a.*) Var. **surmuletus.**

Trigla capite glabro, lineis utunque quatuor, luteis longitudinalibus parallellis Artedi, Ichthyol., 1738, 43 (Mediterranean Sea; Ocean by Cornwall).

Mullus surmuletus Linnæus, Syst. Nat., 1758, ed. 10, 300 (Mediterranean); Linnæus, Syst. Nat., 1766, ed. 12, 496 (Mediterranean); Brunich, Ichthyol. Massiliensis, 1768, 72 (Marseilles); Pennant, “Brit. Zool., iii, 1769, 368, pl. 64”; Bloch, Ichthyologia, Taf. 57, 1785; Bonnature, “Ichthyol, 1790, 144, pl. 59, fig. 233”; Linnæus, “Fauna, Suec. ed. Retz, 1800, 341”; Shaw, “Brit. Zool., iv, 1800, 1819, 613, pl. 88”; Bloch & Schneider, Syst. Ichthyol., 1801, 77, Taf. 18; Donovan, “Brit. Fish., i, 1801, pl. 12”; Turton, “Brit. Zool., 1807, 102”; Risso, Ichthyol. de Nice, 1810, 215 (Nice); Martens, “Reise nach Venedig, ii, 1824, 427” (Venice); Fleming, “Brit. An., 1828, 216”; Cuvier & Valenciennes, Hist. Nat. Poiss, iii, 1829, 433 (Marseilles; Ivica; Nice; Naples); Cuvier, Règne Animal, ed. ii, 1829.

Mullus surmuletus Lacépède, Poiss., v, 1832, 75 (Mediterranean, Baltic, Atlantic Ocean); Jenyns, “Manual Brit. Vert., 1835, 337”; Yarrell, “Brit. Fishes, i, 1841, 31”; Guichenot, Explor. Sci. Alger. Poiss., 1850, 38 (Algiers); White, “Cat. Brit. Fish., 1851, 14”; Thompson, “Nat. Hist. Ireland, iv, 1856, 70” (Ireland); Günther, Cat. Fish. Brit. Mus., i, 1859, 401 (Brixham; British Channel; Medeira, Mediterranean; Dalmatia); Couch, “Fish. Brit. Isles, i, 1862, 208, pl.

47"; Collet, Norges Fiske, 1875, 17 (Christianafjord; Lindesnaes; Bergen): Bean, Proc. U. S. Nat. Mus., 1879, 26 (Europe); Vinciguerra, Risult. Ittiol. del Violante, 1883, 41 (Dalmazia; Marcova, Melida; Curzola; Lissa; Lagosta and Cazza).

Mullus barbatus De la Roche, "Ann. Mus. xiii, 1809, 306"; Gronow, Cat. Fish. 1854, 108; Steindachner, Uebersicht Meeresfische an Küsten Spaniens und Portugals, 1867, 33 (Cadiz; Lisbon; Gibraltar; Teneriffe): Botteri, Cat. Pisci di Lesina, 1873, 60 (Lesina).

Mullus barbatus surmuletus Day, Fishes of Great Brit., 1880, 22, pl. 8, fig. 2 (Mevagissey).

Mullus dubius Malm, "Ofversigt of Kongl. Vet. Akad. Forhandl., 1852, 224" (Sweden).

(*b.*) Var. **auratus.**

Mullus barbatus auratus Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 280 (Pensacola); Jordan & Gilbert, Syn. Fish. N. A., 1882, 931 (Pensacola; Wood's Holl).

Mullus auratus Jordan Proc. U. S. Nat. Mus., 1884, 39 (Pensacola).

Habitat.—Var. *surmuletus*, on all southern and western coasts of Europe, from Sweden to Africa; the most common species in most parts of Europe. Var. *auratus*, eastern coast of America, Wood's Holl to Pensacola.

This form called *auratus*, has been occasionally taken on our Atlantic and Gulf coasts, but it is evidently rare. The single specimen examined by us came from deep water at Pensacola. It seems to us to be a variety of *M. surmuletus* rather than a distinct species, and it is certainly nearer *M. surmuletus* than *M. barbatus*, as the latter is described.

Many European writers have denied the distinctness of *M. surmuletus* and *M. barbatus*. The following account of the two, translated from Vinciguerra's Risultati Ittiologici del Crociere del Violante, seems to give a final answer to the question as to the difference between these two species.

"No one of the Mediterranean ichthyologists has yet been willing to accept the fusion of these two forms, an opinion which I regard as really incorrect, and caused by the scarcity of *M. barbatus* in the waters of the Atlantic and Baltic. I have been able to verify, on an extensive series of examples, that in *barbatus*, as in *surmuletus*, there exist two forms; the one with the profile oblique, the other with the profile rectilinear. These probably represent the two sexes, and those who wish to take as a differential character the form of the head are thus easily led into error. The real differences which exist between *surmuletus* and *barbatus*, besides that of coloration, are the following: In *M. surmuletus*, the diameter of the eye is much smaller, and the barbels are more robust and longer, reaching beyond the lower angle of the opercle (in *barbatus* they scarcely reach this point), and the body is notably deeper. To these characters may be added the greater adherence of the scales in *surmuletus*, while in *barbatus* these are readily deciduous, and only in extraordinary cases is a specimen found possessing a single scale. In every market on the coast of the Mediterranean the fishermen distinguish between the two species by different names, according to their coloration, relative length of barbels and the place where they live by preference; inasmuch as *surmuletus* is found most readily in rocky places (and hence the common name 'Triglia di Scoglia'), and *barbatus* is found in muddy places (and hence the common name 'Triglia di Fango')."

2. UPENEUS.

Upeneus Cuvier, Règne Animal, ed. 2, 1829 (*vittatus; russelli; bifasciatus; trifasciatus*).

Hypeneus Agassiz, Nom. Zool., Index Universalis, 1846, 190 (amended orthography).

Mulloides Bleeker, "Ceram II, 697, 1852–65 (*flavolineatus*)."

Pseudupeneus Bleeker, Poiss. Côte de Guinée, 1862, 56 (*prayensis*).

Parupeneus Bleeker, Notice sur le *Parupeneus bifasciatus* de l'Ile de la Reunion, 1867, 345 (*bifasciatus*).

Mullhypeneus Poey, Syn., 1868, 307 (*maculatus*).

We include under the head of *Upeneus* all the *Mullidæ* having teeth on both jaws and none on the vomer. The variations in the size and number of the teeth seem to us of minor importance.

Analysis of Species of Upeneus.

a. Teeth on under jaw uniserial, on upper jaw uniserial or occasionally irregularly biserial with the outer teeth turned outward; all the teeth coarse and distinct; maxillary $2\frac{3}{4}$ in head, not reaching vertical from front of eye by one-half of its length; barbels extending to a point half-way between the vertical of preopercle and extremity of opercular spine, $1\frac{1}{3}$ in length of head; eye 4 in head; scales in lateral line

31; depth, 4 in length; dorsal VIII–I, 8; anal, II, 6. Color in spirits, steel-blue above, descending on sides in three blotches; one above point of opercular spine, sometimes extending on opercle; one under each dorsal fin. Under-parts of body pale. *maculatus*. 2.

aa. Teeth of upper jaw uniserial, of lower biserial; teeth rather strong, weaker than in *U. grandisquamis;* barbels extending nearly to vertical of preopercle; eye large, 3 in head; scales in lateral line, 37; depth about $5\frac{3}{5}$ in total length, $4\frac{1}{3}$ in length. Dorsal VII–I, 7; anal I, 5 or 6. Color, bright pink or rose, with broad red band extending from eye to caudal and suffusing caudal (*Gill*). *dentatus*. 3

aaa. Teeth on both jaws in more than one series.

b. Teeth on anterior part of jaws in two irregular series; lateral teeth on jaws in a single series; all the teeth obtusely conical and distinct from each other; teeth on upper jaw turned inwards; barbels extending to vertical of preopercle, $1\frac{1}{2}$ in length of head; eye $3\frac{1}{3}$ in length of head; scales in lateral line 39; depth 4 in length. Dorsal VIII–I, 8; anal II, 6. "Color in life, flesh-color above, sides silvery, tinged with yellow below; a bright yellow band from eye to base of caudal; a whitish streak above and below this; another above lateral line; both dorsals and caudals bright yellow." *Martinicus*. 4.

bb. Teeth on anterior part of jaws in two series; the outer series of the upper jaw being formed by very obtuse and partly confluent teeth. Barbels extending to vertical from root of pectoral fins; eye 4 in head; scales in lateral line 32; dorsal VIII–I, 8; anal I, 6. Color light greenish brown above, rose-color below lateral line; scales with indistinct pearly spot at centre; black blotch on lateral line behind spinous dorsal; a smaller, sometimes indistinct black spot behind orbit; dorsal fins with spots the color of the back; other fins immaculate. *grandisquamis*. 5.

2. **Upeneus maculatus.**

Mullus maculatus Bloch, "Ichthyol. about 1790, Taf. 348 (Brazil);" Lacépède, Poiss., iii, 1798–1803, 403 (West Indies; Brazil).

Mullus surmuletus var. *maculatus* Bloch & Schneider, Systema Ichthyol., 1801, 78 (Brazil).

Upeneus maculatus Cuvier & Valenciennes, Hist. Nat. Poiss., iii, 1829, 478 (Martinique; Brazil); Storer, "Syn. Fish. N. A., 1846, 48;" Poey, Mem. Pisc. Cuba, i, 1851, 223 (Martinique; Brazil); Castelnau, "Anim. nouv. ou rares Amer. Sud, 1850–61, 6 (South America); Günther, Cat. Fish. Brit. Mus., i, 1859, 408 (Atlantic coasts of Tropical America; Jamaica); Cope. Trans. Amer. Phil. Soc., 1870, 471 (St. Croix); Jordan & Gilbert, Syn. Fish. N. A., 1882, 565; Jordan, Proc. U. S. Nat. Mus., 1884, 129 (Key West).

Mullhypeneus maculatus Poey, Syn., 1868, 307 (Cuba).

Mullhypeneus maculatus Poey, Enum. Pisc. Cuba, 1875, 34 (Havana; Jamaica).

Hypeneus maculatus Goode, Bull. U. S. Nat. Mus., v, 1876, 49 (no specimen).

Upeneus punctatus Cuvier & Valenciennes, Hist. Nat. Poiss., iii, 1829, 482 (Mexico); Kner, Novara Fische, 1857–59, 71 (Rio Janeiro); Cope, Trans. Amer. Phil. Soc., 1870, 471 (St. Kitts).

Habitat.—Atlantic coasts of Tropical America, from Key West to Rio Janeiro.

The specimens of this species examined by us are from Key West and Havana.

3. **Upeneus dentatus.**

Upeneus dentatus Gill, Proc. Acad. Nat Sci. Phila., 1862, 256 (Cape San Lucas); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 363 (Cape San Lucas).

Habitat.—Pacific coast of Tropical America; Lower California.

This species is known to us only from the description of Gill, and the notes of Jordan and Gilbert on Gill's original types.

4. **Upeneus martinicus.**

Upeneus martinicus Cuvier & Valenciennes, Hist. Nat. Poiss., iii, 1829, 483 (Martinique).

Upeneus balteatus Cuvier & Valenciennes, Hist., Nat. Poiss., iii, 1829, 484 (Cuba); Poey, Mem. Cuba, i, 1851, 224 (Cuba); Jordan, Proc. U. S. Nat. Mus., 1884, 129 (Key West).

Mulloides balteatus Cope, Trans. Amer. Phil. Soc., 1870, 471 (St. Kitts).

Upeneus flavovittatus Poey, Mem. Cuba, i, 1851, 225 (Cuba).

Mulloides flavovittatus Günther, Cat. Fish. Brit. Mus., i, 1859, 403 (Caribbean Sea; Jamaica; Cuba).

Upeneus parvus Poey, Mem. Cuba, i, 1859, 225 (Cuba).

The specimens of this species examined by us are from Key West and Havana. Poey has identified his *flavovittatus* and *parvus* with the *balteatus* of Cuvier and Valenciennes. There seems to be little room for doubt that the scanty description of *martinicus* refers to this species also.

5. **Upeneus grandisquamis.**

Upeneus grandisquamis Gill, Proc. Acad. Nat. Sci. Phila., 1863, 168 (West coast Central America); Günther, Fish. Central America, 1864, 420 (copied from Gill); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 626 (no description); Steindachner, Ichthy. Beiträge, iv, 1875, 6 (Panama).

Upeneus tetraspilus Günther, "Proc. Zool. Soc., 1864, 148;" Günther, Fish. Central America, 1864, 420, Pl. 66, fig. 1 (Panama).

Habitat.—Pacific coast of Tropical America; Panama.

This species is known to us only from the descriptions of Gill, Günther, and Steindachner. Professor Jordan tells us that the *Upeneus tetraspilus* of Günther is certainly the same as the *Upeneus grandisquamis* of Gill.

[We regret to announce that while this paper was going through the press, one of the authors, Mr. EDWARD ALLEN HALL, was drowned in Salt Creek, about eleven miles from Bloomington, Ind., on May 22, 1885. He was born at Rushville, Ind., January 9, 1864, and had, during his course of study at the State University of Indiana, proven himself to be an energetic and faithful student.—E. J. N.]

MAY 26.

Mr. JOHN H. REDFIELD in the chair.

Forty-one persons present.

The following papers were presented for publication:—

"Marginal Kames," by H. Carvill Lewis.

"Description of New Species of Lepidoptera," by Herman Strecker.

The death of Jacob P. Jones, a member, was announced.

Antonio de Gregorio, of Palermo, was elected a correspondent.

JUNE 2.

Mr. EDWARD POTTS in the chair.

Thirty-seven persons present.

The following papers were ordered to be printed:—

MARGINAL KAMES.[1]

BY H. CARVILL LEWIS.

Introduction.—During the course of an investigation, in 1881, of the extreme southern edge of the great ice-sheet in Pennsylvania, as marked by its *terminal moraine*, the writer had an opportunity of studying several phenomena produced by the glacier along the line of its southern terminus; one of the most interesting of which phenomena were certain short hummocky ridges of stratified drift, which, often closely connected with the terminal moraine, appear to belong to a class of surface deposits elsewhere called *Kames.*

The kames of Scotland, the *Eskers* of Ireland, and the *Asar*, or *osars*, of Scandinavia, all closely related, if not identical, deposits, find an analogue in the ridges of stratified drift which have been described by a number of geologists as occurring in northeastern America, including Canada.

They may be described as narrow ridges of stratified, water-worn, generally sandy drift, which, sometimes forming a series of tortuous and reticulated hills, sometimes a nearly regular straight ridge, and often forming knob-like conical hills ("hummocks"), alternating with similar conical depressions ("kettle-holes"), generally lie along valleys or depressions, and have a general downward slope from a higher to a lower level.

These gravel ridges are generally quite steep—as steep often as the nature of the material will allow. This steepness is quite striking to a geologist accustomed to the gentle slopes of the gravel formations in the non-glaciated portion of this country, and at once suggests the *recency* of their origin.

The internal structure of kames is in general anticlinal. "Flow-and-plunge" structure, and oblique lamination, the evidence of rapid fluviatile action, is often seen in their interior; and as a rule the material is finest in the interior, and most coarse on the exterior portions of the kame.

Wherever along the course of the terminal moraine the writer has had an opportunity of examining recently made transverse sections of these drift ridges, he has found clean water-worn sand within,

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[1] Read before the British Association for the Advancement of Science, Montreal, August 29, 1884.

showing distinct torrential action, and a coarse gravel on the outside. Sometimes, but rarely, large boulders lie on top of the kames. The writer has never observed large boulders within them. The material is generally small, and well water-worn and rounded, showing no glacial scratches on its pebbles, and for the most part is of local origin.

The contours of these kames in their "hummocky" appearance, are very like those of moraines. Indeed, it is often impossible to distinguish kames from moraines by external features alone. When, however, we take into consideration their structure and their position, they cannot readily be confounded. Their distinguishing characters are (1) their internal structure, kames being distinguished by an absence of till and glaciated pebbles, and by stratified, generally anticlinal, structure—all of these characters being very different from the unstratified pell-mell character of moraines; (2) their geographical position and the influence of the surrounding topography upon them. Topography has practically no influence on the moraine of the great glacier. The terminal moraine on the Pocono plateau closely resembles that in Cherry Valley, 1000 feet below it; and the moraine at the height of 2500 feet, in central Pennsylvania, cannot be distinguished from that in New Jersey, at the sea-level. The moraine may lie on the downward slope of a hill, as at Fishing Creek, Columbia Co.; may form a dam across a creek, as at Cole's Mills, or it may stretch transversely across a mountain ridge such as the Kittatinny Mountain.[1]

On the other hand, kames as a rule depend directly upon topography. While they do not always coincide with the present drainage systems, they extend from higher to lower levels. They follow valleys generally along the central line, but sometimes, indeed, rising over considerable elevations. Where the valleys are distinct and sharply defined by high ridges on either side, the kames are confined to them, and follow more or less closely the modern water-courses; but where, as in southeastern Massachusetts, the valleys are not well marked, and there is no defining wall, the country being nearly level or rolling, and there being no mountain ranges, kames often cross where there are now no

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[1] This independence of the terminal moraine as regards topography, is prominently brought out in the detailed description of it given by the writer in Report Z, Second Geological Survey of Pennsylvania.

water-courses, even crossing rivers, as may be seen on the Merrimac at Lawrence, which is said to be crossed at right-angles by a kame.[1] In no sense, however, can kames be regarded as the work of rivers merely. For, as Prof. Stone has shown so clearly in Maine, they sometimes rise out of a valley and pass through a gap in the hillside or cross a ridge perhaps 150 feet high, to low grounds beyond. Prof. Stone has in several cases followed them *up-hill* for a short distance.

Such facts may best be explained by the supposition that the stream of water which formed them must have either been enclosed within high walls of ice, or have flowed in a subglacial tunnel.

Literature.—A large number of kames, occurring under various conditions, have been observed in different portions of the glaciated area of North America. None occur south of that area.

As long ago as 1842, Dr. Edward Hitchcock described a series of gravel ridges which pass through Andover, Mass., and which is known locally as "Indian Ridge." At that time he regarded this ridge, composed, as he well described it, "of a collection of tortuous ridges and rounded even conical hills with corresponding depressions between them,"[2] as a species of moraine. These have been more recently studied in detail by Prof. G. F. Wright,[3] who has shown that they form part of a chain of such ridges, many miles in length, running from Franklin, N. H., to Malden on the ocean, and are true kames.

The most complete studies of kames in this country are those made by Prof. Geo. H. Stone,[4] who has mapped some thirty-one linear systems of kames in the State of Maine, all running from the high interior of the State southeastward toward the sea. He describes them as meandering like rivers in their course from the mountains oceanward. They start sometimes at elevations as high as 1600 feet above the ocean, they freely cross low transverse hills 100 feet high, but not 200 feet high, and they have a strong inclination to keep within straight lines, notwithstanding minor obstacles. These ancient gravel streams were not so easily turned from their course as streams of to-day. When once in a valley

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[1] Wright, Proc. Bost. Soc. Nat. Hist., xix, 47.

[2] Trans. Am. Assn. Geol. and Nat., 1841–2, p. 191.

[3] Proc. Bost. Soc. Nat. Hist., Dec., 1876.

[4] Kames of Maine. Proc. Bost. Soc. Nat. Hist., xx, 430, 1880.

coinciding with the main direction of the kame, the latter is apt to keep in it. Prof. Stone states that these long ridges are homologous with the Scandinavian Osars, rather than with the short ridges classed as kames.

In other parts of New England, kames have been described by several authors. In New Hampshire, Prof. C. H. Hitchcock and Mr. Warren Upham have made noteworthy contributions to this subject. In vol. iii of the New Hampshire Geological Survey, Mr. Upham has contributed a valuable chapter on surface deposits, among which the most important are the numerous kames. One of these, described by Mr. Upham as occupying the valley of the Connecticut River, has subsequently been studied by Prof. Dana, who believes [1] that it is merely a portion of the terrace formation in that valley, and that the name of kame should not properly be applied to it. Prof. Hitchcock,[2] however, has subsequently examined a critical locality in the Connecticut Valley, and finds the arched kame-gravel dipping beneath a horizontal terrace-loam, thus showing the greater age and different origin of the kame, and supporting Mr. Upham's views.

Prof. J. S. Newberry [3] and Prof. N. H. Winchell have described kames in Ohio, where they are known locally as "hog-backs.' Prof. Newberry at that time regarded them as due to the action of breakers and shorewaves at a period when the region was submerged under an inland fresh-water lake. Kames and kame-like ridges have also been described in Michigan and in Minnesota. In Canada, Sir William Dawson [4] has described certain ridges known as "Boar's-backs" and "Horse-backs," which he regards as eskers. One of these, in Cumberland, is a narrow ridge, so level on top that it forms a natural carriage-road for eight miles; another one, in Shelburne County, is a long ridge, also used as a carriage-road; while shorter and more interrupted ridges occur in a number of places. Sir William Dawson remarks that they bear no resemblance to glacial moraines, and believes that they were thrown up by "the surf or marine currents and tides." Prof. T. C. Chamberlin [5] has given an excellent description of kames

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[1] Am. Jour. Sc., xxii, 451, 1881.

[2] Proc. Am. Assn. Adv. Sc., xxxi, 325, 1882.

[3] Geol. Surv. of Ohio, vol. ii, p. 41–47.

[4] Notes on the Post-Pliocene Geol. of Canada, 1872, p. 40.

[5] Hillocks of angular gravel and disturbed stratification. Amer. Jour. Sc., xxvii, 1884, p. 378.

associated with terminal moraines in Wisconsin and elsewhere, and his paper contains a good reference list to the literature of kames. The kames described by him differ from those described in the present paper in being knob-like hills, "simple isolated mounds," or clusters of such mounds, rather than linear ridges, and also in lying transverse to the glacial movement, which is not the case with the Pennsylvania deposits.

Origin of Kames.—The early view of geologists as to the origin of kames, was that they were washed into shape by the waves and currents of the ocean. This was the view held by Dr. Jas. Geikie in the first edition of his "Great Ice Age,"[1] and was formerly advocated by many geologists both in Europe and America. But recent researches have shown that this view is untenable, and in the second edition of Dr. Geikie's book kames are regarded as the work of subglacial rivers.[2]

The researches of American geologists, especially the work in New England of Upham, Wright and Stone, have shown the occurrence of kames in positions out of the reach of oceanic currents. When marine deposits occur, as they do along the border of New England, in the St. Lawrence Valley, and elsewhere, they are seen to be horizontally stratified sands and clays often holding marine fossils, and clearly overlying the kame ridges. The terrace material of flooded rivers is also observed to overlie the kames.

On the other hand, kames are newer than glacial till, and overlie and swing around the drumlins of Massachusetts. These "drumlins," like those described by Kinahan and Close in Ireland,[3] are low oval hills, composed of unstratified glacial till, and are most satisfactorily explained as lenticular ground moraines formed under the ice sheet during its advance. They have been called "lenticular hills." Their longer diameter is generally parallel to the direction of the ice flow, as shown by neighboring striæ, and they appear to be of a mid-glacial age.[4]

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[1] Page 229.

[2] Page 217, etc.

[3] Glaciation of Iar-Connaught, Kinahan and Close, 1872.

[4] For discussion of "lenticular hills," see papers in Proc. Bost. Soc. Nat. Hist., by N. S. Shaler (xiii, 196), and by C. H. Hitchcock (xix, 63), and Geol. Survey of N. H., iii, p. 287; also, an article by W. M. Davis, Science, iv, 419.

Kames, therefore, would appear to be intermediate in age between the time of the deposition of the till or ground moraine and the age of the terraces and marine deposits. Mr. Upham[1] regards them as due to rivers flowing in channels formed upon the surface of the ice near its retreating edge. As the wall of ice on either side disappeared at the final melting of the ice sheet, the gravel and sand remained in long ridges or in mounds. He believes that kames were formed at or near the mouths of these surface streams, extending along the valley as fast as the ice front retreated.

Prof. G. F. Wright[2] believes that in many cases they are due to the sliding down from the surface of the ice of morainic debris accumulated near its end, so that they may represent medial moraines. He shows that they do not lie in channels worn in the till, and that very often they are unstratified, and thinks that the material composing them may have first formed lines upon the top of the ice. But, as Prof. Stone has shown, it is only among the highlands that the material of kames are poorly stratified; as soon as open valleys are reached the materials are worn, rounded and stratified.

Quite recently Prof. T. C. Chamberlin, of the U. S. Geological Survey, in an important paper "On the Terminal Moraine of the Second Glacial Epoch,"[3] proposes to separate kames from "Åsar," regarding kames proper as *tranverse* to the slope of the surface, the course of the valleys and the direction of the drift movement,"[4] while the term åsar is employed to designate long river-like ridges of gravel. Asar are described as extending "from higher to lower levels, following in general but not in detail the course of the greater valleys and the direction of glacial striation." As stated elsewhere,[5] they are held to be "the products of the drainage system of practically extinct glaciers."

This is practically the view of Professor Stone, and of other recent workers in this field, as it is that of the present writer. Moraines are the product of the *advance* of the ice-sheet, osars

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[1] Geol. of N. H., vol. 3, pp. 14–176.

[2] Proc. Bost. Soc. Nat. Hist., xx, 219.

[3] Third An. Rep. U. S. Geol. Surv., p. 295, etc.

[4] *Loc. cit.*, p. 300.

[5] Amer. Jour. Sc., xxvii, 378.

and kames of its *retreat*. If the distinction between osars and kames be sustained, the deposits described in the present paper might more properly be called "*marginal osars*." In many characters, however, they are intermediate between osars and kames as defined by Professor Chamberlin.

Kames are shown by the same authority to be composed of material derived from the adjacent till, and of local derivation, and from a study of their topographical situations and other features, the just conclusion is drawn[1] "that these hills could not have been produced by any form of beach action, whether assisted by ice or not," but that "they were formed along the edge of the ice-sheet by numerous marginal streams."

Prof. Chamberlin makes these kames "associates if not constituents of terminal moraines;" and classes them among moraine deposits. He says,[2] "It is my belief that they were due to special aqueous action attending glacial advances in such close relationship that they become distinctive incidental products, and mark the position of halt and retreat, as characteristically as the true moraines of mechanical origin themselves, which they so often overlie and conceal."

He therefore regards certain stratified knob-like hills of gravel in western and central New York State as representing a true terminal moraine of the second glacial epoch, and he has traced such a *kame-moraine* from Chautauqua Lake to the Mohawk and Catskills. These lines of hills he regards as representing the boundary of the great ice sheet at the period of its longest halt. He says that this inner morainic belt is "more massive and pronounced in development than the moraine referred to the older epoch,"[3] and "that its surface is fresher and less subdued by meteoric modification."

Granting that the line of kames so carefully traced out by Professor Chamberlin is correctly interpreted as representing a halt in the retreating ice-sheet, the present writer holds that, on account of their stratified character, such gravel deposits should not be identified with the unstratified masses of glacier-made till which constitute the true terminal moraine. The one is due to

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[1] *Loc. cit.*, p. 387.

[2] Third An. Rep. U. S. Geol. Surv., p. 376.

[3] *Loc. cit.*, p. 346.

water action, the other to ice action. The term *kame-moraine* is, in the opinion of the writer, a more appropriate name for such deposits than terminal moraine, which latter term would then be kept to designate the extreme outer mass of debris pushed out or dropped by the glacier at the time of its farthest extension.

That kames may be associated with the terminal moraine, is a fact which the writer will endeavor still further to demonstrate. But that they are distinct from it in structure, origin, and significance, will, it is believed, be granted after a careful consideration of the facts observed in Pennsylvania.

Marginal Kames in Pennsylvania.—That the terminal moraine separating the glaciated from the non-glaciated district has, throughout the greater part of its course in Pennsylvania (Plate III), an essentially unstratified character, has been sufficiently demonstrated in the author's report describing it.[1]

It has been shown that even where crossing river-valleys its unstratified condition is maintained; as, for example, opposite Belvidere in the Delaware, and at Beach Haven on the Susquehanna, at both of which places it is clearly distinguished from the stratified material lapping up against it. But immediately back of the moraine there occur in many places other stratified deposits, which, although similar in contour to the moraine proper, are worthy of separate consideration.

The class of kames which it is now proposed to describe, have, the writer believes, not heretofore been recognized in their true significance. These are either directly connected and continuous with the terminal moraine in Pennsylvania, or they are in such close proximity to it that they may properly be known as *marginal kames*. This term is given in order to distinguish them from longer kames or osars which may have no relation to the margin of the ice-sheet. None of them are transverse to the motion of the glacier, like a moraine, unless the drainage makes them so, and in this respect they do not answer to the definition of a kame given by Prof. Chamberlin, but have distinct characters of their own. They are all short, from a few hundred feet to a few miles in length, and they all follow the direction of the drainage. They have a general downward slope, and all lead toward a river-valley or other water-course. All those observed are made of water-worn materials, and where sections can be

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[1] Report Z, Second Geological Survey of Penna.

obtained show an anticlinal structure within. As already stated, their materials are finer in the interior, and most coarse in the exterior, and sometimes, though rarely, large boulders lie on the surface. The comparative shortness of their courses distinguish them from the long river-like osars. Their origin and significance can best be appreciated after a description of a few of them in detail. The accompanying map gives their general position with regard to the terminal moraine.

There are three kames in Northampton County, Pa., which are especially instructive. The most prominent of these is that which traverses the centre of Mt. Bethel Township in a northeast direction, follows approximately the valley of Jacobus Creek, and ends upon the banks of the Delaware at Portland.[1]

This kame, which has been mistaken for the terminal moraine,[2] is composed of a series of interlacing ridges and hummocks, often enclosing kettle-holes, and formed of stratified sand and water-worn gravel, carrying occasional rounded boulders upon the surface.

The town of Portland is built upon the kame, which here rises 100 or more feet above the river, forming a prominent hill. Some fine railroad cuts, through several ridges of the kame, 2½ miles from Portland, show it to consist of a stratified sand overlaid by a boulder-bearing clay, or till, as though it had been formed by running water *beneath* the ice, which on melting dropped the till. At this place, one mile southeast of Roxborough (Johnsonville P. O.), the kame is composed of a series of reticulated ridges, enclosing typical kettle-holes. One of these, known locally as the devil's kettle, and supposed by some to be an old Indian fort, is a symmetrical oval depression, surrounded by a raised rim, 300 feet long by 200 wide, and 30 deep. Like most kettle-holes, it has its longer axis parallel to the direction of the kame in which it lies. In the same neighborhood, similar rounded shallow depressions, with neither inlet nor outlet, lie upon the very summit of sandy ridges 100 feet above the level of the surrounding country.

These kettle-holes do not appear to be the result of natural erosion, and they are in no way allied to ordinary valleys or ravines, produced by the action of running water. The instruc-

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[1] See Page Plates 8 and 9, in Report Z, pp. 53, 68.

[2] F. Prime, Proc. Amer. Phil. Soc., xviii, 85.

tive fact that a raised rim frequently completely surrounds the kettle-hole, so as to elevate it above the surrounding country, is conclusive against any theory of ordinary erosion. In fact, the comparative *absence of erosion*, is one of the most remarkable facts relating to kames and their kettle-holes.

The kame here described is confined to the valley of Jacobus Creek. The high hills on the south are sprinkled with boulders, but hold no deposits of stratified drift.

The length of the kame is five miles. Its general elevation near Johnsonville is 600 feet above the sea, or 300 feet above the Delaware River at Portland; giving a northeastward slope to the kame of nearly 100 feet to the mile. It seems to have been caused by a stream, probably subglacial, draining *backwards* into the Delaware River at Portland. The direction taken by the stream producing the kame was just contrary to the direction of ice-flow, which was southeast. This kame is a good example of a *backward-draining* marginal kame.

Another locality which throws light on the origin of kames is in Upper Mount Bethel township, close to the base of the Kittatinny Mountain, and about a mile east of the moraine.

Here, on the road to the Fox Gap, a number of small, rounded, hummocky drift hills, and a series of ridges, irregularly interlaced with each other, composed of sandy water-worn drift within, but bearing upon their surface many boulders, form a fine series of small kames. These kames are not straight; they follow a curved line around Offset Knob.

Close to the flank of the mountain they bear south 20° west; somewhat lower and farther from the mountain, they bear south 30° west; still farther down the road, they veer yet more southwest. They seem to represent streams which, descending from the melting ice on the mountain, flowed at first southward, and then westward around Offset Knob, and, after issuing from the end of the glacier, emptied into the deeply flooded valley of Bushkill Creek, in Plainfield township.

Immediately north of these kames, a great accumulation of till and boulders forms a high ridge upon the side of the mountain. Most of the boulders are of Medina sandstone, but occasional boulders of limestone, and of fossiliferous rocks brought from the valley on the other side of the mountain, are found. This accumulation at a higher elevation than the series of kames represents the portion of the glacier whose melting supplied the kame streams. These small kames represented an outward drainage.

There are two curious little kames immediately south of Ackermanville, in Washington Township, Northampton County, which, though but miniature examples, have all the characters of larger kames, and offer a suggestion as to their origin.

Two small, straight, narrow ridges of stratified drift, 15 feet high and about 100 feet long, may be seen just below the village, running nearly at right-angles to the valley of the west branch of Martin's Creek. Both of these ridges run from the base of a hill west of the creek toward the stream, their direction being south 75° east; and west of each of them there is an opening in the hill, near the summit of which the moraine lies.[1]

Upon examining the structure of these ridges, as exposed by transverse cuts made by the railroad, they are found to be composed of fine stratified sand within and gravel without. The sand shows flow-and-plunge stratification, with a distinct anticlinal structure.

Here again the only satisfactory explanation is that they are due to subglacial streams which drained the melting edge of the glacier on the hillside *backward* into the subglacial valley, now occupied by the west branch of Martin's Creek. They are here at an elevation of 500 feet above the sea and about 190 feet below the edge of the moraine and are beautiful examples of miniature kames. An important point to note is that on placing the eye along the crest of each of these they are seen to be opposite small depressions in the hill on which the moraine rests. They are thus in precisely the position that would be occupied by the natural drainage of the edge of the ice-sheet.

The most interesting of all the kames of Monroe County are the curious conical hills and short ridges of sandy drift which lie along the centre of Cherry Valley, between the moraine and the Delaware River. A remarkable series of conical hills of peculiar and characteristic topography either stand singly, or (more generally) are connected one with another by irregular banks of gravel, to form a series parallel with the valley.

Near the Delaware Water Gap these hills rise often over 200 feet above the river, and often inclose basin-shaped depressions

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[1] See sketch-map in Report Z, p. 34.

or kettle-holes. They are most abundant between Stormville and the river. Where the valley widens, just east of Stormville, two sets of kame-like ridges on either side of the valley have the form of a V.

Short *tributary kames*, whose axes are at right-angles to the main kame in the valley, appear opposite ravines or depressions in the hills bordering the valley.

A *buried kame* lies along the north and south valley of Broadhead's Creek, almost completely covered by subsequent deposits of terrace material. The *top* of the kame stands out of the level terrace plain which borders the creek at Stroudsburg and vicinity. A fine section of the buried kame at Stroudsburg shows its anticlinal structure and a *fault* in it caused by settling.

Another most interesting *buried kame* is in the valley of McMichael's Creek, in Hamilton Township, where the top of the kame appears through the sandy terrace plain which covers the valley. The kame runs along the centre of the valley while the creek wanders irregularly through it. The kames are clearly older than the terrace material.

Of the other kames and kame-like ridges of Monroe County, reference only need here be made to certain kames upon the summit of the Pocono plateau, which are of interest in draining *northward;* of these there may be mentioned the steep, sharp ridges of sand near Tompkinsville, Tolyhanna Township, which run toward lower ground northward, thus draining the glacial waters toward the Lehigh. These are immediately back of the terminal moraine.

Again, just west of the Lehigh River, and immediately north of the moraine, there appear kame-like ridges of sand and gravel in small valleys emptying into the Lehigh. These are *parallel to the moraine*, and are so simply because the drainage is here south of east, while the moraine trends to the northwest.

Below Scranton, on the Lackawanna River, and also on the Susquehanna, are long ridges of stratified sandy material, which are quite distinct from the terrace deposits of those rivers, and which appear to be portions of a kame similar to that described by Mr. Upham on the Connecticut River, and of similar origin. These cannot be classed among the marginal kames.

In "Pope Hollow," close to the line between South Valley township, Cattaraugus County, and Carroll township, Chautauqua County, N. Y., and resting upon the water-shed between Pope Run (a tributary of the Allegheny) and Case Run (a tributary of the Conewango), the moraine is finely shown as a ridge of till, which, stretching completely across the valley, and covered by numerous boulders of gneiss, rises upon the highlands on either side. The moraine ridge here, as in other places, is most prominent *behind* or toward the west.

A very small *marginal kame* runs westward and down-hill from the back of the moraine, in Chautauqua County, as though a subglacial stream had drained the moraine backward, into the valley of the Conewango. The moraine itself is apparently unstratified, and no drift was noticed in front (E.) of it. Its only drainage, therefore, must have been *backward*, into the Conewango.

An interesting *double kame*, consisting of two ridges of sand united into one, the double anticlinals being exposed, was observer by the writer in Mercer County.[1] It is probably not a true marginal kame.

An examination of the marginal kames, of which sufficient examples have now been given, leads, as has been seen, to the conclusion that they were made by *subglacial streams draining the edge of the ice-sheet.* The occasional boulders and till on top of, but not in, these kames argue a subglacial origin, the boulders and till having been dropped by the retreating glacier on the kames; while the position and direction of each of the kames described is just such as would be taken by streams flowing beneath the ice-sheet. Among the facts ascertained with regard to marginal kames are their water-worn and stratified character; their rude anticlinal structure, often of finer sand within than without; the presence of occasional boulders and even *till* on top of them; the absence of any fixed relation to the movement of the glacier; the general coincidence of their course with that of the natural drainage; the total absence of shells, driftwood, beach-marks, or other indications of the action of ocean currents, waves or tides; their intimate connection with the terminal moraine in such positions as to indicate a *backward*, as well as a forward subglacial drainage.

These kames are very different from those tongues of stratified drift which often occur in or near the glaciated region at the

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[1] Report Z, p. 191.

junction of two streams (ancient or modern). These deposits do not show an anticlinal structure, and instead of occurring in the centre of a valley, are seen at points where an eddy in the drift-laden waters, or more commonly the shelter of a projecting rock, has allowed them to be formed. They may be termed *eddy-ridges* or *terrace-deltas*, and are clearly of entirely different origin from kames. The writer has seen a number of such ridges in northern Pennsylvania, and there is little difficulty in distinguishing them from kames.

That stratified deposits may exist beneath a glacier, undisturbed by the weight or motion of the ice, has been shown by observation at the base of the Swiss glaciers. Among the most interesting of these observations, because so well correlated with the phenomena of the American ice sheet, are those of Prof. Chamberlin, made at the base of the Rhone glacier. He remarks:[1] "At other points, near the centre of the valley, the ice may be seen resting directly upon well-assorted stratified sand and gravel. Level sheets of fine detrital matter extend without disturbance of continuity or surface beneath the edge of the glacier. The assorting and stratification of this material was apparently accomplished by subglacial streams, which seem afterwards to have found other avenues, when the ice occupied their place either by settling down from above, or advancing from behind. The singular fact is that the stratified sands should not have been disturbed."

The similarity between the contours of kames and of moraines is accounted for on the supposition that both were moulded beneath the ice sheet. While the moraine shows the edge of the glacier, the kames indicate the direction of its drainage. Flat terrace plains, such as that at Berwick, on the Susquehanna, are made by floods issuing from the front of the glacier, but when the drainage was subglacial, whether forward or backward, kames are the result.

Subglacial Drainage.—The most important conclusion arrived at by a study of the *backward-draining* marginal kames is that of a great *subglacial drainage.* The same conclusion is drawn from observations on the terminal moraine itself, which in many places shows evidence of having been drained *northward*, not southward. Many such instances might be described.

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[1] Wis. Geol. Survey Report for 1878, p. 17.

On the high mountain plateau of Potter County, Pa., for example, at an elevation of 2500 feet, although the Allegheny River flowed at the very foot of the glacier, there is no drift in the valley of the river, and no indication of any drainage to the south; while north of the moraine the whole country is covered with clays, terrace plains, kames and every indication of the presence of both ice and water.

Again, in Columbia County, Pa., although Fishing Creek flows in front of the edge of the ice sheet which once rested on its eastern bank, there are no gravel deposits in the creek; while immediately back of the moraine we find them in great quantities, leading around to another outlet.

So on the Pocono plateau, in Carbon Co., the drainage was reversed; while in Northampton County, and Monroe County it was clearly in both directions, outward and inward.

The writer has adduced evidence that the Allegheny River, near Olean, N. Y., flowed into the glacier and out of it again in the same channel that it now occupies; flowing in a *subglacial* channel through or under a tongue of ice ten miles broad by two miles long.[1]

Everywhere there are indications of a great subglacial drainage. The observations of other geologists, especially of Prof. Newberry, in Ohio, lead to the same conclusion. Studies among modern glaciers confirm these interpretations of glacial phenomena.

Prof. Nordenskiöld described the "large and swift rivers," plunging from the surface into profound crevasses of the Greenland ice-sheet, and Dr. Rink speaks of the copious subglacial streams which flow out from under the Greenland ice.

From beneath the Muir glacier of Alaska,[2] there issues a subglacial stream 100 feet wide, and 4 feet in average depth, the flow being the same winter and summer. Prof. Dana[3] has rightly assumed that the ice sheet of North America would have had "subglacial streams as much more extensive than those of Greenland, as the precipitation was more copious and the drainage areas larger."

Much of the boulder clay and till throughout the lower por-

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[1] Report Z, p. 154.

[2] Meehan, Proc. Acad. Nat. Sc. Phila., 1883, p. 249.

[3] Am. Jour. Sc., xxii, p. 366, 1882.

tions of both the United States and Canada, shows evident aqueous action, not only subsequently to, but during its deposition.

The great lake basins, and the St. Lawrence Valley, receiving subglacial streams from south as well as from north, may have been flooded with water while the ice still covered them.

Important deductions regarding the physical condition of the lowlands while covered by the glacier, and of the origin of certain aqueous varieties of till might be drawn from a further consideration of this subglacial drainage. The method of movement of a great glacier, a problem not yet fully understood, is also largely dependent upon the presence or absence of water beneath the ice.

The northward-draining marginal kames are undoubtedly but an insignificant portion of the widespread deposits made by the subglacial drainage which they indicate.

Since this paper was read at Montreal, Mr. J. H. Kinahan, of Dublin, who was present when the paper was read, has, in an article entitled "On the use of the term Esker or Kăm Drift" (Amer. Journ. Science, xxix, 1885, p. 135), criticized the pronunciation and use of the word kame by American geologists; while at the same time reaffirming his belief that "true esker or kăm drift" is "due to currents and eddies generated by the meeting or colliding of two or more currents in a mass of water, such as that of a sea or large lake." He argues that because of an ancient Celtic word "cam" or "kăm" meaning *crooked or winding*, we should pronounce the word kame short, as if spelled căm.

It is not probable that American geologists will adopt this short pronunciation. The word has long been pronounced kame both in England and Scotland, and in the latter country is often spelled *kaim*. Indeed Mr. Kinahan himself formerly used this spelling, and therefore also, the long pronunciation. (See his article "On the Drift in Ireland," Journ. Roy. Geol. Soc. Ireland, vol. i, p. 200, where he speaks of "eskers or *kaims*.")

The now antiquated idea that eskers and kames are due to oceanic or lacustrine currents has naturally enough been held in Ireland, where the land often lies but little above ocean level, but such a theory is untenable in America. Mr. Kinahan himself says, that the marginal kames of America must be quite different from the Irish eskers, and ventures the explanation that "there were at times 'flashes' or areas of shallow water accumulated margining the faces, portions of which were still water, while in other portions there were currents; or it might have been a mass of snow margining a narrow flash of flowing water." This explanation, like one held by Sir William Dawson (Proc. Amer. Assoc. Adv. Sci., xxxii, 1884, p. 25), that the terminal moraine simply marks the "limit of the deep water of a glacial sea," would probably be greatly modified had those geologists the opportunity of studying in the field the margin of the glaciated area of Pennsylvania.

How could any area of water, still or flowing, accumulate along the margin of an ice sheet which rests against an upward slope, as it so often does in this State? And if such areas of water did exist south of the moraine, why have not some relics of such a body of water been left in the shape of sand, gravel or clay? There is no fact in relation to glaciation more satisfactorily determined in the writer's "Report on the Terminal Moraine" than the absence of any body of water, deep or shallow, in front of the moraine. This unexpected fact is clearly shown by the entire absence of drift south of the moraine except in river valleys (the narrow glacial "fringe," elsewhere described, is excepted). While kames and many other deposits made by melting ice abound immediately back of the moraine, all these stop abruptly at the moraine, and the line of demarkation is at times so sharp that "it is almost possible to stand with one foot upon the glaciated and the other upon the non-glaciated ground" (Second Geol. Surv. of Pa., Z, p. 103).

The study of glacial phenomena is in a much more advanced stage in America than it is in Europe. To the smaller areas studied, and to the artificial changes which have modified the surface deposits of the Old World, are in great part due the limited views, the confusion of terms, and the contradictory theories which characterize much of the very voluminous literature of the glaciation of Europe. No better field for the prosecution of glacial studies can be found than in America, where single deposits extend for thousands of miles under varying conditions of mountain and valley, of flood plains and of prairies, and where in many places they stand to-day almost in the form in which they were originally made, untouched by the hand of man, and gently dealt with by that of time.

DESCRIPTIONS OF NEW SPECIES OF LEPIDOPTERA.

BY HERMAN STRECKER.

Papilio Nezahualcoyotl.

♂ expands 3 to 3½ inches. Head and body of same color, and marked as in the ordinary *Philenor;* all the wings broader, and not nearly as elongate as in that species, and the secondaries without tails.

Upper surface. Primaries blackish brown, with a dark blue shimmer towards the inner angle; a submarginal transverse row of five white spots, the first which is between the discoidal nervules is much the smallest, the next three are of nearly uniform size, and the last one, between the last median nervule and the submedian nervure, is geminate. Fringe near the apex black, from thence to the lower discoidal nervule black and white alternately, and from the latter to inner angle white, with black only at the termination of the veins.

Secondaries dark shining blue, with a submarginal row of six large white more or less lunate spots, the one at anal angle narrow, and much the smallest. Fringe of marginal indentations white; at termination of veins bluish black.

Under surface. Primaries paler than above, markings the same.

Secondaries after the manner of *Philenor*, but the brown of basal half extending over greater area; the continuous submarginal band of large spots of a deeper orange, more inclined to a red or brick-color.

From New Mexico, close to the Mexican border.

This insect bears about the same relation to the true *Philenor* that *Hospiton* does to *Machaon*, or *Anticostiensis* to *Asterius*, though in neither of the latter is there that almost total obsolescence of the wing-tails that so remarkably distinguishes the present form. It would be curious to know by what process nature has effected this abortion of the caudal appendages, and why it should occur in an exceedingly limited extent of territory.

All the examples of *Philenor* which I have seen from California have short tails to the wings, not much over half the length of eastern examples, and often much less; in the Californian examples the wings are also broader than in the eastern ones, but there is not that wide aberrancy that marks in a moment the above-described New Mexican form.

The largest examples of *Philenor* that I have seen were from Ohio, Pennsylvania and New York, whilst the smallest were from Georgia, and especially Florida, where, to the contrary, another of our species, the well-known *Turnus*, is found of large and frequently enormous size. The Californian examples of *Philenor* are small, or, at most, only of medium size.

Papilio Cleombrotus.

Expands 3¼ inches. Head and body black; on head are two obscure yellowish spots, two more on the collar, and one on each shoulder. Abdomen with yellow lateral stripes.

Primaries narrow.

Upper surface black, with greenish blue sheen on basal third; a large yellow central spot, partly within the median cell, and partly outside the median nervure. Fringes on upper half outer margin black, on inner half black and white.

Secondaries rounded outwardly, outer margin dentated. Deep shining greenish blue, except along the costa, where the blue shades into or is replaced by black; a row of small white submarginal lunules; dentations narrowly fringed with white.

Under surface. Primaries uniform dark chestnut-brown, with the yellow central spot of upper side repeated.

Secondaries same brown as primaries, with the same small white submarginal lunules of upper surface; above each of these latter is a crimson more or less lunate spot, the one near the anal angle very much larger than the others; at the base of wing three crimson spots placed one at shoulder, one within base of discoidal cell, and one between the median vein and inner margin; this latter is the largest, and is sagittate in shape.

From the condition of the abdomen I am unable to decide as to the sex of the single example on which the above description was based.

Hab.—Amaz. Sup.

This insect is closely allied to *Pausanias* Hew., but differs decidedly from it in the following particulars: In the entire absence of the large pale semitransparent apical patch, and in the fringe of inner half of outer margin being white and black instead of black only as in its analogue. In the much greater length of secondaries, and in their rounded outer margin, which in *Pausanias* is in a straight line from anal angle to apex. In the secondaries being, except along the costa, entirely blue, whilst in the other species that color is confined to the basal half of wing only.

On the underside in all wings being uniform dark brown, the primaries being devoid of the paler color of outer margin and apical part, as well as of the two or three small yellowish submarginal spots near the inner angle, and in the secondaries being without the alternating pale brown rays which emanate from the submarginal crimson lunules in *Pausanias*, as well as in the absence of the crimson line which in the latter continues from the anal lunule along the median nervure to base.

Both these species imitate in a remarkable manner *Heliconius Clytia*, but the mimicry is more complete in *Pausanias*, owing to its greater length of fore-wing and narrowness of hind-wing.

Of the last-named species I have seen many examples, of the present described only the single type now before me.

Theorema Titania.

Expands 2 inches; form of *T. Eumenia.*

Upper surface. Primaries black, disc and base covered with dark shining greenish scales; apex tipped with a paler silvery green, which is cut with white by the veins at and near their termination; a black marginal line succeeded by pure white fringe.

Secondaries black with a slight powdering of shining green atoms; a fairly broad glittering green marginal band extending from apex where it is narrowest to beyond the last median nervule where it attains its greatest width, this band is cut by the veins, which are black, and is separated from the white fringe by a black line; on the inner margin above anal angle is a small white spot. Tail black, fringed with white.

Under surface. All wings black. Primaries narrowly margined with greenish silver, broadest at apex; fringe white. Secondaries with three parallel rows of bluish white or silvery spots; those nearest the margin are crescent-shape, connected with a marginal line of same color; in the next row they are small, and with the exception of one, which is lunate, are round or oval; those composing the innermost row are smallest, and slightly and somewhat variously lunate. Fringe white.

From one example taken by the late Prof. Gabb in Costa Rica, now in Mus. Strecker.

On the upper side, omitting the tails, this insect bears a close resemblance to the females of *Eumæus Toxea* and *Minyas*.

There is, as far as I am aware of, but one other species of this genus known, *T. Eunomia* Hew.,[1] from New Granada, from which the one here described is entirely distinct.

Agrias Amydon, Hew. ♀

Expands $3\frac{1}{4}$ inches. Head black with four minute white spots above; palpi yellowish white. Body above deep ochraceous orange, below black with pale spots and marks. Wings, primaries broader than in the male; exterior margin straight until near inner and outer angles, where it is rounded.

Upper surface. Primaries, basal half, or rather more, bright ochraceous, deepening in tint towards the base; the outer part of wing black; this latter color starts at the inner angle and extends across in an arched line to within the middle of costa, forming a large triangular patch, which covers the outer part of the wing; a dash or an abbreviated band of black extends from inner angle along inner margin to over half its length; a band of three whitish yellow spots cross the black color towards the apex.

Secondaries, black with a small patch of deep ochraceous near the base, and a whitish edging at the apex.

Under side of all wings colored and marked as in the male, with the exception of the ground-color of primaries, which is ochre yellow instead of red.

Described from a single example which came to me in a lot of several thousand butterflies, taken at or near Pebas, on the Peruvian Amazon.

On the upper side this insect is the exact counterpart on a gigantic scale, of *Catagramma Sinamara* Hew., and (if my example, received from Mr. Hewitson be that species) of *C. Amazona* Bates, which is doubtless the ♀ of *C. cynosura* Hew., and further between which and the figure of *C. Sinamara* I can see no difference.

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[1] Hew. Ill. Diur. Lep., p. 69, t. 27, figs. 1, 2 (1865).

As far as they are known the females of the red species of *Agrias* mimic in an extraordinary manner the females of certain *Catagrammas*, and the blue ones the same sex in some of the species of *Callithea.*

Plusia corusca.

Size and shape of *Mortuorum* Guen. Head and body pale brown, inclining to ochrey beneath.

Upper surface. Primaries, ground color brownish pink; sinuate white or silvery basal and transverse anterior lines edged irregularly with deep bronzy brown; a transverse posterior line, this latter is broken, irregular, of exceeding fineness, and edged at intervals with deep brown; the space between this line or band and the transverse anterior line, and between the median nervure and inner margin is a deep golden or coppery bronze, according to the light in which it is seen, the same shade occupies most of the space between the submarginal, which is pink and sinuate, and the transverse posterior line, and also covers, except at inner angle, the space between the former and the exterior margin; a large and very distinct gamma mark as in *P. gamma* L.

Secondaries brownish, pale and ochraceous at basal half, and smoky on outer half.

Hab.—Colorado. One example, Mus. Strecker.

Though in detail the markings are somewhat different, still this insect forcibly reminds one of *P. mortuorum*, were the silver ground of the latter to be replaced by coppery bronze the resemblance would be very strong.

Plusia alterna.

Expands 1¾ inches. Allied to *Ampla* Wlk., but entirely distinct, all wings narrower than in that species, and primaries not as much produced at inner angle. Head and thorax light ashen or purplish gray; patagiæ with broad, dark brown margin, which color forms a continuous band across the back. Abdomen light brown.

Primaries of an even, shining pale, somewhat purplish gray, and without the shading and clouding of outer half as in *Ampla ;* a large dark space interior to the median nervure, and between the transverse anterior and posterior lines, this space is a dark rich brown, shading into black at upper part where it is outlined by a strong, well-defined silver mark, straight nearest to base, hooked outwardly ; this mark is quite different from the nearly straight insignificant mark of *Ampla ;* above the outer edge of the dark central patch, the transverse posterior line is double and inconspicuously continued towards the costa ; the transverse anterior line does not extend beyond the central patch, only at the place where it should terminate on the costa, is a dark spot. A small dark inconspicuous apical spot.

Secondaries orchrey brown, shading into smoky towards outer margin.

Hab.—Colorado. One example, Mus. Strecker.

JUNE 9.

Dr. GEO. A. KOENIG in the chair.

Seventeen persons present.

JUNE 16.

Dr. W. S. W. RUSCHENBERGER in the chair.

Fifteen persons present.

The death of Dr. J. Henle, a correspondent, on May 15, 1885, was announced.

JUNE 23.

Mr. JOHN H. REDFIELD in the chair.

Fourteen persons present.

A paper entitled "Descriptions of new species of Partula, and a synonymical catalogue of the genus," by Wm. D. Hartman, M. D., was presented for publication.

JUNE 30.

Rev. HENRY C. McCOOK, D. D., Vice-President, in the chair.

Twenty-eight persons present.

A paper entitled "Cervalces Americanus, a fossil Moose, or Elk, from the Quaternary of New Jersey," by W. B. Scott, was presented for publication.

JULY 7.

Mr. THOMAS MEEHAN, Vice-President, in the chair.

Fifteen persons present.

The death of Dr. Franklin B. Hough, a correspondent, on June 11, 1885, was announced.

The following were ordered to be printed:—

CERVALCES AMERICANUS, A FOSSIL MOOSE, OR ELK, FROM THE QUATERNARY OF NEW JERSEY.

BY W. B. SCOTT.

Several species of Elk or Moose have been found in the Quaternary deposits of the United States, and have been described by various observers. For the most part, however, the remains described have been so imperfect as to be of little value from a morphological point of view. The earliest account we have of such fossils is to be found in the Proceedings of the American Philosophical Society for 1818, p. 375. This is "an account of two heads found in the morass called the Big-Bone Lick, and presented to the Society by Mr. Jefferson," and was written by Dr. Caspar Wistar. One of these heads is assigned by Dr. Wistar to *Cervus*, and is thus described: "If it belonged to the genus *Cervus*, it was one of the largest species of that genus.

"The comparison of figures 4 and 5 with figures 6 and 7 (skull of wapiti), shows that the lately discovered skull resembles that of the Round-Horned Elk at the occiput, although it differs from it greatly in the position and projection of the horns. There is also in the Round-Horned Elk a considerable prominence of the frontal bone between the bases of the horns, which does not appear to have been the case in the newly-discovered head. [In part, at least, this is due to abrasion of the specimen.—S.] The bones of this last-mentioned head have a concavity or depression on the under surface near the root, which is not the case in the Round-Horned Elk.

"The cranium of the Moose, or *Cervus alces*, is very different. The occipital portion is concave exteriorly, and the superior margin has an angular indentation in it. There is a remarkable prominence between the horns, which extends considerably towards the nose. The horns of it project laterally like those of the newly-discovered head, and they have a concavity on the under surface near the root." . . . "I believe that each of the last-mentioned heads (*i. e.*, wapiti and moose), is at least of the ordinary size, as their horns are large, and it appears, from a comparison of the respective measurements, that the head lately discovered is larger than either of them."

Wistar did not name the species here described; this was done in 1825 by Harlan, in his Fauna Americana, who called it *Cervus americanus.* The only addition of importance to our knowledge of this species we owe to Dr. Leidy, who, in his "Ancient Mammalian Fauna of Dakota and Nebraska," p. 379, describes a pair of metacarpals accompanying the head described by Wistar, which Leidy says indicate an animal of greater stature, but more graceful proportions, than the great Irish Deer.

When Harlan named the species, the genera *Cervus* and *Alces* had not been separated; their later separation gave rise to a great confusion of nomenclature. In 1835 Sir William Jardine (Naturalists' Library, vol. xxi, p. 125), elevated *Alces* into a distinct genus, and called the American species *A. americanus.* Jardine supposed that Harlan's species was a true *Cervus*, and refers to it as the "fossil cranium and horns of a stag, . . . to which Dr. Harlan has applied the name of *C. americanus*," (p. 162). In 1836 Ogilby named the European elk *Alces machlis* (P. Z. S., 1836, p. 135), the name now generally employed for both varieties, while Harlan's name for the species described by Wistar has never been disturbed or questioned. But judging from Wistar's specimen, it becomes at once evident that this species is altogether different from *Cervus*, and belongs either to *Alces* or some closely allied genus. If it is to be classed in *Alces*, its specific name must be *A. americanus*, which name has been used by Jardine for the American moose. It will thus be seen that a serious confusion of names has arisen.

No other American fossil moose has received a special name, though many specimens have been found, some of the finest of which were in the Museum of the Chicago Academy of Sciences, and were destroyed in the great fire of 1871.[1]

Through the kindness of the Rev. A. A. Haines, the Museum at Princeton has received an almost complete skeleton of a very large extinct species of elk or moose, which was discovered in a shell-marl deposit under a bog at Mt. Hermon, New Jersey, six miles from Delaware Station on the Delaware, Lackawanna and Western Railroad. This superb specimen is practically complete, the only missing bones being five caudal vertebræ; two ribs; the right scapula and humerus; the right unciform and pisiform, and

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[1] See Judge Caton's Antelope and Deer of America, p. 194.

the trapezium of each side; one anterior ungual phalanx; the left calcaneum, and a number of bones of the rudimentary lateral digits. With the exception of the caudal vertebræ every missing bone of importance is represented by its fellow of the opposite side, so that it was well nigh impossible to go astray in making the necessary restorations.

The skeleton was of an adult, but not old, individual, as is shown by the condition of the epiphysis and teeth. The missing parts have been restored, and the entire specimen most skilfully mounted by Curator F. C. Hill. (See Pl. II).

A careful comparison of the Princeton specimen with that described by Wistar, which, together with the metacarpals described by Leidy, is preserved in the Academy of Natural Sciences of Philadelphia, convinces me that in all probability the two specimens belong to the same species. There are some unimportant differences and the old specimen is too imperfect to put this identification beyond question. But what remains of the Philadelphia skull agrees almost perfectly with the Princeton one, and at present there can be no reason for assigning them to different species.

On examination, however, it becomes evident that the species in question cannot be included in any known genus, as these are at present defined. While its affinities are undoubtedly closest to *Alces*, yet if we include it in that genus, the generic definition must be altogether remodeled and some of its most prominent characteristics would have to be suppressed. The differences from all known species which this fossil form shows, are of sufficient importance to entitle it to rank as a separate genus. With considerable reluctance, therefore, and in view of the confused nomenclature of the species, I feel compelled to form a new name for the genus. I would propose the name *Cervalces*, as indicating the types which it seems to connect. The genus may be defined as follows: *Cervalces*. Antlers dichotomous and palmated, though much less so than in *Alces;* beams horizontally directed, as in that genus, but with much longer pedicels; bez-antler and posterior tine present as in *Dama*, but these are connected by a broad and flaring process of bone, which descends below the level of the eyes. This does not occur in any other member of the *Cervidæ*. Nasals much longer than in *Alces*, a little shorter than in *Cervus;* anterior nares very much smaller than in the former, but larger than in the latter; premaxillæ shaped as in *Cervus* and reaching the nasals. Head broader than in *Alces*, prominence on frontal ridge and supra-occipital indentation absent. Upper and lower molars with supplementary columns; no upper canines. Ante-orbital vacuity bounded above by a separate bone (prefrontal?). Neck and trunk short, legs exceedingly long. Distal ends of lateral metacarpals present; internal cuneiform fused with the metatarsal.

As Harlan's name must undoubtedly be retained this species will be known as *Cervalces americanus.*

In the skeleton of this curious and striking fossil, the most obvious peculiarity is the great length of the legs, which gives the animal a remarkably stilted appearance, while the thorax is shallow, and the neck short. The shoulders are higher than the hips, as in the moose, and unlike the stag. The combined length of the head and neck shows that in the ordinary position of the legs, the muzzle would not reach the ground by 14 or 15 inches. Measured in the same manner the moose's muzzle reaches within about 10 inches from the ground, and that of *Megaceros* 8 or 9. These facts are of importance with reference to the question of the animal's habits and the presence of a prehensile upper lip.

Turning now to the characteristics of the skeleton in detail, we begin with:

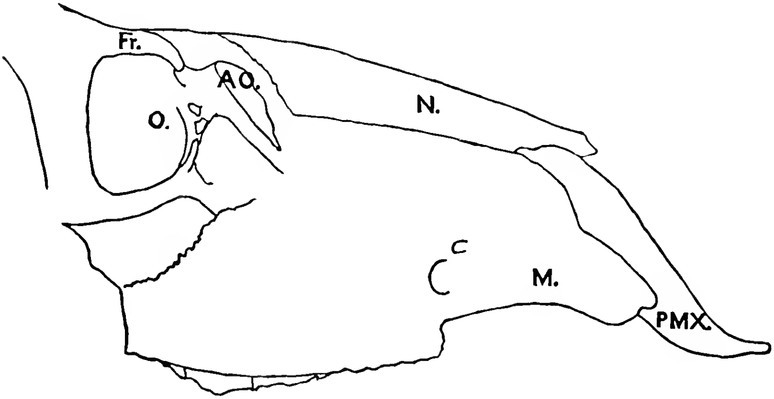

Fig. 1. Side view of face of *Cervus Canadensis*.

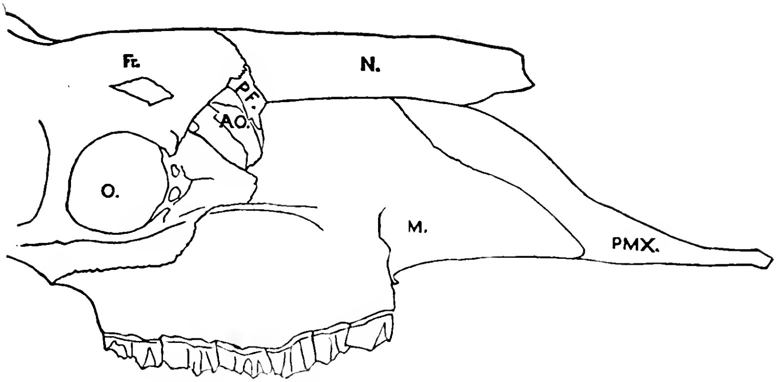

Fig. 2. Side view of face of *Cervalces Americanus.*

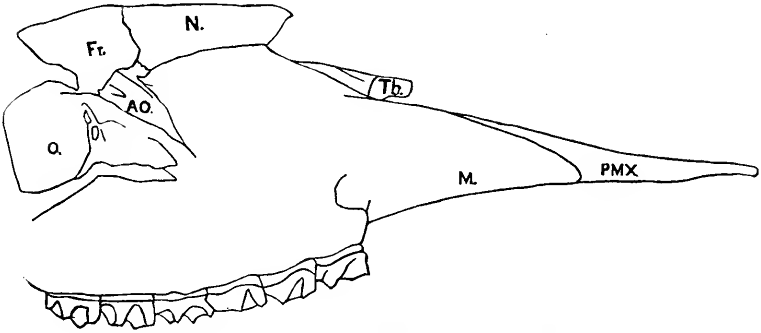

Fig. 3. Side view of face of *Alces machlis.*

The Skull.

The skull resembles most that of the living moose, though strikingly different from it in many respects, in which it approximates to *Cervus*. In spite of the greater size of the animal, the skull is both absolutely and relatively shorter than in the moose; this reduction, however, is chiefly confined to the region in front of the molar teeth. The cranium is considerably broader than in *Alces*, especially between the bases of the antlers. The appearance of that part of the face which is in advance of the molar teeth is strikingly different from the same region in the moose, and approximates rather that of *Cervus* (see figs. 1, 2 and 3). This difference is further increased by the fact that the nasals of the fossil are more than twice as long as in the moose; this increase of length of the nasals, together with the shortening of the face renders the appearance of the anterior nares very different from those of the moose. The edge of the nares in the latter measures nearly 11 inches, in the fossil hardly 8; in a large skull of *Cervus canadensis* the measurement is 4½ inches.

The *Premaxillæ* are like those of *Cervus* and not at all like those of *Alces;* they lie external to the anterior ends of the maxillæ and reach up to the nasals with which they articulate by a surface nearly an inch in length, while in the moose the ascending ramus of the premaxilla is inserted into a groove in the front edge of the maxilla and does not reach the nasals by several inches. This is not due merely to a shortening of the nasals, for though the ascending ramus is very long, its direction is so oblique that it does not rise to the level of the nasal, and no prolongation of the latter would effect a junction. The shape of the premaxilla is also very different in the two species, the horizontal portion being shorter, the ascending portion longer, and the posterior angle between the two sharper in the fossil than in the recent form. In all these respects the former shows an approximation to the shape of the bone in *Cervus*. Seen from the side the edge of the nasal opening is very different from that of the moose. In the latter this edge is very long and directed obliquely downwards and forwards (see fig. 1), while in the former the descent is much more abrupt. The whole tube inclosing the nasal cavity is much longer than in the moose, in which animal the turbinal bones project beyond the edge of the premaxillæ (fig. 3), and so can be seen from the side, while in the fossil they do not quite reach the edge of the nares (fig. 2).

The *Maxillæ* are more like the corresponding bones of *Cervus* than those of the moose. The difference, however, is almost altogether in the anterior part. The front edge is much less oblique and takes no part in the formation of the anterior nares. The edentulous part of the bone in advance of the molars is much shorter than in the moose, but the upper facial portion is of about the same length. As in *Alces*, the palatine plates in front of the molar teeth are contracted much more than in *Cervus*. There is a further difference from either of the genera in the fact that the alveolus behind the last molar is very narrow and short, ending in a mere hook. The condition is not unlike that seen in *Megaceros*.

The *Nasals* are intermediate in size and shape between those of *Cervus* and *Alces*. In *C. canadensis* these bones are about $\frac{2}{5}$ the entire length of the skull, in the moose a little less than $\frac{1}{6}$, in *Cervalces* $\frac{1}{3}$. In length, in their narrower and emarginate free ends, the nasals are like those of the true deer, but resemble those of the moose in not being so flat, but having the upper and lateral parts meeting at nearly a right-angle. The nasals in the fossil are in contact throughout their entire length, not having their posterior ends separated by the wedge-shaped process of the frontals, as is the case in the moose. These posterior ends are sharper and less abruptly truncated than in the latter animal.

The length of the nasals and shape of the anterior nares in *Cervalces* show that if the animal possessed a proboscis-like snout at all, it could not have been anything like as prominent and well developed as in the moose; such a proboscis being always accompanied by a great shortening of the nasals, as in the elephant, tapir, moose, *Sivatherium*, etc.

The *Frontals* present us with another difference from the moose and resemblance to the deer. As in both genera, there is an abrupt depression of the forehead in front of the antlers, but this is less than in *Alces*. In the latter there is a sharp knob on the ridge connecting the pedicels of the antlers, but in the fossil this knob is but faintly indicated. The forehead is broader and the orbits more projecting than in the moose, in both respects showing approximations to the cervine type.

The *Lachrymal* is of the ordinary size and shape, but the pit is unusually shallow. The ante-orbital vacuity is more quadrate in shape than is the case in *Alces*. The upper edge of this vacuity is bounded by a small distinct bone which I have not been able to find in any other of the *Cervidæ*, though what looks like a rudiment of it is attached to the nasal in the moose. The bone in question articulates with the nasal, frontal and maxillary; thus in position corresponding to the prefrontal, though morphologically it may be a separated portion of the nasal. It is hardly probable that this is a mere sport, as the bone is present on both sides, and is certainly a great peculiarity. (Fig. 2, *P. F.*)

The *Jugal* has more the shape of that in *Cervus* than that of the moose, in the simpler maxillary suture and shorter anterior process. The orbit is somewhat smaller than in the moose, and more nearly circular, the vertical diameter being greater in the latter, while the antero-posterior diameter is about the same in both. While the frontal rim of the orbit is more projecting than in *Alces* and the whole orbit is deeper, the jugal rim is less distinctly marked off from the body of the bone.

The *Squamosal*, with its zygomatic process, is almost exactly like that of the moose, the zygoma being directed downwards and forwards, instead of being almost horizontal as in the other *Cervidæ*. This peculiar shape of the zygoma is due to the great depression of the forehead, which, though somewhat less than in the moose, is greater than in the deer. If the plane of the upper molar alveolus be produced backwards, it will be found that the distance from the summit of the sagittal crest to this plane is much greater than in *Megaceros* (*Cervalces* 9 in., *Megaceros* not quite 6).

The *Occiput*. As Wistar pointed out, the occiput of the fossil is rather deer-like, in lacking the indentation of the supra-occipital, and in the greater flatness of the entire occiput. As in the moose, however, the condyles are nearly in contact below, while in *Cervus* they are quite widely separated. The basi-occipital has two large rugosities just in advance of the condyles, as in *Alces* and *Megaceros*. The paroccipital processes are stout and of the same shape as in the moose, though somewhat shorter. The proportions of the exposed part of the periotic are about as in that animal. The same is true of the tympanic which does not form an inflated auditory bulla.

The structures at the base of the skull—sphenoids, pterygoids, palatines, vomer and turbinals—need no special description, being very much as in the moose.

The *Inferior Maxillary* resembles the corresponding bone in the moose more than that of the other *Cervidæ*, but with some differences. The jaw, as a whole, is somewhat shorter and broader, the diastema and symphysis slightly shorter, and the coronoid process shorter and heavier.

The *Dentition* is like that of the moose, though with some cervine features. The crowns of the upper molars are shorter than in *Cervus*, but as in some species of that genus they have well-marked internal supplementary columns; all the lower molars have distinct external columns. In some specimens of the moose there is a small column on the first molar, a slight indication of one on the second, and none on the third; in others the second and third have small rudimentary columns. This may, perhaps, indicate that in this species the columns are in process of disappearance, having vanished in the upper jaw from all but the first molar. According to Owen, these columns are present in the upper molars of *Alces* (Brit. Foss. Mam., p. 450). This may be true of the Swedish elk, but not of the American specimens I have been able to examine. These supplementary columns do not appear to be constant generic characters, perhaps not even specific, though this latter is doubtful.

The stylo-hyals are present in the specimen, but are not especially peculiar.

The *Antlers*. The most striking peculiarities of *Cervalces* are to be found in the antlers, which are different from those of any of the *Cervidæ*, recent or fossil, with which I have been able to compare it, or of which I have seen any figure or description.

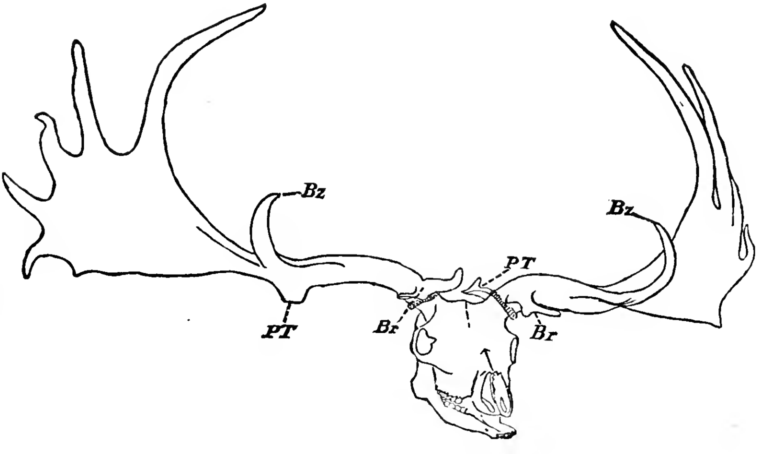

FIG. 4. Skull and antlers of *Megaceros hibernicus*.

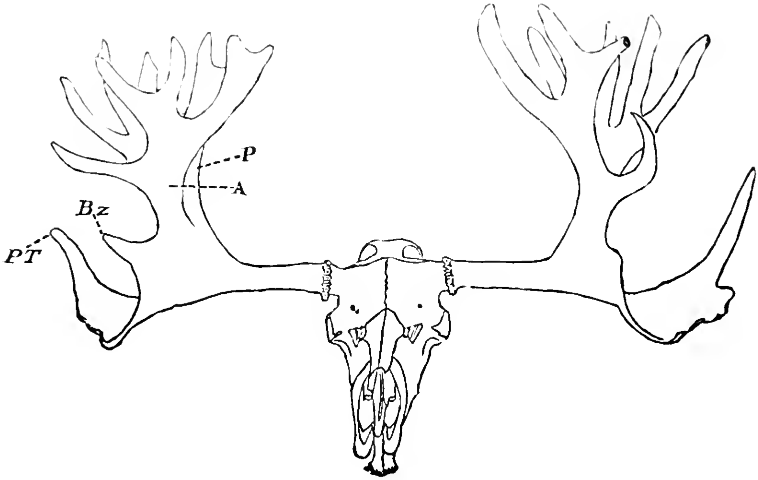

FIG. 5. Skull and antlers of *Cervalces Americanus.*

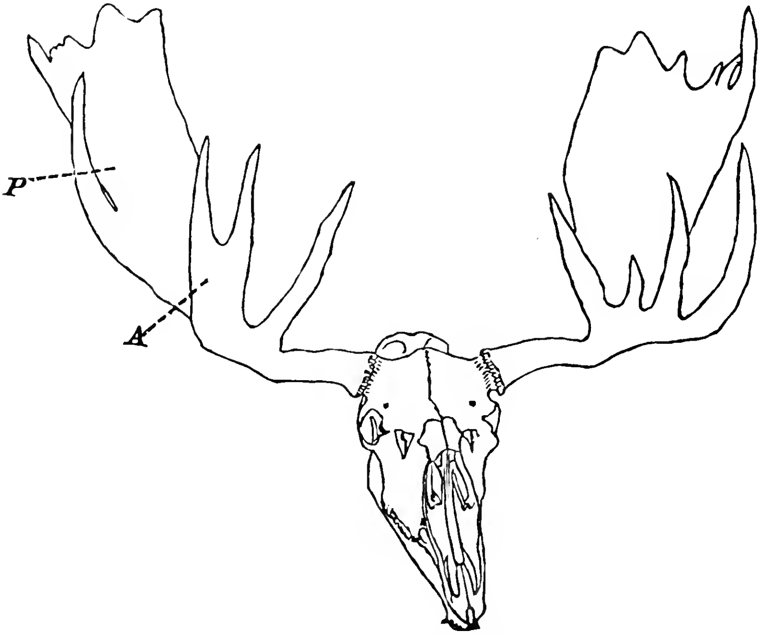

FIG. 6. Skull and antlers of *Alces machlis.*

The pedicels have an altogether horizontal direction, are somewhat longer than in the moose, and show a deeper posterior constriction, to allow the unobstructed movement of the coronoid process. The burrs are quite widely separated, almost an inch more than in the specimen described by Dr. Wistar. The beam is directed horizontally outwards, as in *Alces*, even drooping a little, as noticed by Leidy, and is unusually long before reaching the point of branching. Leaving out of account for the present the peculiar portion of the antler, it obviously belongs to the palmated dichotomous type of *Alces*. The ordinarily accepted view with regard to the antlers of that animal is that brow-antlers are not present. Sir Victor Brooke, however, considers the anterior division of the antler the homologue of the brow-branch (P. Z. S., 1878, p. 915). Assuming the correctness of the ordinary view, the fossil form agrees with the recent in being devoid of the brow-branch. The main antler is divided into two palmated portions, of which the anterior is the smaller, though it is both proportionally and absolutely much larger than in the moose (figs. 5 and 6, *A*). This portion is twisted on itself so that its flat side is presented forwards in a plane almost at right-angles to that of the posterior division. The palmation of this anterior portion is somewhat more pronounced, and the tines more flattened than in the moose. In the figures all the tines appear somewhat blunt, though this is due to the fact that the animal died while the antlers were yet in "the velvet." In the moose the division into the two palms takes place in a plane only a little above the level of the frontal ridge ($2\frac{1}{4}$ in.), in the fossil the beam turns sharply upwards for several inches ($6\frac{1}{2}$) before the point of separation is reached. The appearance of the anterior branch is very different from what is seen in the moose. In the specimen before us there arises from the point of division a narrow flat plate somewhat twisted on itself, which gives off a sharp and stout lateral tine, two or three inches above the point of division; above this tine the plate broadens for a little distance and then bifurcates. On the right side both of these divisions are again bifurcated, the outer one much more deeply than the inner; on the left side the inner prong does not divide, though it is broad and flat. This gives five prongs on the right side and four on the left. Except the lateral tine, all the tines are flattened antero-posteriorly, having a plate-like appearance from the front.

In the moose, on the other hand, the anterior division shows a broad basal palm, which sends up a number of long, sharp and rounded tines, all arising at about the same level (fig. 6, *A*), though adjacent ones may be more or less connected by palmation.

The posterior division of the antler also differs markedly from that of the moose in being much smaller and much less palmated. The size of the palm in its greatest diameter being 9 by 8 inches, while in one specimen of the American moose at Princeton these dimensions are 28 by 17 inches. In the latter animal the tines of this division of the antler are, with the exception of the first mere finger-like processes from the top of the palm (fig. 6). In *Cervalces*, as in the European elk, and some specimens of the American moose, the tines are very much longer, though the palm in the European variety is still much greater than in the fossil. Owing to the height at which division into the anterior and posterior branches of the antlers takes place in *Cervalces*, the first tine of the hinder branch is very much shorter than in the moose (*Cervalces* 13½ inches, *Alces* 21 inches).

The proportionate number of tines in the two divisions is also different in the living and extinct species. In one American moose I find the numbers to be: right antler, anterior 3, posterior 8; left, ant. 4, post. 8. Another specimen gives: ant. 2, post. 5; in a third specimen, ant. 4, post. 8. A European specimen gives ant. 4, post. 7; another is ant. 3, post. 6. In the fossil, on the other hand, we have on the right side, ant. 5, post. 5; left side, ant. 4, post. 4; showing a different method of growth in *Cervalces* from that observed in any known species of *Alces*.

The feature, however, which differentiates the antler of *Cervalces* from that of all other known *Cervidæ* remains to be described. Where the upper edge of the beam rises to form the palmated portion of the antlers, the lower edge expands into an immense concave process, which is presented outwards like the mouth of a trumpet, and which ends both anteriorly and posteriorly in a round, pointed tine, the latter being long, the former quite short (fig. 5, *P. T.* and *Bz.*). The posterior tine is directed obliquely outwards and backwards, so that the distance between those of the two antlers exceeds five feet. On the left side there is a rudimentary tine or snag at the base of the long posterior tine, on the right side the broad plate of bone gradually tapers off into the tine. It is a curious fact that these great ear-like processes descend considerably below the level of the eyes, so that the animal's vision in a lateral direction must have been seriously interfered with. It is difficult to understand how any such structure of the antlers could have arisen or what its purpose was.

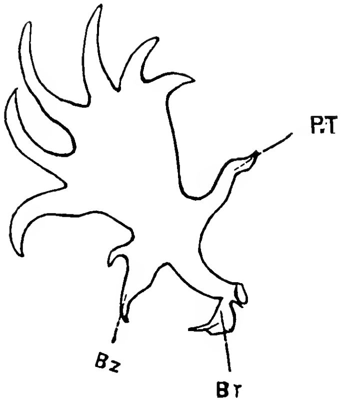

Fig. 4 *a*.

Right antler of *Megaceros hibernicus*, from the inside.

On comparing the antlers of the extinct species with those of the moose, it becomes evident that the former consist of the same parts as those of the latter, with something added to them. Just what these additional parts are is by no means easy to say. The anterior tine (of the ear-shaped process) may be the bez-antler, while the posterior one may correspond to the tine which in *Megaceros* (figs. 4 and 4 *a*, *P. T.*), the fallow deer (see Brooke, P. Z. S., 1878, p. 914, fig. 9), and some others, is given off from the hinder surface of the beam nearly opposite the bez-antler (*d* in Brooke's system). If in *Megaceros* the palmated portion of the antler were bent sharply upwards nearly at right-angles with the beam, the posterior tine directed more outwards and connected by a broad and flaring plate of bone with the bez-antler in front, the resulting condition would be very much what we find in *Cervalces*. If this conjecture as to the homologies of these tines be correct, Sir Victor Brooke's views on the parts of the moose's antler can hardly be accepted (P. Z. S., 1878, p. 915). It is worthy of notice that in *Cervalces* almost all the weight of the antlers is in advance of the occiput. To a much smaller extent this is true of the moose, while in most of the *Cervidæ* the weight is entirely back of the occiput.

It might be suspected (as for a time I did suspect) that in this fossil we have to do with a case of monstrosity rather than with a true species character—some such phenomenon as the double-palmed moose antlers from Sweden, and those found fossil in America, as illustrated by Judge Caton,[1] or as in the case of the curiously palmated antlers from Texas, reported by the same observer (*American Naturalist*, vol. xviii, p. 736). While of course this may possibly be the case, it seems very improbable for the following reasons: (1) The symmetry of the antlers, which show no sign of injury or distortion, and which are precisely alike on both sides, except that on one side two tines are bifid, which on the other are single. But such inequality is very common on all large antlers; in fact, is rather the rule than the exception. The double-palmed antlers of which Judge Caton speaks are so only one side. (2) Monstrosities, except in cases of atavism or in mere *repetition* of parts normally present, are much more apt to be in the direction of simplification than of increased complexity. It is therefore very unlikely that these antlers are simply sports from the ordinary *Alces* type, for they contain elements which are never found in the moose, but which seem rather to belong to the true deer.

Gray's view that *Cariacus* lacks the brow-antler can hardly be correct, as the so-called "basal-snag" of that genus is clearly nothing else. Prof. Cope's statement[2] that palmation of the antlers transfers a form from *Cariacus* to *Alces*, is one that I cannot accept. Of the many differences which separate the two genera, the palmation of the antlers is the least important. Any such transfer must ignore the much more significant features of the teeth, skull, and limbs.

SKELETON OF THE TRUNK.

Cervical Vertebræ. The neck is short when compared with the height of the animal, shorter even than in the moose. The atlas is provided with a large and heavy hypapophysis, of which only a small rudiment is to be seen in the moose or in *Megaceros*, but is quite well developed in *Cervus elaphus*. Richardson, however, figures a moose's atlas from Canada, in which the hypapophysis is very distinct (Zoology, Voyage of Herald, pl. xxi and xxii). The remaining cervicals show only differences of detail from those of *Alces;* thus the transverse process of the axis is more slender,

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[1] Antelope and Deer of America, p. 194.

[2] American Naturalist, vol. xviii, p. 738.

the pleurapophysial plate on the sixth vertebræ is smaller, that on the fifth larger.

The only other member of the *Cervidæ* with which *Cervalces* can be compared in size, is the great extinct Irish deer *Megaceros.* But in the latter we find a very much longer neck, the vertebræ of which are vastly heavier, and all the processes are larger and stouter, showing the great muscular power necessary to wield the immense antlers. In *Cervalces* the cervical vertebræ appear puny in comparison.

Trunk Vertebræ. In *Megaceros* these vertebræ are provided with very long and heavy spines; those of the anterior thoracic being twelve or thirteen inches in length, on the posterior about eight. In *Cervalces* the spines are shorter and especially lighter. The rise of the back at the withers is even less marked than in the moose. The vertebral centra are also shorter and lighter than in *Megaceros*, giving a much shorter trunk. The lumbar, sacral and caudal vertebræ do not differ in any important way from those of the moose, except that the neural spines of the sacrum are somewhat more closely co-ossified.

The *Ribs* are rather short, only a very little longer than in the moose, and therefore proportionately considerably shorter. The thorax is consequently shallow, and together with the long limbs gives the animal a stilted appearance. The greatest depth of thorax from tip of neural spine to the sternum is in *Megaceros* 34 inches, in *Cervalces* 29, in the moose 28.

The *Sternum*, curiously enough, is somewhat different from that of the moose; the manubrium being smaller and of a somewhat different shape. The first two segments of the mesosternum resemble the corresponding parts in *Cervus*, and differ from those of *Alces* in being long and narrow, instead of short and broad.

THE LIMBS.

The limbs are remarkable for their great length and slenderness. Though considerably longer than those of the great Irish deer,[1] they are not nearly so stout. The hind legs are especially long, but the withers are higher than the rump, as is the case

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[1] It is very unfortunate that the name "Irish Elk" is so commonly applied to this animal, which seems rather to have been a gigantic fallow-deer.

with the moose. The *Scapula* is rather small in proportion to the size of the animal, being a little shorter than in the moose, and much more so than in *Megaceros*. In shape the bone is more cervine than alcine; the anterior border is straighter, and the prescapular fossa smaller than in the moose, while the neck is less contracted and the coracoid larger.

The *Humerus* is not different in any important way from that of the moose, except for a slight increase in length.

The *Ulna* and *Radius* show a still greater increase in length, but are only slightly thicker than in the moose, so in proportion they are more slender. As in *Alces*, the two bones are co-ossified only at the distal end, instead of being firmly united for two-thirds their length as in most deer.

The *Carpus* is like that of the moose in almost every particular, consisting of scaphoid, lunar, cuneiform, pisiform, trapezium, trapezo-magnum, and unciform.

The *Metacarpus* is very long, much of the great height of the animal being due to it. It is about one-half an inch shorter than in the largest of the two Philadelphia specimens, but the proportions are almost identical. The rudimentary lateral metacarpals are like those of the moose in shape, but are longer.

The *Phalanges* of the median digits are unusually long and slender, even when compared with those of the moose. The unguals are very long and pointed. The phalanges of the rudimentary digits are larger and heavier than in the moose.

The *Pelvis* is almost precisely like that of the moose, and needs no particular description.

The *Femur* is slightly longer, but no heavier than in the moose, and offers a striking contrast to the massive thigh-bone of *Megaceros*, which is as heavy as that of an ox. The trochlear groove is shallow, with sharp edges, and the patella is small. The great trochanter is higher than in the *Megaceros*, and rises more vertically from the shaft, but all the other processes for muscular attachment are much less prominent.

The *Tibia* is an exceedingly long bone, but its increase in length has not been accompanied by any corresponding increase in thickness. The astragalar groove is like that of *Alces*, the fibular facet and the fibula are like those of *Cervus*.

The *Tarsus* is somewhat longer than in the moose, of about the same length, but narrower than in *Megaceros*. The calcaneum is nearly an inch longer than in either form, giving a prominent "hock-joint." In the smaller bones of the tarsus we find some curious relations. On the left side the arrangement of these bones is nearly the usual one among the *Cervidæ*. That is to say, the cuboid and navicular are fused into one bone, the second and third cuneiforms into another, but, strange to say, the first cuneiform is firmly ankylosed with the metatarsus, forming a little step against which the compound cuneiform abuts. In the right foot the process of ankylosis has gone further and gives a tarsus which is even more concentrated than in the Tragulina. (See fig. 7). The compound cuneiform is fused with the cubo-navicular (fig. 7, *N.* and *Cb.* and *C.*, 2 and 3), and the first cuneiform, as in the left foot, with the metatarsus (fig. 7, *C* 3). This fusion of tarsal bones with the metatarsus is very curious. It does not occur in any known ungulate, and I am acquainted with no other mammal in which it can be found. A tarso-metatarsus, in the same sense, but to a less degree, as in birds, is thus formed.

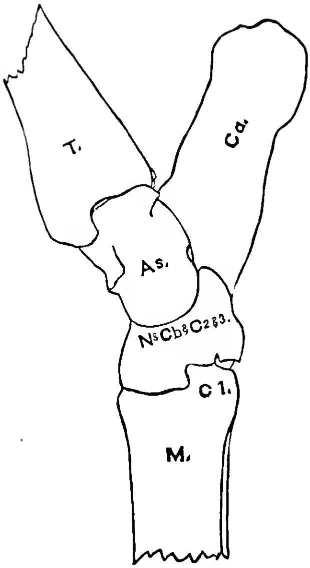

Fig. 7.

Right Tarsus of *Cervalces Americanus.*

The *Metatarsus* is very long, and of about the same proportions as in the moose.

The *Phalanges* of the median digits are a little longer than in the fore-foot, those of the rudimentary digits of about the same size.

Conclusion.

Cervalces Americanus is a very interesting form, and offers some morphological suggestions of great value. Geologically it teaches little that was not known. Its occurrence so far south of the moose's range, points to a colder climate than the present, though the perfect preservation and freshness of the bones in the Princeton skeleton make it hard to believe that they are more than a few years old.

In all probability the habits of the animal, and to a great degree its appearance, were those of the moose. Its short neck shows that it would have great difficulty in grazing, and so probably lived by browsing upon shrubs and trees. This was aided, no doubt, by a more or less prehensile upper lip, which the character of the nasal opening shows to have been more proboscis-like than in the deer, though far less so than in the moose.

Morphologically the fossil is of interest for the light which it seems to throw upon the question of the origin of the genus *Alces*, and its relations to the typical deer. Sir Victor Brooke and Prof. Garrod have shown that the *Cervidæ* may be subdivided into great groups according to the characters of the skull and fore-feet. According to the latter we have the Plesio- and Telemetacarpi, or those which retain the proximal and distal ends of the metacarpals respectively. With one exception, *Cervus canadensis*, all American deer are Telemetacarpi, while nearly all of the Old World deer are Plesiometacarpi. Those of circumpolar range, the reindeer and moose, are both Telemetacarpi. Another distinction is found in the structure of the skull. In one division, the American deer (except *C. canadensis*), the vomer reaches the palatines and projects beyond them, dividing the posterior nares into two. The Old World deer have a vomer that does not reach the palatines, and the posterior nares are not divided. In *Alces* we have the latter type of skull.

The chief differences between the true *Cervus* and *Alces* are as follows: (1) The former is plesio-, the latter tele-metacarpal, both agreeing in the structure of the nasal passages. (2) *Cervus* has cylindrical antlers, with brow- and bez-tines rising abruptly from long pedicels. *Alces* has palmated antlers, without brow- or bez-tines, the beam directed horizontally from the short pedicels. (3) In *Alces* the nasals are very short, the anterior nares of great extent; in *Cervus* the nasals are long, and the anterior nares small. (4) In *Alces* the premaxillæ are imbedded in a groove of the maxillæ, and do not reach the nasals; in *Cervus* they lie external to the maxillæ, and (in some species at least) do reach the nasal. (5) In *Alces* there is a deep notch on the supraoccipital, and a prominent knob on the frontal ridge, neither of which is present in *Cervus*. (6) In *Cervus* the skull is short and broad, and the diastema of moderate length; in *Alces* the skull is long and narrow, and the diastema very long. (7) In *Cervus* the tympanic bulla is inflated; in *Alces* not. (8) *Cervus* has a horizontal zygoma; in *Alces* it is directed downwards and forwards. (9) *Cervus* possesses canine teeth in both sexes; *Alces* in neither. (10) *Alces* has a short neck and trunk, long limbs and head; *Cervus* has longer neck and trunk and shorter legs. (11) In *Alces* there is a proboscis-like upper lip and almost obsolete rhinarium; *Cervus* has larger rhinarium and ordinary snout. In nearly all of these particulars, *Alces* is plainly a greater departure from the ordinary cervine type than is *Cervus*, and must, therefore, be regarded as a more differentiated and highly specialized form. If this be the case, we should naturally conclude that *Alces* is the descendant of some form much more closely allied to *Cervus* than itself is. That the descent cannot be from the actual genus *Cervus* seems to be plain from the character of the fore-foot. A reasonable inference seems to be that the common ancestor of the two genera had already attained the structure of skull found in the Old World deer, but that its fore-feet were tetradactyl, the lateral metacarpals, though slender, were complete or nearly so in length.

Now *Cervalces* throws some light upon this community of origin and subsequent divergence of the two genera. In many respects, as we have already seen, *Cervalces* differs very decidedly from *Alces*, and nearly all these differences are approximations to the structure of *Cervus*, a result which can hardly be accidental. But except in the skull, the structure of the fossil form is much nearer to that of *Alces*. The fossil agrees with *Alces:* (1) In the short neck and trunk and very long legs; (2) in being telemetacarpal; (3) in having palmated antlers; (4) in the absence of an inflated tympanic bulla; (5) in the shape of the zygoma; (6) in the absence of canine teeth.

On the other hand it agrees with *Cervus:* (1) In the presence of the bez-tine (?) and posterior tine on the antlers; (2) in having long nasals; (3) in the shape and relations of the premaxillæ; (4) in the absence of the supra-occipital notch and knob on the frontal ridge; (5) in the greater proportionate breadth of the skull; (6) *Cervalces* almost certainly had a rhinarium and upper lip more like that of *Cervus* than of *Alces*.

Cervalces differs from both genera: (1) In the intermediate condition of the anterior nares; (2) the peculiar antlers; (3) the distinct prefrontals; (4) the remarkable concentration of the tarsals.

It thus seems very probable that *Alces* is descended from a type with limbs, skull and antlers of the ordinary type and with tetradactyle fore-feet, but has modified these in various ways. The length of limb seems to be connected with the habitat of the animal in snowy regions, and we are told that the moose can make his way with great swiftness through snow-drifts that will engulf ordinary cattle. The unusual size of the lateral digits seems to have reference to the animal's habit of living in swampy lands during the summer, and so needing a broad surface to prevent sinking in the mud. The shortening of the neck is difficult to account for, but the proboscis-like upper lip seems to be clearly connected with the habit of browsing upon trees. Shortening of the neck is very generally associated with the development of a prehensile lip; *e. g.*, the combined length of head and neck in the rhinoceros is relatively greater than in the tapir.

Cervalces seems to have been a contemporary of the moose which also occurs in quaternary deposits, though in all probability the former is the older of the two. Its extinction may be referred to the general causes which destroyed so many of the large quaternary mammals, though the competition of the more perfectly adapted moose may have had something to do with it.

Whatever taxonomic value be allowed to the peculiarities of this strange fossil, the fact remains that in it we can catch some glimpse of the successive steps by which the remarkable genus *Alces* has originated.

Measurements.

	Alces.	*Cervalces.*	*Megaceros.*
	M.	M.	M.
Length of trunk from 1st rib to end of ischium,	1·478	1·550	1·683
Length of thorax,	·703	·755	·840
Length of lumbar region.	·440	·435	·444
Length of sacrum.	·235	·225	·241
Length of neck,	·515	·563	·756
Length of skull,	·550	·536	·453
Breadth of forehead,	·205	·255	·220
Distance between burrs of antlers,	·165	·234	·120
Length of nasals.	·103	·181	·170
Anterior nares from nasals to tip of premax.	·285	·185	·120
Span of antlers,	1·175	1·620	2·260
Length of antler, measured along outside curve,	·925	·863	1·702
Length of pedicels.	·020	·028	·048
Greatest height at withers,	1·695	1·810	1·890
Height at sacrum.	1·565	1·680	1.610
Height at occiput,	1·610	1·790	1·940
Height at tip of antler.	2·253	2·342	2·740
Length of fore-leg (straight line).	1·565	1·685	1·620
Length of scapula,	·443	·443	·455
Length of humerus (fr. tuberosity).	·405	·425	·375
Length of radius,	·415	·450	·378
Length of carpus.	·043	·055	·045
Length of metacarpus (outside),	·318	·355	·324
Length of phalanges,	·193	·225	·188
Circumference of humerus, (below exter. tuber.),	·175	·185	·200
Circumference of radius.	·132	·140	·145
Circumference of metacarpus,	·118	·132	·135
Length of hind-leg (straight line).	1·450	1·477	1·360
Length of femur (from head).	·435	·440	·435
Length of tibia.	·485	·512	·450
Length of tarsus.	·097	·117	·114
Length of metatarsus,	·385	·421	·343
Length of phalanges.	·213	·234	·197
Circumference of femur.	·147	·155	·180
Circumference of tibia,	·175	·170	·190
Circumference of metatarsus,	·135	·147	·150
Longest dorsal spine.	·283 (3d)	·290 (3d)	·367 (8th)
Circumference 4th cerv. vertebra.	·340	·373	·490
Circumference of last lumbar (incl. spine),	·290	·295	·375
Length of pelvis.	·501	·490	·520
Longest rib (from tubercle),	·533 (8th)	·550 (8th)	·610 (9th)

It will be noticed that the dimensions here given for *Megaceros*, which are taken from a skeleton in the Princeton Museum, are very different from those given by Owen in his "British Fossil Mammals." The discrepancy is largely due to different methods of mounting.

EXPLANATION OF FIGURES AND PLATE.

Fig. 1. Side view of skull of *Cervus canadensis.*
Fig. 2. Side view of *Cervalces americanus.*
Fig. 3. Side view of *Alces machlis.*
References for figs. 1–3.—*Fr.*, frontal; *N.*, nasal; *Tb.*, turbinal; *Pmx.*, premaxilla; *M.*, maxilla; *Pf.*, prefrontal (?); *O.*, orbit; *A. O.*, ante-orbital vacuity.
Fig. 4. Skull and antlers of *Megaceros hibernicus.*
Fig. 4 *a*. Right antler of *Megaceros hibernicus*, from the inside (from Owen, British Foss. Mam. and Birds. fig. 186, p. 456).
Fig. 5. Skull and antlers of *Cervalces americanus.*
Fig. 6. Skull and antlers of *Alces machlis.*
References for figs. 4–6.—*Br.*, brow antlers; *Bz.*, bez-tine; *P. T.*, posterior tine (as of Brooke's system); *A.*, anterior division of main antler; *P.*, posterior division of main antler.
Fig. 7. Right tarsus of *Cervalces americanus.* *T.*, tibia; *Ca.*, calcaneum; *As.*, astragalus; *N*, *Cb.* & *C* 2 & 3, compound bone formed by fusion of cuboid, navicular, second and third cuneiforms; *C*1, first cuneiform, fused with metatarsus; *Mt.*, metatarsus.

Plate II.

Skeleton of *Cervalces americanus* (from a photograph). The scale is in feet, and tenths of feet.

I wish to express here my obligations to Dr. F. C. Hill, Curator of the Museum, for his invaluable assistance in this work. I am indebted to him for the drawings of Figs. 1, 2, 3 and 7.

DESCRIPTIONS OF NEW SPECIES OF PARTULA AND A SYNONYMIC CATALOGUE OF THE GENUS.

BY WM. D. HARTMAN, M. D.

Partula Magdalinæ, nobis.

Shell short, conic, dextral, inflated, thin and fragile; spire short, half the length; umbilicus somewhat compressed; whorls 4½, apical whorls very thin, rounded and sub-transparent, with the embryonic lines of fovea deeply impressed, which become numerous waved spiral striæ, decussated by fine oblique lines of growth, causing a granulated appearance of the surface; body-whorl much inflated, with the basal half thickened and rounded; columella wide at the base, and nodulose; color white, epidermis thin, pale green, in bands on the basal half; aperture perpendicular, large, rounded ovate, lip thin, white, concave and reflected.

Length 10, width 11 mill.; aperture, length 8, width 5 mill.

Hab.—Magdalena Island, Marquesas.

Obs.—I am indebted to Mr. Andrew Garrett, of Huaheine, for four examples of this shell; it is about the size of *P. decussatula*, but more inflated, thinner, with a short, and less acute spire. Like *P. Ganymedes* and *P. inflata*, from Marquesas, the basal half of the shell is thicker and more opaque than the superior part.

Partula bellula, nobis.

Shell abbreviately ovate, dextral, umbilicate, thin, translucent; whorls 5, rounded, suture impressed, apex acute, spiral striæ decussated by coarse oblique lines of growth, giving the surface a waved appearance; aperture perpendicular, round-ovate, columella wide at the base, lip thin, white, reflected; color pale straw, with the apex very pale rose.

Length 15, width 9 mill.; aperture, length 7, width 4 mill.

Hab.—Wapo Island, Marquesas.

Obs.—Mr. A. Garrett collected one example of this pretty species on Wapo, at an altitude of 2500 feet above sea-level. A similar shell, sent by him to the Museum Godeffroy, was found at Dominique at the same altitude.

Partula Tryoni, nobis.

Shell acuminately oblong, dextral, moderately thick, rimate perforate; whorls 5, rounded, body-whorl equal to the spire, oblique lines of growth coarse, spiral striæ almost obsolete; color pale fawn, with white oblong, interrupted, lime-like dots, in oblique rows, in the substance of the shell; aperture perpendicular, ovate, with a nacreous deposit connecting the margins of the peritreme, lip white, flat, and broadly expanded.

Length 21, width 12 mill.; aperture, length 9, width 4 mill.

Hab.—Solomon Islands.

Obs.—For one example of this fine species I am indebted to Mr. Garrett, who received it from our mutual friend, Dr. Cox, of Sydney, Australia. Like *P. actor* Albers, = *zebrina* Gould, it possesses the lime-like deposit in the substance of the shell. It is a larger and more oblong shell than the latter, but like it, has a broadly reflected flat lip.

Partula flexuosa, nobis.

Shell acuminately oblong, flexuose, dextral, umbilicate, thin and semi-transparent; whorls 5, slightly rounded, spiral striæ numerous and very fine; body-whorl half the length, slightly compressed at base; color light brown or ash; aperture oval, slightly oblique, lip concave and reflected, with a very thin deposit connecting the margins of the peritreme.

Length 15 to 20, width 8 to 9 mill.; aperture, length 7 to 8, width 4 mill.

Hab.—St. George's and Eddystone Islands, Solomon Islands.

Obs.—Several examples of this shell, from Dr. Cox and Mr. Garrett, have been in my possession for a long time, and I hesitate to describe them, supposing they might be *P. cinerea* Albers. Dr. Cox having kindly sent me all his collection of Partula, for examination, I found the same shell amongst others from Eddystone and St. George's Islands. Some examples are thin and quite flexuose, while others are stouter and more direct.

Partula glaber, nobis.

Shell acuminately oblong, dextral, somewhat inflated, translucent, rimate-perforate; spire more than half the length; whorls 6, slightly convex, smooth, oblique lines obscure, spiral striæ absent, except the spiral fovea on the two apical whorls; a white fillet beneath the suture; aperture widely oval, perpendicular, lip slightly reflected, columella expanded at base, of a pale rose color, staining the umbilicus; color white, aperture a very pale rose, with the apex dark purple.

Length 21, diam. 10 mill.; aperture, length 10, diam. 5 mill.

Hab.—?

Obs.—This pretty species was received amongst other shells as *P. turricula* Pease, New Hebrides (?), without a voucher. A comparison with the description of *turricula* disproves its identity with that species. It is very distinct from any Partula with which I am acquainted.

Synonymic Catalogue of the Genus Partula.

In the year 1881 I published a catalogue of the genus *Partula*, Férussac, in which I proposed several sub-genera. These were subsequently withdrawn in consequence of not possessing sufficient distinctive characters. In the present list I have arranged the species in groups, designating each by the name of a well-known species, which, in most instances, typifies its general characters and facies. Hybridization is probably a factor in the variability of some species, which may account for the confusion of their synonymy. Owing to similarity of general appearance, it is often difficult to recognize a species by the diagnosis, when unaided by figures. Since the publication of my Bibliographic Catalogue of Partula, in 1881, I have embraced every opportunity to perfect my list, in which I have been aided by a number of friends. To Capt. Jno. Brazier, C. M. Z. S., and Jas. C. Cox, M. D., C. M. Z. S., I am indebted for correct localities of the species from New Hebrides and Solomon Islands, as well as for examples from several habitats on those groups. To the generosity of Mr. Andrew Garrett, of Huaheine, I am indebted for several new species. When in London in 1883, I was unable to inspect the Cumingian Collection, which was boxed preparatory to its removal to the New Kensington Museum of Natural History. By the kindness of E. A. Smith, F. Z. S., some of my species have been compared with those in the British Museum, which has partly atoned for this disappointment. I am indebted to the politeness of Dr. Paul Fischer and Dr. A. T. de Rochebrunne, of the Jardin des Plantes, for affording me every facility in the examination of the Partulæ in the Museum.

All species marked with a dagger (†) are embraced in my collection.

Genus **PARTULA**, Fér.

Auriform Division.

I. *Faba Group.*

† **P. faba** Martyn (Limax), Univers. Conch., vol. 2, p. 667, figs. 78, 79, 80, vars. *Raiatea.*

Limax faba Chenu. Bib. Conch., ii, p. 24, pl. 24, f. 2 *a*.
Helix faba Gmel., p. 3625 ; Wood, Index, p. 33, fig. 47. Linn., Dill., Mull.
Helix substriata Gmel., p. 3437, n. 11.
Otis faba Humph.
Auris Midæ fasciata Chemn. Conch., tab. 141, fig. 1041.
Voluta auris malchi, var., Gmel., p. 3437.
Voluta fasciata Dill. Des. Cat., p. 502, Id. *Helix faba*, p. 906.
Bulimus Australis Brug. Enc. Meth.. i, p. 347. Desh.
Bulimus inconstans and *tricolor* Muhlf. Teste Anton, Verz., p. 40.
Bulimus faba Albers.
Partulus Australis Beck. Ind. Moll., p. 37. Albers.
Partulus bulimoides Fér.
Partulus bulimoides Pfr. Mon. Hel. Viv., 302 (non Lesson).
Partula Australis Fér. Prod., p. 66, n. 2.
† *Partula faba* Sowb. Rve., Pfr., Woodw., Chenu, A. Adms., Pse., Päet., Schm., Hartm., Garr.
† *Partula faba*, var. *subangulata*, Pse. Jour. Conch., 491. Hart., Garr.
† *Partula ventricosa* Pse. MS. Coll. Pse., Hartm., Garr.
† *Partula amanda* Garr. MS. Hartm.
† *Partula dubia* Garr. MS. Hartm.
† *Partula marginata* Garr. MS. Hartm.
Partula bella Pse. MS. Ex. in A. N. S. ex auctore. *Raiatea.* Non *bella* Pse. in P. Z. S., p. 473, 1871. Hartm., Garr.
† *Partula brunnea* Pse. MS. Coll. Pse., Hartm., Garr.
† *Partula pallida* Pse. MS. Coll. Pse., Hartm., Garr.
† *Partula biangulata* Pse. MS. Coll. Pse., Hartm., Garr.
† *Partula propinqua* Pse. MS. Coll. Pse., Hartm., Garr.
† *Partula ventrosa* Auth. MS. Coll. Pse., Hartm.
Partula marginata Garr. MS.

† **P. citrina** Pse. A. J. C., ii, p. 195, 1866. *Raiatea.*

P. citrina Garr. Terr. Moll. Society Isls., J. A. N. S., vol. ix, p. 6, pl. 3, fig. 52. Schm., Pfr.
P. citrina Pfr. Mon. Helic. Viv., p. 302.
P. faba, var., Carpt., Hartm.

Obs.—In common with Pse., Cuming and Pfr., in former catalogues, I regarded this shell as a variety of *faba*. Other varieties of *faba* are equally constant in color, but less abundant. I defer to the opinion of Mr. Garrett, who is fully convinced of its specific value, having collected it in great quantity.

† **P. vittata** Pse. A. J. C., p. 194, 1866. *Raiatea.*

P. vittata Garr. Terr. Moll. Soct. Isls., J. A. N. S., vol. ix, p. 75, pl. 3, fig. 56.
P. vittata Pfr. Hartm.
† *P. terrestris* Pse. MS. Coll. Pse., Päetl., Gloy., Hartm., Garr.
† *P. castanea* Pse. MS. Coll. Pse., Hartm., Garr.
† *P. approximata* Pse. MS. Coll. Pse., Schm., Gloy., Hartm., Garr.
P. faba, var., Carpt. P. Z. S., p. 675, 1864.
† *P. microstoma* Pse. MS. Coll. Pse., Hartm. (non Garr.).
P. vittata Pfr. Mon. Helic. Viv., p. 302.

Obs.—Mr. Garrett very properly unites the three MS. varieties of Mr. Pease, *terrestris*, *castanea* and *approximata*, with *vittata*, of which they are modified forms. *P. microstoma* Pse. MS., Coll. Pse., are large examples of *vittata* without the pillar tooth. *P. microstoma* Pse., is certainly not synonymous with *P. radiata* Pse. MS.

† **P. fusca** Pse. A. J. C., p. 193, 1866. *Raiatea.*

P. fusca Päetel. W. G. Binn., Pfr., Schm., Hartm.
P. fusca Garr. Terr. Moll. Society Isls., J. A. N. S., vol. ix, p. 71, pl. 3, fig. 50.
P. ovalis Pse. A. J. C., ii, p. 194, 1866. Pfr., Hartm. (non Garr.).
P. dentifera Carpt. = *ovalis* (non Pfr.).
P. faba, var., Carpt. P. Z. S., p. 675, 1864 = *protea*.
P. protea Pse. MS. Coll. Pse., Schm., Pfr , Hartm. (non Garr.).
P. navigatoria Carpt. (non Pfr.).

Obs.—In former catalogues I included all the variable terrestrial species, *lugubris*, *protea*, *ovalis* and *fusca*, under *fusca*. The type examples of *fusca* (Coll. Pse.) are immature shells of the uniform dark fuscous *ovalis*, two quarts of which were included in the Pease duplicates, labeled *P. ovalis* by Pease. The shell is solid, of a uniform dark chestnut-brown or fuscous color, with a white expanded lip, and the pillar tooth is absent. I have seen several suites labeled *fusca*, from the hands of Mr. Pease, in which the banded *ovalis* and *protea* predominated. His description calls for "an edentate shell, of a wholly dark chestnut color, or with an occasional light band encircling the last whorl, or yellowish striped longitudinally and irregularly with chestnut, and the lip stained with brownish purple." Mr. Garrett's fig. = *protea*, as it possesses the denticle and peripheral band. There is considerable variation in my suites of this shell, which may eventually result in its being divided into two species.

† **P. lugubris** Pse. P. Z. S., p. 672, 1864. *Raiatea.*

P. lugubris Pfr. Schm., Garr., Hartm.
P. ovalis Garr. Hartm. (non Pse.).
P. fusca Hartm. (non Pse.).

Obs.—I have followed Mr. Garrett in separating *lugubris* from *fusca*. *P. lugubris* is certainly not *Pacifica* Pfr. (E. A. Smith).

† **P. Navigatoria** Pfr. (Bulimus), Mon., iii, p. 449. *Raiatea.*

P. Navigatoria Rve. Mon. Part., tab. 4, fig 21.
P. Navigatoria Carpt. Hartm., Garr.
P. variabilis Pse. A. J. C., ii, p. 203; Id., p. 81, pl. 1, f. 13–15, 1866–67.
P. variabilis Pfr. Schm., Päetel., Hartm.

Obs.—A comparison of examples with Pfeiffer's types in the British Museum, establishes the fact that these species are synonymous. As *variabilis* is found only on the island of Raiatea, and not at the Navigator Islands, the former is a misnomer, and the name of Mr. Pease should be retained for the species.

† **P. radiata** Pse. MS. Type in A. N. S., ex auctore. *Raiatea.*

P. radiata Garr. Terr. Moll. Society Isls., J. A. N. S., vol., ix, p. 74, fig. 45.
P. radiata Hartm. Ancey.
P. compressa Carpt. (non Pfr.). Pse., Schm.
P. microstoma Garr. (non Pse.).
P. vittata Garr. (non Pse., Hartm.).

Obs.—This shell has been disseminated by Pease and the Museum Godeffroy as *compressa* Pfr., an error which I corrected in my Bibliographic Catalogue of the Genus Partula, and which was subsequently noted by Mr. Ancey.

† **P. planilabrum** Pse. P. Z. S., p. 672, 1864. *Tahaa.*

P. planilabrum Pfr. W. G. Binn., Schm., Hartm., Garr.
P. suturalis Pse. MS. (non Pfr.).

Obs.—The dark variety with white suture is the Pease type of *suturalis*, MS. *P. suturalis* Pfr., in the British Museum = *alternata* without bands.

II. *Auriculata Group.*

† **P. auriculata** Brod. P. Z. S., p. 33, 1832. *Raiatea.*

Bulimus auriculatus Pfr., 1841. Jay, Cat., p. 204.
Partulus auriculatus Beck, Index.
Partula Otaheitana Rve. Mon., pl. 2, fig. 11 *a*, 11 *b*.
Partula Otaheitana Pfr. Mon. Helic. Viv., p. 302.
Partula robusta Pse. MS. Coll. Pse., Hartm.
Partula solidula Pse. MS. Coll. Pse.
Partula auriculata Müll. Carpt., Päetel, Schm., Hartm., Garr.

Obs.—Owing to the variable size and coloration of this species, some of the old authors confounded this shell with *Otaheitana* Brug., from which it is very distinct.

† **P. bilineata** Pse. A. J. C., p. 201; Id., p. 81, pl. 1, fig. 10, 1866–67. *Tahaa.*

P. bilineata Wm. G. Binn. Pfr., Gloy., Schm., Hartm., Garr.
P. auriculata Carpt. (non Brod.).

† **P compacta** Pse. A. J. C., ii, p. 200: Id., iii, p. 81, pl. 1, fig. 9, 1866–67. *Raiatea.*

P. compacta Päetel. Schm., Pfr., Hartm., Garr.
P. auriculata, var., Carpt.
P. callifera Gloyne (non Pfr.).

Obs.—Mr. E. A. Smith writes: "This shell agrees exactly with *solidula* in the British Museum, except that *compacta* possesses a denticle."

† **P. thalia** Garr. Terr. Moll. Society Isls., J. A. N. S., vol. ix, p. 69, fig. 46. *Raiatea.*

P. abbreviata Pse. MS. Coll. Pse. (non Mouss.).
P. auriculata, var., Carpt. P. Z. S., p. 675, 1864.
P. Peaseiana Garr. MS. (non *Peasei* Cox).
P. Thalia Garr. MS. Hartm.
P. solidula Küst. See fig. (non Pfr.).

Obs.—This shell has been distributed as *abbreviata* Pse.

III. *Dentifera Group.*

† **P. dentifera** Pfr. P. Z. S., p. 85, 1852. *Raiatea.*
  P. dentifera Chemn. T. 44, figs. 14, 15.
  P. dentifera Pse. Carpt., Schm., Hartm., Garr.
  P. decorticata Pse. MS. Coll. Pse., Hartm.
  P. recta Pse. MS. (Non *recta* Pse., in A. J. C.) Hartm.
  P. Raiatensis Garr. MS. Exemp. ex auctore. Hartm., Bib. Cat., p. 186.
  P. labiata Pse. MS. Coll. Pse., Hartm., Päetel., Schm., Pfr.

Obs.—My examples of *Raiatensis* from Mr. Garrett are much smaller than *imperforata* Pse., to which he has recently referred it. See Obs. on the Pease duplicates, Bibliographic Catalogue, p. 194.

† **P. callifera** Pfr. P. Z. S., p. 333, 1856. *Raiatea.*
  P. callifera Garr. Terr. Moll. Society Isls., J. A. N. S., vol. ix, p. 60, fig. 82.
  P. callifera Carpt. Pse., Hartm.
  P. megastoma Pse. MS. Schm.
  P. callistoma Schm.

† **P. formosa** Pse. MS. Coll. Pse., Hartm. *Raiatea.*
  P. formosa Garr. Terr. Moll. Society Isls., J. A. N. S., vol. ix, p. 60, pl. 3, fig. 49.
  P. formosa Hartm.

† **P. imperforata** Pse. MS. Coll. Pse., Hartm. *Raiatea.*
  P. imperforata Garr. Terr. Moll. Society Isls., J. A. N. S., vol. ix, p. 54, pl. 3, fig. 53.
  P. imperforata Päetel. Pfr., Hartm.
  P. dentifera Carpt. (non Pfr.).
  P. recta Pse. MS. Coll. Pse. (non *recta* Pse. in A. J. C.).
  P. auriculata var. Carpt. P. Z. S., p. 675, 1864.
  P. Raiatensis Garr. MS. (non Hartm.).

† **P. virginea** Pse. MS. Coll. Pse., Hartm. *Tahaa.*
  P. virginea Garr. Terr. Moll. Society Isls., J. A. N. S., vol. ix, p. 61, pl. 3, fig. 54.
  P. virginea W. G. Binn. Schm., Hartm.
  P. solidula, var., Carpt. P. Z. S., p. 675, 1864.

† **P. lutea** Lesson. Voy. Coq., p. 325, 1856. *Bora-bora Islands.*
  Bulimus luteus Desh. Pfr.
  Partula lutea Pfr. Pse., Hartm.
  P. solidula Schm. (non Rve.).
  P. lilacina Pfr. Pse., Hartm.

Obs.—The type *lilacina* is an example denuded of epidermis, exhibiting the lilac color of the shell beneath. The locality, Marquesas, is probably an error.

† **P. Garrettii** Pse. P. Z. S., p. 672, 1864, p. 473, 1871. *Raiatea.*
P. Garrettii Garr. Terr. Moll. Society Isls., J. A. N. S., vol. ix, p. 56, pl. 3, fig. 48.
P. Garrettii Pfr. Schm., Hartm.
P. gonocheila Schm. (non Pfr.).

IV. *Umbilicata Group.*

† **P. umbilicata** Pse. A. J. C., ii, p. 200, 1866; Id., iii, p. 81, pl. 1, fig. 7, 1867. *Tahaa.*
P. umbilicata Päetel. W. G. Binn., Schm., Hartm., Garr.
P. auriculata, var., Carpt.

† **P. gibba** Fér. Prodr., p. 66, No. 66. *Guam Island.*
P. gibba Rve. Con. Icon., Monog. Part., fig. 15 *a*, 15 *b*.
Helix gibba Quoy.
Bulimus gibbus Desh. Chemn.
Partula gibbus Beck.
Partula mastersi Pfr. Hartm.

† **P. bicolor** Pse. P. Z. S., p. 473, 1871. *Guam Island.*
P. bicolor Pse. A. J. C., vii, p. 26, pl. 9, f. 4, 1872.
P. bicolor Hartm. Bib. Cat., p. 180, 1881.

† **P. crassilabris** Pse. A. J. C., ii, p. 199: Id., iii, p. 81, pl. 1, f. 6, 1866–67. *Raiatea.*
P. crassilabris Schm. Pfr., Hartm.
P. Otaheitana Rve. (Non Brug.) *Raiatea.*
P. Hebe, var., Carpt.
P. rustica Pse. A. J. C., ii, p. 199; Id., p. 81, pl. 1, fig. 5.
P. rustica Schm. Pfr.
P. auriculata Carpt. (non Brod.).
P. crassilabris Gloyne. Hartm.
P. pinguis Garr. MS. Hartm.

Obs.—I do not agree with Pease and others in separating this variable terrestrial form into two species. See Bibliographic Catalogue Partula, page 187.

† **P. Hebe** Pfr. (Bulimus). P. Z. S., p. 39, 1846. *Raiatea.*
Bulimus Hebe Chemn.
Partula Hebe Pfr. Rve., Pse., Päetel, Schm., Hartm., Garr.
Partula globosa Pse. MS. Coll. Pse., Hartm., Gloyne, Schm.
Partula ventricosa Garr. MS. Hartm.
Partula Hebe, var. *bella*, Pse. P. Z. S., p. 473, 1871.

V. *Expansa Group.*

† **P. expansa** Pse. A. J. C., p. 26, pl. 9, f. 3, 1871. *Tutuila.*
P. extensa Pse. P. Z. S., p. 473, 1871 (error for *expansa*).
P. extensa Pfr., viii, p. 204. Nom. Helic. Viv., 302.
P. extensa Hartm. Bib. Cat. Part., 182.

Obs.—In Europe this shell is usually mistaken for *zebrina* Gld.

† **P. Peasei** Cox. P. Z. S., p. 644, pl. 52, f. 2, 1871. *Malayta Island, Solomon Islands.*
P. Peasei Pfr., vi, 48. Nom. Helic. Viv., 303.
P. Peasei Hartm. Bib. Cat. Part., 185.

Obs.—I am indebted to Dr. Cox for this extremely rare shell. This group does not approximate in structure any other species except *umbilicata;* they have been placed here provisionally, the anatomy of the animal may confer upon them another status.

VI. *Otaheitana Group.*

† **P. Otaheitana** Brug. (Bulimus). Ency. Meth., i, p. 347, No. 84, 1792. *Tahiti.*
Bulimus Otaheitanus Desh. Lam., Küst., Pfr.
Bulimus amabilis Pfr.
Bulimus Isabellinus Pfr.
Bulimus laevis Gray.
Bulimus auriculatus Pfr.
Helix perversa Chemn.
Helix Otaheitana Dillw.
Helix laevis ? Wood.
Partulus Otaheitanus Beck. Albers.
Partulus Vanikorensis Beck.
Partulus auriculatus Beck.
Partula Otaheitana Fér. Grat., Rve., Jay, Pfr., Päetel, Hartm., Garr.
Partula Vanikorensis Lam. Pfr., Gld., Päetel, Hartm., Garr. (non *P. Vanikorensis* Quoy and Gaim. (Helix).
† *Partula Isabellina* Rve. Pfr., Päetel, Hartm., Garr.
† *Partula amabilis* Pfr. Rve., Pse., Päetel, Gloyne, Hartm., Garr.
† *Partula rubescens* Rve. Pfr., Pse., Hartm., Garr.
† *Partula Reeveiana* Pfr. Chemn., Hartm., Garr.
Partula Tahitana Gld. Pse., Schm., Hartm., Garr.
Partula Taheitensis Päetel.
Partula Tahulana Anton. Hartm.
Partula lignaria Garr. (non Pse., Pfr., Chemn., Hartm.).
Partula affinis Garr. (non Pse., Pfr., Schm., Hartm.).
Partula rufa Carpt. Hartm. (non Less.).

† *Partula sinistorse* Pse. MS. Coll. Pse., Päetel, Schm., Pfr., Gloyne, Hartm., Garr.
Partula sinistralis Pse. MS. Coll. Pse., Päetel, Pfr., Hartm., Garr.
† *Partula crassa* Pse. MS. Coll. Pse., Hartm., Garr.
† *Partula perversa* Pse. MS. Coll. Pse., Hartm., Garr.
† *Partula turricula* Pse. MS. Coll. Pse. (non *turricula* Pse., in A. J. C., 1872), Hartm., Garr.
Partula varia Carpt. (non Brod.).
Partula Pacifica Pfr. Hartm.
Partula diminuta C. B. Adms. Hartm.

Obs.—From the list of synonyms attached to this variable shell, it would seem that for many years it has been regarded as "a refuge for the destitute."

P Vanikorensis Quoy and Gaim. (Helix). Voy. Astrolabe, ii, p. 115, pl. 9, fig. 12–17, 1830. *Vanikoro Island.*
Bulimus Vanikorensis Lam., Pfr.
Partulus Vanikorensis Beck.
Partula Vanikorensis Pfr. Päetel, Hartm., Garr.

Obs.—In former catalogues I followed Dr. Gould, who placed this species as a synonym of *Otaheitana* Brug. After an examination of the types of Quoy and Gaimard, in the Collection of the Jardin des Plantes, Paris, I cannot but restore the species. The shell is thinner than *Otaheitana*, of a uniform pale red color, with the apical whorls inflated and rounded. In collections it is usually represented by *Otaheitana*, *affinis*, and *stolida.*

† **P. lineata** Lesson (Bulimus). Voy. Coquille, p. 324, figs. 8–9, 1826. *Oualan Island.*
Partulus torosus Beck.
Partula lineatus Albers.
Partula lineata Hartm. Bib. Cat., p. 183.

Obs.—Lesson's figure is so very different from that of Mr. Reeve, that for the present I am inclined to keep the species separate, notwithstanding Captain Brazier writes, "that he crossed the Island of Oualan twice, without finding it." Mr. Reeve first confounded it with *vexillum* Pse. Mr. E. A. Smith writes, "*Vexillum* Pease is not *lineata* in the British Museum," and he believes that "Reeve's determination of *vexillum* = *lineata* Less., is erroneous." Pease in the Smithsonian Collection says *lineata* = *elongata.* The latter is smaller, and wants the single narrow bright red band on the middle of the body-whorl. Lesson's figure is the size and outline of *P. producta* Pse., and like *producta* the denticle is absent on the pillar lip, both in his figure and description.

† **P. Mooreana** Hartm. Proc. A. N. S., p. 229, 1880. *Moorea, Marquesas.* Garr., Terr. Moll. Society Isls., J. A. N. S., vol. ix, p. 59, fig. 55, tab. iii.

† **P. lignaria** Pse. P. Z. S., p. 671, 1864. *Tahiti.*
P. lignaria Pfr. Schm., Päetel, Gloyne, Hartm. (non Garr.).
P. affinis Pse. Pfr., Schm., Hartm. (non Garr.).
P. nitens Pfr. Hartm.
P. rufa Carpt. Hartm. (non Lesson).
P. Otaheitana, var. *fasciata*, Fér. Coll. Jardin des Plantes.

Obs.—I do not assent to *lignaria* and *affinis* as synonyms of *Otaheitana*. See my Bibliographic Catalogue of Partula, pages 179 and 183. I possess numerous examples of all the varieties of this species; several are albinos, some are white with a brown band, var. *fasciata* Fér., others are dark brown with darker oblique striæ and a dark band at the periphery, var. *lignaria*. The variety *affinis* is always of a dark bay-brown, usually with darker oblique striæ and a smooth surface. All possess a button-like pillar tooth, and the base of the aperture has a looped appearance, which is a constant character of this shell. Some of the smaller examples of *Otaheitana* resemble it (probably the result of hybridization), but they may always be distinguished by the red color of the shell and lip. In most collections this shell is labeled *rufa*.

† **P. stolida** Pse. A. J. C., ii, p. 198, 1868. *Tahiti.*
P. stolida Garr. Terr. Moll. Society Isls., J. A. N. S., vol. ix, p. 70, pl. 3, fig. 58.
P. stolida Pfr. Hartm.
P. Vanikorensis Carpt. P. Z. S., p. 675, 1864 (non Quoy and Gaim.).

† **P. filosa** Pfr. P. Z. S., p. 262, 1851. *Tahiti.*
P. filosa Chemn. Hartm.
P. filosa Garr. Terr. Moll. Society Isls., J. A. N. S., vol. ix, p. 64.
P. lineolata Pse. A. J. C., p. 224, 1867. Schm., Pfr.

† **P. nodosa** Pfr. P. Z. S., p. 262, 1851. *Tahiti.*
P. trilineata Pse. A. J. C., iii, t. 1, f. 10, Pfr.
P. nodosa Hartm.
P. nodosa, var. *trilineata*, Pse.

† **P. producta** Pse. P. Z. S., p. 671, 1864. *Raiatea.*
P. producta Garr. Terr. Moll. Soct. Isls., J. A. N. S., vol. ix, p. 66, pl. 3, fig. 51.
P. producta Pfr. Schm., Hartm.

† **P. suturalis** Pfr. P. Z. S., p. 98, 1855. *Moorea.*

P. *suturalis* Pfr. Nov. Conch., vol. i, tab. 17, figs. 18–19.
P. *stenostoma,* Pfr. P. Z. S., p. 97, 1855. Hartm.
P. *stenostoma.* Nov. Conch., vol. i, tab. 17, figs. 16–17.
P. *strigosa* Pfr. P. Z. S., p. 384, 1856. Hartm.
P. *vexillum* Pse. A. J. C., ii, p. 198; Id., iii, p. 81, pl. 1, fig. 8, 1866–67. Hartm.
P. *alternata* Pse. MS. Coll. Pse., Hartm.
P. *nodosa* Carpt. (non Pfr.).
P. *lineata* Rve. Garr. (non Lesson).

Obs.—I agree with Mr. Garrett in combining all these variable shells from Moorea under one species, but I doubt if they = *lineata* Lesson. *Suturalis* and *strigosa*, in the Cumingian Collection, are only varieties of the Moorea shell; *stenostoma* and *suturalis* were described by Pfeiffer from examples in the British Museum, which are only varieties of *alternata* and *vexillum* Pease.

VII. *Tæniata Group.*

† **P. tæniata** Mörch (Bulimus). Cat. Conch. Kierulf., p. 29, pl. 1, fig. 5, 1840. *Moorea.*

P. *tæniata* Pfr., iii, p. 451. Carpt., Hartm.
P. *spadicea* Chenu, t. 64, fig. 31–32. Pfr., Rve., Hartm.
P. *striolata* Pse. A. J. C., ii, p. 197, 1866; iii, p. 81, pl. 1, fig. 4, 1867. Pfr., Hartm., Garr.
P. *simulans* Pse. A. J. C., ii, p. 202, 1866, p. 81, pl. 1, fig. 11. Pfr., Hartm., Garr.
P. *elongata* Pse. A. J. C., ii, p. 196, 1866; iii, p. 81, pl. 1, fig. 2, 1867. Pfr., Schm., Hartm., Garr.
P. *Erhelii* Morelet. J. Conchyl., t. 2, f. 7, 1853. *Moorea.* Pfr., Hartm.
P. *nucleola* Pse. MS. Coll., Pse., Hartm., Garr.
P. *peraffinis* Pse. MS. Pfr.

Obs.—Mr. Garrett very properly remarks, "this is truly a protean species." Of this fact I have been cognizant since I examined the duplicate collection of the late Mr. Pease. In six pints of duplicates from Moorea the connection between the varieties was readily traceable; on comparison "there is no difference between examples of these shells and those of *spadicea* in the British Museum, except that some are a trifle shorter." Mörch's habitat, *Fiji Isles*, for *tæniata*, is probably an error, as his examples "were purchased of a whale fisher." Pfeiffer, in the last edition of his Catalogue of Partula, says *peraffinis* Pse. MS. = *elongata* Pse.

† **P. clara** Pse. P. Z. S., p. 671, 1864. *Tahiti.*
P. clara Pfr. Hartm.
P. clara Garr. Terr. Moll. Society Isls., J. A. N. S., vol. ix, p. 56, pl. iii, fig. 75.
P. hyalina var.? Carpt. Pfr., Nom. Hel. Viv., p. 301.

P. micans Pfr. P. Z. S., p. 138, 1852. *Solomon Islands.*
P. micans Chemn. Tab. 66, figs. 12, 13.
P. micans Pfr. Nom. Helic. Viv., p, 303 (non Hartm.).

† **P. Carteriensis** Quoy and Gaim. (Helix). Voy. Astrol., ii, p. 117, pl. 9, fig. 10. *Carteret Island, N. Ireland.*
Bulimus Carteriensis Pfr., ii, 68. Desh.
Partulus Carteriensis Beck.
Partula Carteretensis Rve.
Partula Carteriensis Hartm. Pfr., Nom. Helic. Viv., p. 301.

† **P. hyalina** Brod. (Bulimus). P. Z. S., p. 32, 1832. *Tahiti, Maguaia Isld.*, Garr., Rurutu, Le Gage; *Tumaco* Cuming.
P. hyalina Pse., ii, p. 67. Chemn., t. 64, f. 19, 20.
Bulimus hyalinus Desh.
Partulus hyalinus Beck.
Partula hyalina Rve. Hartm.; Pfr., Nom. Helic. Viv., p. 301.

Obs.—This is the most widely distributed of any known species of Partula.

† **P. attenuata** Pse. P. Z. S., p. 672, 1864. *Raiatea, Tahiti.*
P. attenuata Pfr., iv, 507. Schm., Gloyne, Hartm., Garr.
P. gracilis Pse. A. J. C., p. 197, 1867; Id., p. 81, pl. 1, fig. 3.
P. gracilis W. G. Binn. Pse., Päetel, Hartm., Garr.
P. gracilior Pse. MS. Hartm., Ex. in A. N. S., ex auctore. *Isabel Island.*
P. Carteretensis Garr. (non Rve.).

Obs.—Mr. Garrett makes *Carteretensis* Rve. synonymous with this shell, to which I do not assent.

P. Hartmani E. A. Smith. P. Z. S., 1884. *Wild and Pigeon Islands.*

P. cinerea Albers. Mal. Blatt., p. 98, 1857. *Solomon Islands.*
P. cinerea Pfr., iv, 510. Hartm.
P. cinerea Pfr. Nom. Helic. Viv., p. 301.

† **P. lyrata** Mousson. Jour. Conchyl., xviii, p. 126, 1870. *Tavinu, Viti Isles.*
P. lyrata Hynem., in Mal. Blatt., xiv, t. 1, fig. 1 (Dentes). *Somma Island, Feejee Islds.*
P. lyrata Pfr., iv, 158; Hartm.; Pfr., Nom. Helic. Viv., p. 301.

† **P. flexuosa** Hartm. P. A. N. S., 1885.

† **P. lævigata** Pfr. P. Z. S., p. 334, 1856.
P. lævigata Pfr., iv, Hartm.; Pfr., Nom. Helic. Viv., 302.

P. grisea Lesson (Bulimus). Voy. Coquill., xiii, p. 325, pl. 13, f. 11, 1829. *New Guinea.*
Bulimus griseus Pfr.
Partulus griseus Alb.
Partula grisea Pfr., Nom. Helic. Viv., p. 301. Hartm.

† **P. concinna** Pse. A. J. C., vii, p. 196, 1872. *Tanna Island, New Hebrides.*
P. concinna Pfr., viii, 205; Pfr., Nom. Helic. Viv., p. 302. Hartm.

† **P. pellucida** Pse. P. Z. S., p. 457, 1871. *Guadelcanar Island, Solomon Islands.*
P. pellucida Pfr., viii, 199; Nom. Helic. Viv., p. 301.
P. micans Hartm.

Obs.—This shell was collected by Mr. John Brazier and presented to Mr. Pease. Heretofore I confounded this shell with *Coxi* Angas MS., and *micans* Pfr., it is smaller than either of the former and very thin and pellucid. It is the smallest Partula known.

† **P. Coxi** Angas MS. Cox, Cat. Land and Mar. Shells, Austr. and adjacent Islands, p. 46, 1868. *Isabel Isld., Solomon Isles.*
P. Coxi Hartm. Bib. Cat. Part., p. 181, 1881.

Obs.—Through the kindness of Captain Brazier, of Sydney, Australia, I have been presented with a number of examples from the original lot collected by himself. It is rather larger than *pellucida* Pse., more elongated; the aperture is also larger and more elongate, and the lip more expanded. The length of *pellucida* is 10 mill., while that of *Coxi* is 15 mill.

VIII. *Decussatula Group.*

† **P. decussatula** Pfr. (Bulimus). P. Z. S., p. 131, 1850. *Dominique Island, Marquesas.*
P. decussatula Rve. Mon. Part., Spec. 24, pl. 4, fig. 23, 1849.
P. decussatula Chemn., t. 65, figs. 8, 9. Hartm.
P. decussatula Pfr. Nom. Helic. Viv., p. 303.

† **P. Magdalinæ** Hartm. P. A. N. S., 1885. *Magdalena Isld., Marquesas.*

† **P. bellula** Hartm. P. A. N. S., 1885. *Wapo Isld. and Dominique, Marquesas.*

IX. *Turgida Group.*

† **P. turgida** Pse. (Bulimus). P. Z. S., p. 670, 1864. *Raiatea.*
P. turgida Hartm. Bib. Cat. Part., 188.
P. turgida Garr. Terr. Moll. Society Isls., J. A. N. S., vol. ix, p. 56, pl. 3, fig. 74.

† **P. annectens** Pse. (Bulimus). P. Z. S., p. 671, 1864. *Huaheine.*

P. annectens Pfr., vi, p. 48; Pfr., Nom. Helic. Viv., p. 303. Hartm.
P. annectens Garr. Terr. Moll. Society Isls., J. A. N. S., vol. ix, p. 66, pl. 3, fig. 70.

† **P. arguta** Pse. (Bulimus). P. Z. S., p. 670, 1864. *Huaheine.*

P. arguta Pfr., vi, 46; Hartm.; Garr., Terr. Moll. Society Isls., vol. ix, p. 62, pl. 3, fig. 57.
P. arguta Schm., Martn. and Langk.

P. minuta Pfr. P. Z. S., p 384, 1856. *Admiralty Islands.*

P. minuta Pfr., iv, p. 514. Hartm.
P. minuta Pfr. Nom. Helic. Viv., p. 303.

X. *Rosea Group.*

† **P. rosea** Brod. (Bulimus). P. Z. S, p. 125, 1832. *Huaheine.*

P. rosea Müll. Rve., Jay, Pfr., Pse., Päetl., Schm., Hartm., Garr.
P. rosea Pfr. Nom. Helic. Viv., p. 301.
P. purpurascens Pfr., iv, p. 511. Hartm.
P. simplaria Morelet. Jour. Conchyl., iv, p. 370, pl. 11, figs. 13–14, 1853.
P. cognata Pse. Coll. Pse., Schm., Gloyne, Hartm., Garr.

† **P. calypso** O. Semper. Jour. Conchyl., xiii, t. 12, fig. 7. *Island Pelelin.*

P. calypso Pfr., vi, 185; Hartm.; Pfr., Nom. Helic. Viv., p. 300.
P. thetis O. Semp. Jour. Conchyl,, xiii, t. 12, fig. 6.
P. thetis Pfr., vi, 155; Hartm.; Pfr., Nom. Hel. Viv., p. 300.
P. leucothaë O. Semp. Jour. Conchyl., xiii, t. 12, f. 5.
P. leucothaë Pfr., vi, 155; Hartm.; Pfr., Nom. Hel. Viv., p. 300.

Obs.—These shells are all from one island. "The figures are all of one type, differing only in size and coloration."[1]

† **P. varia** Brod. P. Z S., p. 125, 1832. *Huaheine.*

P. varia Müll. Rve., Pfr., Pse., Päetel, Schm., Hartm., Garr.
Bulimus varius, Pfr.
Bulimus roseus, var., Pfr.
P. varia Pfr. Nom. Hel. Viv., p. 301.
P. glutinoso Pfr. Päetel, Hartm., Garr.
P. mucida Pfr. Hartm., Garr.
P. pulchra Pse., MS. Mus. Godeff. Cat., v, p. 92.
P. Huaheinensis Garr., MS. Hartm., Garr.
P. bicolor Garr., MS. Hartm., Garr.
P. adusta Garr. Hartm., Garr.
P. perplexa Pse. Coll. Pse., Hartm., Garr.

Obs.—Mr. Garrett's residence at Huaheine for some years has

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[1] Hartm., in Bib. Cat.

afforded him excellent opportunities of observing this species, and he records very full particulars of its varieties and distribution. I have been in accord with him for a long time in assigning *glutinosa* Pfr. to *varia*. I think Pfeiffer at one time claimed Reeve's fig. 17 *b*, pl. 3, Monog. Part., as his *glutinosa*. This fig. represents the shell in Coll. A. N. S. labeled *P. strigosa* Pse. ex auctore. The latter, however, is a Marquesas shell, which I have recently discovered to = a dark variety of *recta* Pse.

See *recta* Pease.

† **P. assimilis** Pse. A. J. C., p. 230, pl. 15, f. 28, 29, 1867. *Rarotonga Island.*
P. assimilis Pfr., viii, 197 ; Pfr., Nom. Helic. Viv., p. 301 ; Hartm.
P. Cookiana Mouss. MS., p. 28, figs. 28, 29 ; Garr. in litt.
P. Cookiana Mouss. Päetel.

† **P. virgulata** Pse. Jour. Conchyl., 3d series, p. 401, 1876. *Rarotonga.*
P. virgulata Hartm. Bib. Cat. Part., p. 189. 1881.

† **P. subgonocheila** Mousson. Jour. Conchy., xix, t. 3, fig. 4. *Fortuna and Barao Islands.*
P. subgonocheila Pfr., viii, p. 203, Nom. Helic. Viv., 302 ; Hartm.

XI. *Ganymedes Group.*

† **P. ganymedes** Pfr. (Bulimus). P. Z. S., p. 39, 1850. *Dominique Isld., Marquesas.*
P. ganymedes Rve. Mon. Part., No. 16, pl. 3, fig. 16.
P. ganymedes Pfr. Nom. Helic. Viv., p. 302. Hartm.
P. fasciata Pse. A. J. C., ii, p. 202, 1866, var. Hartm.
P. gonocheila Hartm. (non Pfr.).

† **P. inflata** Rve. (Bulimus) P. Z. S., p. 197, 1842.
P. inflata Rve. Conch. Syst., pl. 175, fig. 11, 12.
P. inflata Rve. Mon. Part., No. 3, figs. 3 *a*, 3 *b*, 1849.
Bulimus thersites Pfr.
Bulimus thersites Chemn., t. 64, figs. 5, 6.
Partulus thersites Albers.
Partula inflata Pfr. Nom. Helic. Viv., p. 303. Hartm.

P. gonocheila Pfr. (Bulimus). Zeit. für Malacol., p. 82, 1847. *Navigator Islands.*
P. gonocheila Pfr., ii, 69.
P. gonocheila Rve. Mon. Part., t. 4, fig. 19.
P. gonocheila Chem., t. 64, figs. 33, 34.
P. ganymedes Hartm. Bib. Cat. Part., p. 182.
P. gonocheila Pfr. Nom. Helic. Viv., p. 302.

Obs.—There seems to be some confusion about this species; the examples of *gonocheila* in the British Museum do not agree with the figure of *gonocheila* Reeve, which latter = *ganymedes* in my collection. This, however, may be explained by Cuming's habit of substituting what he considered better examples for those already in the Museum collection. Reeve's habitat is Navigator Islands. I have restored the species with the expectation that his *gonocheila* may yet be found at the Navigator Islands. The present examples in the British Museum look to me like some varieties of *recta* Pease.

† **P. recta** Pse. A. J. C., iv, p. 155, pl. 12, f. 8, 1868. *Mountains of Mauni and Nukuhiwa Islds., Marquesas.*
P. recta Pfr., viii, 202. Nom. Helic. Viv., p. 302.
P. strigata Pse. A. J. C., iv, p. 155, pl. 12, f. 7, 1868. *Marquesas.*
P. repanda Hartm. (non Pfr.).

Obs.—This is a very variable shell in size, shape, color and texture. See *recta* Pse., Bib. Cat. Part., p. 186. *P. strigata* Pease = the dark brown variety of *recta*. There were about one-and-a-half pints of examples of this species amongst the duplicates of the collection of the late Wm. H. Pease; four varieties were seemingly embraced in the lot; the larger number were of the white variety, some of which resemble *repanda* Pfr. On a comparison with *repanda* in the British Museum they proved to be distinct. These shells vary from white through different shades of yellow and reddish to dark reddish brown. The inner margin of the aperture is more or less waved and the columella more or less nodose, the lip usually partaking of the color of the shell.

P. repanda Pfr., iv, 512. *New Hebrides.*
P. recta Hartm. (non Pse.).
P. repanda Pfr. Nom. Helic. Viv., p. 302.

† **P. actor** Albers (*Partulus*). Helicien, p. 87, 1850. *Samoa Islds.*
P. actor Pfr., iii, p. 450.
P. actor Chemn., t. 48, figs. 13, 14.
P. actor Pfr. Nom. Helic. Viv., p. 303.
P. Recluziana Petit. Jour. Conchyl., t. 7, f. 5, 1850. *Tutuila.*
P. Recluziana Pfr., iii, p. 452.
P. Recluziana Pfr. Nom. Helic. Viv., p. 303.
P. zebrina Gld. Exped. Shells, t. 6, f. 89. *Tutuila and Samoa.*
P. zebrina Pfr. Nom. Helic. Viv., p. 303.
P. zebrina Hartm. Bib. Cat. Part., p. 189.

Obs.—I have several examples of this shell from the collection of the late Mr. Taylor, England. They were obtained by the

Belcher Expedition (Voyage Samarang). Similar examples are contained in the collections of Gould, Cox and others, from Upolu, Tutuila and Samoa. In Europe *P. expansa* Pse., from Tutuila, is the shell often mistaken for *zebrina*.

† **P. Tryoni** Hartm. P. A. N. S., 1885. *Solomon Islands.*

Buliminoid Division.

XII. *Guamensis Group.*

† **P. Guamensis** Pfr. (*Bulimus*). Phil., Abbild. und Beschreib. Conch., ii, p. 173, pl. 4, f. 9, 1821. *Ponape, Caroline Islands.*

P. Guamensis Pfr., ii, p. 73.
P. Guamensis Rve. Mon. Part., t. 1, f. 4.
P. brumalis Rve. Mon. Part., t. 1, f. 2.
Partula Guamensis Pfr. Nom. Helic., 302. Hartm.

Obs.—*P. Guamensis* Pfr., is not found at Guam, one of the Ladrone Islands, and hence is a misnomer, which might be changed to Ponapensis, one of the Caroline Islands, at which it occurs. The Cox collection contained examples labeled Ascension Island.

P. obesa Pse. A. J. C., iii, p. 223, t. 15, f. 12, 1867. *Fortuna and Vavao Islands.*

P. obesa Pfr., viii, 201.
P. obesa Pfr. Nom. Helic. Viv., p. 302.
P. obesa Hartm. Bib. Cat. Part., p. 184.

Obs.—This species is very scarce as no one has collected in those islands since Dr. Gräff visited them.

P. abbreviata Mousson Jour. Conchyl., xvii, p. 339, pl. 15, f. 7, 1869. *Tutuila.*

P. abbreviata Pfr., viii, p. 200.
P. abbreviata Hartm. Bib. Cat. Part., p. 179 (non *abbreviata* Pse. MS.).

† **P. rufa** Lesson (*Bulimus*). Voy. Coquille, tome 2, pt. 1, p. 324, 1830. *Oualan, Caroline Islands.*

P. rufa Pfr., ii, 229; Nom. Helic. Viv., p. 302.
Partulus rufus Beck.
Partula rufa Less. (non Carpt., Hartm.).

Obs.—This shell, of which Dr. Cox and Capt. Brazier have given me examples, has been re-discovered on the Island of Oualan by Capt. Brazier. It is a much larger shell than *stolida* or *affinis*, with which it is usually confounded.

† **P. conica** Gld. Proc. Bost. S. N. Hist., p. 196, 1841. *Raraka and Samoa Islands.*
P. conica Gld. Exped. Shells, fig. 88.
P. conica Pfr., iii, 445, iv, 507.
P. conica Pfr. Novit. Conch., i, tab. 34, f. 8, 9.
P. conica Pfr. Nom. Helic. Viv., p. 300.
P. Upolensis Mouss. MS. Päetel., p. 104. *Upolu.*
P. canalis Mouss. Jour. Conchyl., xiii, p. 132, 1869. *Upolu, Tulare.*
P. canalis Pfr. Nom. Helic. Viv., p. 300.
P. bulimoides Hartm. Bib. Cat. part, p. 180 (non Less.).

Obs.—I possess these shells from the Islands of Tutuila, Upolu and Samoa. Like *actor* Albers, it is a denizen of several islands of this group. Dr. Gould, in his description of this species, embraces the dextral and sinistral forms of the yellow and brown varieties. Others profess to see a difference, which has resulted in a needless synonymy.

P. bulimoides Lesson. Voy. Coq., p. 326, 1829. *New Guinea.*
P. faba ? var., Pfr. Nom. Helic. Viv. p. 302.
P. bulimoides Hartm. Bib. Cat. Part., p. 180.

Obs.—Although Lesson's brief diagnosis of *bulimoides* approximates nearer to some varieties of *conica* than to any known species, his measurements of the shell and the locality induce me to restore the species.

XIII. *Macgillivrayi Group.*

† **P. Macgillivrayi** Pfr. P. Z. S., p. 325, 1856. *New Hebrides.*
P. Macgillivrayi Pfr., iv, 508; Nov. Conch., i, t. 17, f. 14, 15.
P, *Macgillivrayi* Pfr. Nom. Helic. Viv., p. 301; Hartm., Bib. Cat., Part., 184.
† *P. Turneri* Pfr. P. Z. S., p. 140, 1860 vi, 159; Nom. Helic., Viv., 302. *Erromango Island.*
P. Macgillivarayi Hartm. Bib. Cat. Part., 188.

Obs.—I have a number of examples of this shell, which is somewhat variable. I am indebted to Capt. Brazier for specimens from *Vati*, *Sandwich Island*, *New Hebrides.*

† **P. Caledonica** Pfr. (*Bulimus*). P. Z. S., p. 387, 1861, *Vavua. Tavu, Banks Island, N. Hebrides.*
† *P. Pfeifferi* Crosse. Jour. Conchyl., xix, p. 184, 1871. *Vavua, Tavu.*
P. Pfeifferi Pfr. Nom. Helic. Viv., 301.
† *P. Brazieri* Pse. A. J. C., vii, p. 27, pl. 9, f. 5, 1872. *Tutuila.*
P. Macgillivrayi Pfr., viii, 194; Nom. Helic. Viv., 300.
P. Macgillivrayi Hartm. Bib. Cat. Part., p. 180.

Obs.—Capt. Brazier writes that he only obtained one example of this shell at Tutuila, which was given to Mr. Pease, and never returned. The example in the Coll. A. N. S., labeled "*P. Brazieri* Pease ex auctore" is of the New Hebrides type and agrees with my example of *Turneri.*

P. turricula Pse. A. J. C., p. 196, 1872. *New Hebrides!*
P. turricula Pfr., viii, 197 ; Nom. Helic. Viv., 301.
P. turricula Hartm. Bib. Cat. Part., p. 188.

† **P. glaber** Hartm. P. A. N. S., 1885. *Hab.?*

† **P. compressa** Pfr. (*Bulimus*), iii, 447. *Fiji Islands.*
P. compressa Rve. Mon. Part., t. 4, f. 20.
P. compressa Pfr. Nom. Helic. Viv., 301.
P. compressa Hartm. Bib. Cat. Part., 181.

† **P. alabastrina** Pfr. (*Bulimus*). P. Z. S., p. 39, 1856. *Fiji Islands.*
P. alabastrina Pfr., iv, 509 ; Nom. Helic. Viv., 301.
P. alabastrina Hartm. Bib. Cat. Part., 179.

† **P. radiolata** Pfr. P. Z. S., p. 39, 1846. *Guam Island.*
P. radiolata Pfr., ii, 69 ; Nom. Helic. Viv., 301. Hartm.
P. radiolata Chemn., t. 64, f. 17, 18.
Partulus radiolatus Albers.

† **P. Layardii** Brazier. *Island of Salisboe.*

Obs.—Unlike other Partulæ this species is devoid of embryonic fovea or spiral striæ. The former are minute longitudinal wrinkles, which are continued over the coarse longitudinal striæ of the surface. The aperture is of a reddish orange color, with a large mammilliform tooth on the pillar lip, and a wide columella above, together with an open umbilicus. The general facies is that of a *Placostylus*, which induced Mr. C. F. Ancey to create the subgenus *Diplomorpha* for the species. Mr. Layard having sent me several of the animals in alcohol, they were referred to Mr. Wm. G. Binney, and, notwithstanding the external differences, "he finds the jaw, lingual dentition and genitalia like other Partulæ."

JULY 14.

Mr. **GEO. Y. SHOEMAKER** in the chair.

Thirteen persons present.

On large Crystals of Stibnite.—Dr. A. E. **FOOTE** exhibited a specimen of stibnite which was shown by the Commissioners of the Japanese Empire at the World's Exposition, New Orleans, and pronounced by them to be the finest ever found. It is a large fan-like group, twenty-two inches high by nine inches wide. The crystals vary in diameter from one to two inches. The largest is perfectly terminated. The Japanese locality, which has hitherto been incorrectly given, is Iyo. On account of their remarkable brilliancy, extraordinary size, and great number of crystalline planes, it is the most remarkable metallic mineral ever found. The known planes of stibnite are now eighty-five, of which forty, described by E. S. Dana from this locality, are new.

JULY 21.

Dr. A. E. **FOOTE** in the chair.

Seventeen persons present.

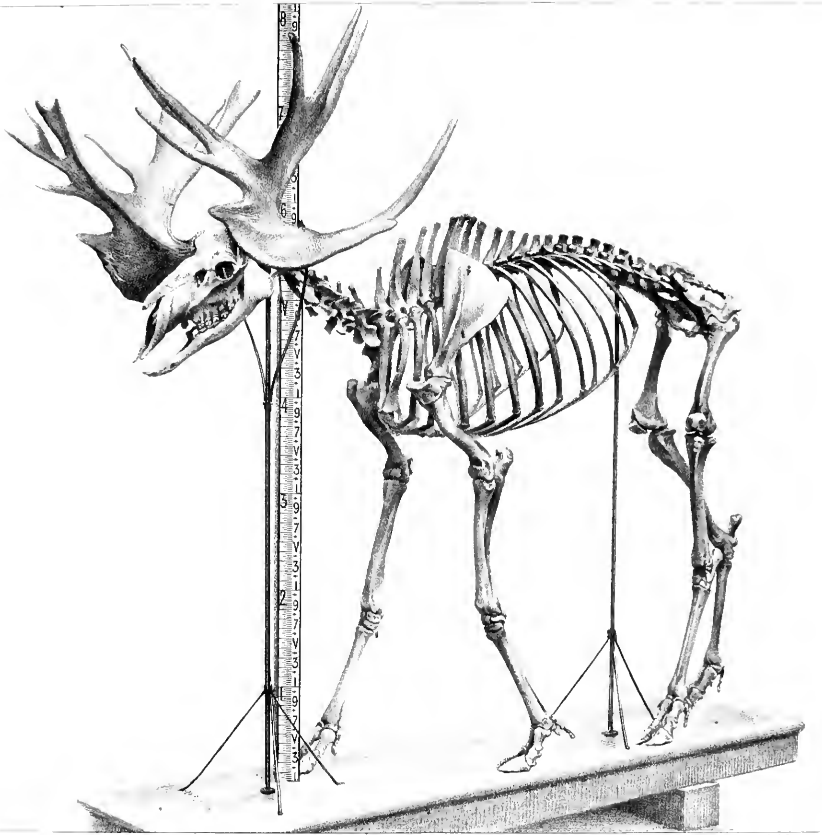
A paper entitled "Revision of the Palæocrinoidea, Part III," by Charles Wachsmuth and Frank Springer, was presented for publication.

JULY 28.

Mr. **THOS. MEEHAN**, Vice-President, in the chair.

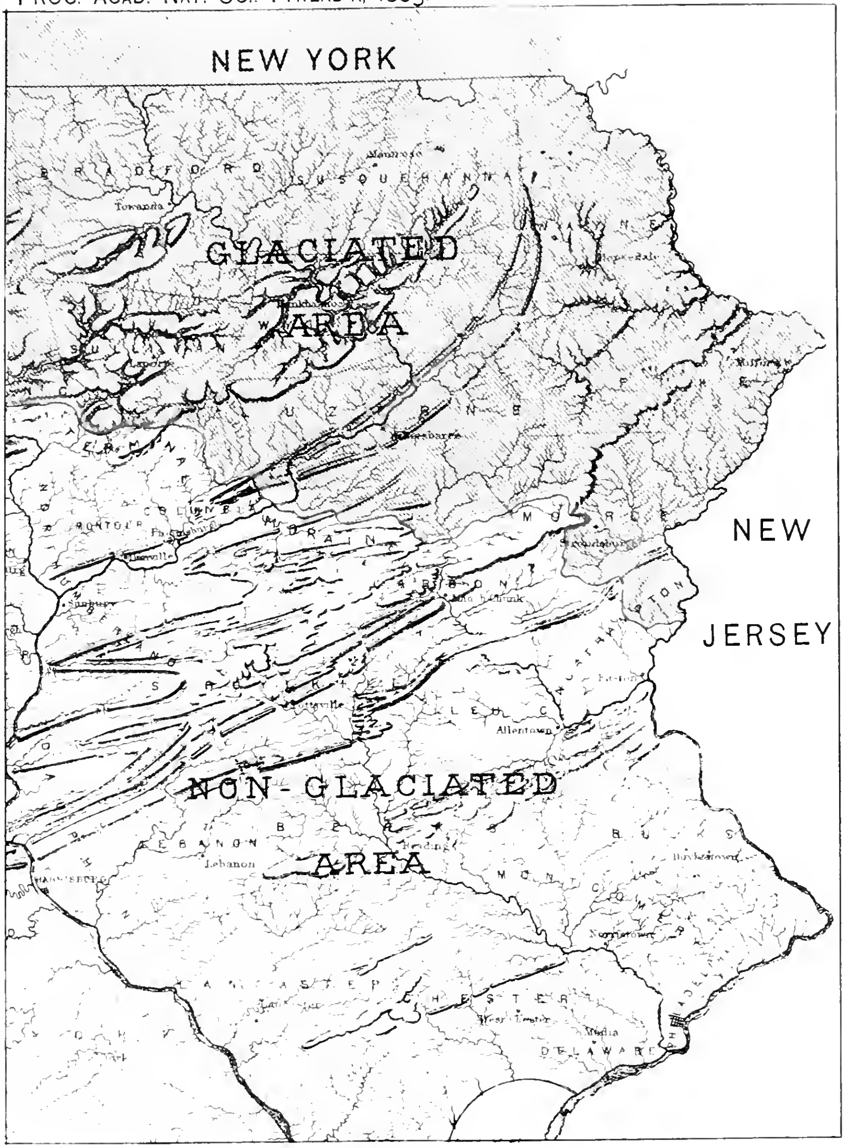
The death of Gen. U. S. Grant, a member, was announced.

The following was ordered to be printed:—



Lith. Werner & Winter Frankfort °M

CERVALCES AMERICANUS.



MAP OF

MARGINAL KAMES

IN EASTERN PENNSYLVANIA,

BY

H. CARVILL LEWIS.

The Terminal Moraine and Kames are marked in red.

REVISION OF THE PALÆOCRINOIDEA.

BY CHARLES WACHSMUTH AND FRANK SPRINGER.

PART III.

DISCUSSION OF THE CLASSIFICATION AND RELATIONS OF THE BRACHIATE CRINOIDS, AND CONCLUSION OF THE GENERIC DESCRIPTIONS.

INTRODUCTORY REMARKS.

During the five years that have elapsed since the publication of the first part of this work, great progress has been made in the study of the Crinoids, both recent and fossil, and many new and interesting forms have been discovered and described.

A number of publications have appeared, which must be regarded as among the most important contributions that have ever been made to the literature of the subject. During the course of our studies for the present paper, we have had the benefit of these discussions and researches, in many instances through the personal kindness of our scientific friends. We have been especially favored in this respect by receiving from Dr. P. Herbert Carpenter many of the proof-sheets of plates and text, in advance of publication, of his magnificent work on the Crinoids of the Challenger collections. This has been of the utmost value to us, and we feel that we cannot be too grateful to the distinguished author for his courteous attention.

We may be pardoned for alluding to the satisfaction we have felt at the kind reception our work has met, at the hands of our co-laborers both in this country and in Europe. That our views would encounter criticism, was expected, and indeed desired by us. The criticisms have for the most part been made in a true scientific spirit, with a view to elucidating the truth. They have in many cases been of value to us, and have enabled us to review the questions raised in a new light. As a matter of course errors on our part have been discovered and pointed out.

In the meantime we ourselves have learned a great deal more about Crinoids than we knew at the time we wrote our first part, independently of the discussions and criticisms above referred to. We have now a far more complete collection of the literature than existed in the United States at that time. Our materials for study in the way of specimens have also been greatly augmented, and for many of the advantages we possess in this respect we are under extraordinary obligations to the naturalists and collectors of the United States and Canada. Many of these gentlemen, with rare liberality, have placed their collections at our disposal, and forwarded to us, at the risk of loss in transit, unique, valuable and original specimens. We desire to express our grateful thanks for favors of this kind to Prof. Whiteaves, Director of the Canada Survey; Prof. Whitfield, of the American Museum, New York; Dr. C. A. White, of the Smithsonian Institution; Prof. Worthen, Director of the Illinois State Survey; Mr. Walter R. Billings, of Ottawa; Mr. S. A. Miller and Prof. Wetherby, of Cincinnati; Mr. I. H. Harris, of Waynesville, O.; Mr. William Gurley, of Danville, Ill.; Mr. R. R. Rowley, of Curryville, Mo.; Mr. James Love, of Burlington, Iowa, and others. We are also under great obligations to our friend, Orestes St. John, who executed the drawings which illustrate this paper. We consider ourselves peculiarly fortunate in enlisting the co-operation, for this purpose, of one who is both a trained and able naturalist and a skilful artist.

As a result of our recent researches, we have naturally been led to entertain new ideas, and in some cases to a modification of views at first entertained.

In the present paper, which appears as Part III of the Revision, we give a description of the genera that have not been considered in Parts I and II, and shall also state the results of our further studies in their bearing upon the genera heretofore discussed.

In the beginning of this work we recognized two great divisions among Crinoids, viz.: Palæocrinoidea and Stomatocrinoidea, for the latter of which we afterwards adopted Carpenter's preferable name Neocrinoidea. We divided the Palæocrinoidea into three great families, based upon as many distinct plans of structure. We did not at first undertake to identify the different subgroups into which these might be divided, except provisionally in some instances, although we recognized the propriety of such subdivision. Prof. Zittel had established twenty-two families of Crinoids, and while his classification has great merit, and is in many essential particulars in accordance with our own views, it was defective in not recognizing the more comprehensive relations which exist among these animals. His groups failed to express the distinctions in plan of structure, which we have pointed out. While we are satisfied that the necessities of classification require the recognition of a large number of family groups, which we have not hitherto sought to define, we are more than ever convinced that the three great groups which we originally established, are the only really reliable ones, for the reason that they are founded upon well-defined plans of structure.

The Plates of the Abactinal System.

Dr. P. Herb. Carpenter in his Challenger Report, p. 1, describes "the organization of a Crinoid to be broadly divisible into two well-marked portions," to which he applies the general names "ambulacral and antiambulacral." The ambulacral portion is "the visceral mass or disk in which is situated the whole of the digestive tube with both its terminal openings, and it contains the central ends of the radial water-vessels and blood-vessels." The antiambulacral portion "consists of the stem and its appendages, the calyx, and the skeleton of the rays, arms and pinnules." The two portions, he states, correspond on the whole to the actinal and abactinal systems of Echinoderms generally, and were developed, respectively, around the left and right water-tube, or what are generally called the left and right larval antimers. The whole of the calyx and the arm skeleton are formed on the right antimer; the disk and the extensions of the peristome, and the perisomic plates clothing its ventral surface, on the left antimer.

In all recent Crinoids, and so far as known, in all Neocrinoids, the calyx is restricted to the dorsal side of the Crinoid, and all structures along the ventral side form a part of the disk or its extensions. The calyx consists of few plates, as a general rule only of basals and radials. Comparatively few genera have underbasals. Interradials have been described only in *Guettardicrinus*, in a few species of *Apiocrinus*, in *Uintacrinus*, and in the remarkable recent genus *Thaumatocrinus* which exceptionally also has anal plates. None of these plates, however, extend beyond the limits of the dorsal cup.

In the Palæocrinoidea the structure of the calyx is much more complex. Underbasals are represented in nearly one-half of the known genera, and all have interradials, by means of which frequently a large series of arm plates are incorporated into the calyx, and thereby elevated to the rank of radials. The term "calyx," although applied sometimes in a general way to the whole skeleton exclusively of arms and column, has been of late restricted to the dorsal cup, and all structures upon the ventral surface were called variously vault, dome or disk. It has been the general opinion that all plates located ventrally, in analogy with the Neocrinoidea, either were perisomic, or at least formed a part of the actinal system. This is the view expressed by Carpenter in the Challenger Report, and we must acknowledge it was our own until quite recently. We now hold that a large part of the ventral surface, throughout the Palæocrinoidea, was covered by abactinal plates, and that the calyx extended to the summit pieces, the so-called "apical dome plates." In this sense the term "calyx" will be used by us in this part of the Revision, while the plates beneath the free arms comprise the "dorsal cup." We further use the term "ventral disk" exclusively to denote the upper surface of the visceral mass, in which the mouth is situated, and from which the food grooves radiate outward. The "disk" is clothed by the "perisome," which may be exposed to view or subtegminal, simply membranous or studded with plates; if subtegminal, it is covered by the "vault," which may be rigid or pliable.

The name "*Camarata*" is proposed for all Palæocrinoidea in which the lower arm plates are incorporated into the calyx by interradial plates, and in which all component parts of the test, dorsally and ventrally, are solidly connected by suture.

Under the name "*Articulata*" we include those families in which the plates of the test are united by loose ligaments or muscles, and in which they are somewhat movable.

The name "*Inadunata*" is proposed for all Palæocrinoidea in which the arms are free above the first radials and which have five single interradials, located ventrally.

These groups will be better defined at the proper place.

A. *The Basals and Underbasals.*

The basals are represented in the Palæocrinoidea by one or two rings of plates. The basals proper constitute the first ring beneath the radials; the second or proximal ring contains the underbasals.

There is, however, one exception to this rule, presented by the remarkable genus *Acrocrinus* (Pl. 6, fig. 1), in which the basals and radials are separated by from four to fifteen rings of small pieces, their number varying in species, and increasing in the growing Crinoid.

The plates of the basal ring are laterally connected except in the two genera *Zeacrinus* and *Calpiocrinus*. In the former they are small, trigonal, acuminate pieces, which externally, and also at the inner floor of the calyx, are separated by the radials, which with their truncated lower angle meet the underbasals. In *Calpiocrinus* four of the basals seem to be totally absent externally, and only the posterior one is represented by a small quadrangular piece. The underbasals differ considerably in size, and are frequently covered entirely by the column. In such cases it is often exceedingly difficult to distinguish them from the upper stem joint. Several species have been described with underbasals which do not possess them, and *Heterocrinus* and *Glyptocrinus* were thought to contain species with underbasals and without them.

Considering the importance that has been given to the presence of underbasals in classification, and the difficulty of identifying them in some groups, it is of some importance, that we have discovered a method, by which, in most cases, the presence or absence of underbasals can be ascertained accurately from the column, the position this occupies toward the general symmetry of the calyx; from the outer angles of the stem joints, their position and that of the cirrhi, whether these are radial or interradial, and from the direction of the rays in the axial canal. The following rules prevail:—

1. In species with underbasals, whenever the column is pentangular, its longitudinal angles are directed interradially, the sides and columnar cirrhi radially; on the contrary, in species with basals only, those angles are radial, the sides of the column and the cirrhi interradial.

2. When there are underbasals and the column is pentapartite, the five sections of the column are radial, the longitudinal sutures interradial, the radiation along the axial canal radial; but the opposite is the case when basals only exist.

For further particulars, we refer to our diagrams on Plate 6, which represent species of widely different groups; and we will state that, notwithstanding we have made the most scrupulous researches throughout our extensive collections and closely examined the descriptions and figures, we have not found a single exception to this rule among all Palæocrinoidea. There are slight deviations, caused by the quadrangular form of certain columns in species which have otherwise a pentamerous symmetry, but we find this also among the basals, which, when composed of four pieces, cannot be strictly interradial.

Among Neocrinoidea, our investigations could be extended only to comparatively few genera, as unfortunately these forms have either a round column or a circular canal. Only in a few species of *Pentacrinus*, *Millerocrinus* and *Apiocrinus* did we succeed in making out one or the other of these points. In these genera, underbasals are said to be absent, but, curiously enough, the outer angles of the column are interradial, the cirrhi and radiation along the axial canal radial, exactly as in the column of Palæocrinoidea with underbasals, and what is more remarkable, as in *Extracrinus*, in which, on the contrary, underbasals are said to be present. The latter seems to suggest that probably many Neocrinoidea either possess small underbasals, or these were present in their larval form. This view is strengthened by the fact that underbasals have been found lately in the younger stages of many Ophiurids and Asteroids.

From our observations it is proved conclusively that the underbasals are not developed from the upper stem joint, as had been supposed by some writers, but represent an independent element, as shown by the fact that the longitudinal sections in Crinoids with a quinquepartite column, always alternate with the proximal plates in the calyx. It is also now apparent to us that the underbasals are morphologically of greater importance than has been generally supposed.

Carpenter's important discovery that the basals represent the genitals, the first radials the oculars of the Echini, and consequently that the proximal radial ring of plates in dicyclic Crinoids cannot be basals, has been now generally conceded by European naturalists, while in America it has been accepted only by Prof. Wetherby, Prof. Williams and ourselves, although no objections were urged against it until lately by S. A. Miller. The latter, instead of attempting to prove the falsity of Carpenter's views, makes the singular remark that the use of the term underbasals, in describing species "has given rise to the expression" "underbasals obsolete," "which everyone must concede is ridiculous." Is the phrase "subradials unrepresented" or "obsolete" less ridiculous to Mr. Miller, especially considering that those plates are interradial in position? He further says: "The policy of changing the nomenclature may well be doubted." "The claim is made that the change will bring the nomenclature used in defining recent Crinoids in conformity with that used in describing fossils, but as long as this is doubted, it is better to adhere to the established or prevailing methods of description." We cannot see what this has to do with recent and fossil Crinoids. If it is right in the one group it is right in the other, for they are built fundamentally on the same plan. The question is simply this: In Crinoids with a dicyclic base are the plates of the proximal ring or those of the inner ring the homologues of the basals in monocyclic Crinoids? If the latter is the case, and we think it has been most satisfactorily proved by Carpenter, the term basals should be applied in all cases to the interradial ring, no matter what the "prevailing methods" have been heretofore. Certainly Mr. Miller would not call the anus of fossil Crinoids the mouth, for the reason that it was called so by the most eminent earlier writers. Besides, the term "subradials" is illogical, as the plates to which the name was applied are interradial in position.

In the Neocrinoidea, the basals, with the exception of *Hyocrinus*, consist of five pieces, and in comparatively few cases an anchylosis took place. In the Palæocrinoidea, however, among Crinoids with a monocyclic base, anchylosis of two or more of its plates is the rule. We find five basals only in Silurian genera, but associated with one genus having four. Four basals do not prevail beyond the Devonian, and apparently not beyond the middle portion of it. Three basals commence in the Upper Silurian and continue to the close of the Subcarboniferous, while two basals are found exclusively in the latter epoch.

The number of underbasals is five, with but few exceptions. *Xenocrinus* has four; the *Ichthyocrinidæ*, *Gissocrinus*, *Lecythiocrinus*, *Tribrachiocrinus*, three; while in the Carboniferous *Stemmatocrinus* the underbasals form a perfectly anchylosed disk. The latter was taken by Carpenter to be a top-stem joint, an interpretation which we cannot accept, but as we discuss this question under *Stemmatocrinus*, we need not enter upon it here. An anchylosis of the underbasals occurs also in *Agassizocrinus* by the deposition of new material around the outer surface before reaching maturity, by means of which the sutures externally and internally become obliterated. The same is the case with the basals in *Edriocrinus*.

In cases of three unequal basals, the position of the smaller plate varies among the different orders, but is unchanged in the same one. In all Palæocrinoidea this plate is located between the anterior and *left* postero-lateral ray (Pl. 6, figs. 21, 25, 26); in the Blastoidea between the anterior and *right* postero-lateral ray (Pl. 6, fig. 24); in the recent genus *Hyocrinus* immediately to the right of the anus (Challenger Report, p. 218). In genera with only two basals, such as *Dichocrinus*, *Talarocrinus*, *Pterotocrinus* and *Acrocrinus*, the interbasal suture passes from the posterior to the anterior side (Pl. 6, fig. 3, and Pl. 9, fig. 1). When there are three unequal underbasals, as in the case of the Ichthyocrinidæ (Pl. 6, fig. 23), and in *Tribrachiocrinus* (Pl. 6, fig. 5), the smaller one is placed anteriorly.

B. *The Radial and Arm Plates.*

With the exception of *Acrocrinus*, the radials proper, the representatives of the oculars, constitute the first row of plates succeeding the basals, with which they alternate. In most of the Palæocrinoidea they do not form a continuous ring, being interrupted posteriorly by an anal piece, and sometimes by additional plates, while in some groups all five radials are separated by five interradials, so as to form jointly a ring of ten plates around the basals. In the Palæocrinoidea generally, the radials and their associates are united by suture with each other and with the basals. In *Cromyocrinus* the union is by syzygy, but in a few of the later Poteriocrinidæ those plates are provided laterally, and toward the basals, with more or less deep fossæ, which suggest a less close union and a certain degree of mobility. In some species of *Forbesiocrinus*, *Ichthyocrinus* and *Taxocrinus*, and probably in the Ichthyocrinidæ generally, the radials were united with one another by muscles; with the interradials, however, by ligament, their lateral faces being provided with deep fossæ and dentations along the edges. (Pl. 5, figs. 3–5).

In some Silurian genera, the radial at the right posterior side makes an exception to the general rule, by either not touching the basals at all, or only toward the right, as in most of the Poteriocrinidæ and Cyathocrinidæ, while the lower left side abuts against the azygous plate.[1] In still others, one or more of the radials are compound, consisting of two sections, horizontally connected by suture, which, combined, have about the form and size of the adjoining single radials, and are succeeded by the same number of brachials as the others. This peculiar structure, which to some extent disturbs the general symmetry, and which occurs throughout different families, but only among Silurian and Lower Devonian genera, is evidently of some importance as representing a very early phase of these Crinoids. The lower segments are probably embryonal plates, which were resorbed by the upper segments, *i. e.*, the permanent radials; in a similar manner as the azygous and anal plate are resorbed by the right posterior radial, which in most of the earlier Inadunata either is missing, as in the case of *Baerocrinus*, or, as in others, imperfectly developed. In *Baerocrinus*,[2] one of the earliest known Crinoids, the azygous piece forms a continuous ring with its four radials, and has the same proportion. In the allied *Hoplocrinus*, however, the right upper corner of the azygous plate is absorbed and replaced by a small trigonal arm-bearing piece, the right posterior radial; the left corner of the plate remaining intact. This is taken up by the anal piece in *Hybocrinus*. In *Dendrocrinus* the azygous plate is reduced to the size of the posterior radial, with which it is connected by a horizontal suture. In *Homocrinus* this suture assumes a sloping position, thereby again decreasing the proportions of the azygous plate. In *Poteriocrinus* the latter is reduced to quite a narrow piece, and the radial toward the right is almost as large as that on the opposite side. In *Cyathocrinus* and *Graphiocrinus* the azygous plate has disappeared entirely, and both posterior radials are equal in size, but separated by an anal piece. In

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[1] The term "azygous plate" is used here, and throughout Part III, exclusively for the unsymmetrical lower plate of the posterior (anal or azygous) interradius, the so-called "first anal plate" of most American writers. We reserve the term "anal piece" for the plate enclosed within the ring of radials.

[2] For further information on *Baerocrinus* and the gradual resorption of the azygous and anal plate in the Inadunata generally, we direct attention to our paper on *Hybocrinus*, *Hoplocrinus* and *Baerocrinus*; *Amer. Journ. Sci.*, 1883, vol. xxvi, p. 365.

Erisocrinus the anal plate also is resorbed, and all five radials are perfectly uniform.

Comparing the gradual reduction of the azygons piece, from a strictly radial non-arm-bearing plate to its ultimate resorption by the right posterior radial, with the modifications which the lower sections of the compound radials undergo among species, it appears to us that the azygous piece may represent the lower segment of the posterior radial. This is further suggested by the genera *Anomalocrinus* and *Heterocrinus*, in which the azygous piece, upon its truncate upper side, supports the right posterior radial, which has the form and position of the upper section of the compound radials; while the azygous piece has the form of their lower section. The respective plates in both cases resemble each other so closely, jointly and separately, that they were all described as radials.

In the Actinocrinidæ, Platycrinidæ, Rhodocrinidæ, and in all groups in which the general symmetry is not disturbed by the presence of an azygous plate, the radials are more or less equal in size, the only remarkable exceptions being the Catillocrinidæ and Calceocrinidæ. In *Catillocrinus* only the two antero-lateral radials are approximately alike. All the others differ widely in shape and size, and while these two plates support from fourteen to thirty arms each, the three others have rarely more than one. Another peculiarity of this genus is that it has no axillary plates, all the arms being given off directly from the radials without the assistance of brachials. *Calceocrinus* has but three radials, of which the anterior one is composed of two parts, which, however, are not always continuous.

Our view, that the arms fundamentally commence with the plate above the first radials, whether this is free or incorporated into the calyx, has been fully accepted by P. H. Carpenter, Chall. Rep., p. 48, who further proves it by the developmental history of the plates. The outer radials, he states, "commence as imperfect rings, which soon become filled up with lengthening fasciculated tissue, just as in the case with the stem joints and later brachials;" but "the first radials, like the basals and orals, commence as expanded cribiform films." He further agrees with us that in practice, for purposes of description, it is more convenient to regard the arms as commencing with the first free plate, provided their real nature is not lost sight of.

The mode of union between the higher radials is either by suture or articulation. A sutural union is found in the Actinocrinidæ, Rhodocrinidæ, Platycrinidæ, Eucalyptocrinidæ, and all genera for which we propose the collective name Camarata. Union by articulation prevails in the radials of the Ichthyocrinidæ, Crotalocrinidæ and the Articulata generally. In most of the Ichthycrinidæ, the transverse faces had muscles and ligament so as to permit motion in all directions (Pl. 6, figs. 3, 4). The lateral faces contain deep fossæ, surrounded by a dentated margin (Pl. 6, fig. 5). P. H. Carpenter and other writers express the opinion that in *Platycrinus* also the first radials were united to the outer plates by articulation. They evidently were led to this supposition by some of the figures, which show what appears to be a transverse articular ridge, but which really marks out the inner end or termination of the small wedge-shaped second radial. This plate, in many of the Platycrinidæ, does not extend out to the end of the scar, the remaining part being only covered by the third plates. We have examined thousands of detached radials of this genus, which indicate plainly that the union was in most of the species by syzygy, and this explains why the upper radials became so generally detached. Others are joined by a more or less close suture, but none by muscles.

The primary radials of the Camarata consist as a rule of three plates, exceptionally of two or four. *Platycrinus* generally has two, but here the second and third evidently were anchylosed. Many plates show a depression indicating the former suture, which in some of the earlier species is yet visible. The second radial of *Stereocrinus* has the proportions of the combined second and third of the allied *Dolatocrinus*, and the same is true with regard to *Anthemocrinus* and *Eucrinus*. In *Batocrinus* the second radial is short, linear, and found occasionally anchylosed with the third. Four primary radials occur in *Reteocrinus*, and also in the imperfectly known *Schizocrinus*. From Hall's figure of *Schizocrinus heterodactylus*, N. York Palæont., i, Pl. 28, fig. 3 *a*, it would appear as if the first and second plate combined were equivalent to the first radial in other genera, and here, as in the case of *Heterocrinus* and *Hoplocrinus*, composed of two parts.

In the Articulata the numbers of their primary radials is more variable, and the presence of four radials by no means the exception; but four are often associated in the same specimen with three or five. *Taxocrinus Egertoni* Phill. (Geol. Yorksh., Pl. 3, fig. 39), even has seven in one, and six in another ray. *Onychocrinus* very frequently has five, *Ichthyocrinus* generally three and four in alternate rays. *Taxocrinus* three or four. *Forbesiocrinus robustus* three and two, and *Pycnosaccus* two as a rule. *Forbesiocrinus Agassizi* sometimes has two primary radials in one or more of its rays, most frequently three, but very often four, and all are articulated on a similar plan.

The secondary and higher orders of radials in the Camarata rarely consist of more than two plates, sometimes, however, of one, three or even four. Only *Glyptocrinus*, *Reteocrinus* and allied genera sometimes have a larger number. In the typical Actinocrinidæ, which branch from alternate sides, the higher orders consist as a rule of a single piece to each division of the ray, which always at the one side supports the radial of the succeeding order, at the other a row of brachials. The latter, however, as should be expected from the term, are not free, but connected laterally by suture with their fellows of alternate orders. In the Ichthyocrinidæ, the higher orders of radials agree in number and form, more or less, with the primary ones, and all are similarly articulated.

Free rays are found as a rule in the Platycrinidæ; in *Eucladocrinus* they extend to nearly the full length of the ray, giving off alternately from every second or third plate an arm, and two at the distal end. Similar rays are formed in *Steganocrinus* and in *Melocrinus;* among the Rhodocrinidæ in *Ripidocrinus*.

The arms of the Camarata bifurcate in their free state only in the genera which Zittel included under the name Glyptocrinidæ, in the Rhodocrinidæ, and in a few Actinocrinidæ, but all branch at least once in the calyx. In all young specimens, as well as in the earlier forms, the arms are composed of a single row of plates, which gradually, embryologically and paleontologically, turn into wedge-shaped pieces at the distal end, or even interlock, while in all later genera the arms are composed of alternate joints. In the Upper Silurian, the biserial arm structure predominates and there is not a single species with uniserial arms in the Devonian. Among the free arms there are no syzygies, but every joint in this group bears a pinnule, and these are frequently so closely folded together, that they appear as if suturally connected. In the Articulata, all arms are composed of single joints, which in their external form agree with the higher radials, being only narrower, and free plates.

In the Inadunata, in which the arms are free from the first radial, the homologues of the outer primary radials, which we have distinguished as brachials, vary in some genera considerably in number. The greatest variation in this regard occurs among the typical Cyathocrinidæ (Cyathocrinites as we called them heretofore), in which the number varies even among the rays of the same species, so much indeed, that one ray may have one, the adjoining two, the next perhaps five or six. The other groups have rarely more than two brachials, and most of them but one. The brachials are regular arm plates, with a well-developed ambulacral furrow, but without pinnules. The arms are composed of single joints, except in the Poteriocrinidæ and Eucrinidæ, in which the biserial arm structure is associated with the uniserial one. Pinnules are wanting in the Hybocrinidæ, Symbathocrinidæ and Cyathocrinidæ, and in the two former the rays are undivided, consisting of a single arm. In the Heterocrinidæ and Belemnocrinidæ, the pinnules are arranged from every second or third joint throughout the entire arm, the non-arm-bearing joints being united by syzygy, while among the Poteriocrinidæ every joint from the second up, bears a pinnule.

C. *The Interradial, Interaxillary and Interbrachial Plates.*

The interradial plates occupy the intermediate spaces between the primary rays; the interaxillaries between the main divisions of the ray; the interbrachials between the arm bases. All these plates may be considered as parts of the same element. The interradials consist primarily of five single plates, which rest either upon the upper or between the lateral margins of two first radials. Only in the genus *Briarocrinus*, and in a few Ichthyocrinidæ, do the interradials commence higher up. Higher orders of interradials are only found in the Camarata and Articulata. Their office is to increase the capacity of the visceral cavity by incorporating the lower arm-plates into the calyx, and also to strengthen it. They are auxiliary pieces, and serve to fill up spaces, and in this capacity adapt their form to adjoining plates. The higher interradials do not possess the morphological importance of the primary ones, which are early developed in the young individual, and represent important elements throughout the earlier Crinoids. The interradials increase by age, vary greatly in number, often in the same species, and even in different rays. There are generally two plates in the second row, but sometimes one or three; beyond these the arrangement of the interradials is more or less irregular. In the Inadunata the interradials are located exclusively on the ventral side; in the Camarata both dorsally and ventrally.

The Reteocrinidæ and Acrocrinidæ, exceptionally, possess no primary interradials properly speaking. In the former group, all radials, from the basals up, are separated laterally by numerous minute pieces, without definite arrangement. *Acrocrinus* has a large belt of small plates, separating radials and interradials from the basals, and the interradial series proper commences with two plates.

In Part II, p. 15, when describing the structure of the vault of the "Sphæroidocrinidæ," we discriminated between true interradials and interradial dome plates, the former as being developed around the dorsal, the latter around the ventral pole. At that time we were under the impression, and it was the general opinion among naturalists, that the plates of the ventral side in all Crinoids, recent and fossil, constitute a part of the actinal system. It was known to be the case throughout the Neocrinoidea, and among Palæocrinoids we found several genera in which the interradials of the dorsal side are separated from those of the ventral side. In *Batocrinus*, the higher orders of radials frequently are not separated by interradials, as in the case of the primary ones, but join laterally with their fellows, thereby causing an interruption in the interradial series. These cases, however, form exceptions to the rule; the interradials of the two hemispheres almost always meet each other, and there is no dividing line by which they can be distinguished.

That the abactinal interradials extend to the ventral side, is well shown by the Platycrinidæ and Hexacrinidæ, our former subdivisions Platycrinites and Hexacrinites, in which the first interradials occupy the equatorial zone, and all succeeding ones are located ventrally. When we defined these groups, we described the first row of interradials to be composed of a single plate, a statement which is not strictly correct.

Consulting our figures (Pl. 7, figs. 5–8, and Pl. 9, fig. 6), it will be seen that in the Platycrinidæ and Hexacrinidæ, the first row of interradials contains not one alone, but invariably three or more plates, placed side by side, all resting upon the upper faces of the first radials. Only the middle plate, the one placed upon the outer ends of two radials, corresponds with the first interradial of other groups; the plates at the sides are accessory pieces, and rank as interradials of the second and third row, respectively. Species with a discoid base have sometimes five plates in the same row, of which only the outer ones meet the second radials. In the simplest form of *Platycrinus*, the middle plate connects directly with the proximals, and at the azygous side with anal plates. In most species, however, the first row is succeeded by other interradials, which either connect laterally with their fellows of adjoining sides, forming with them a continuous belt around the peristome (Pl. 5, fig. 9, and Pl. 7, fig. 6), or are separated by radial structures. In either case there is no dividing line between the plates of the outer and inner rows, and the upper rows always rest against the proximals. The case is the same in *Marsupiocrinus* (Pl. 8, fig. 7), *Hexacrinus*, *Dichocrinus* and *Talarocrinus*, and similar in *Coccocrinus* and *Culicocrinus*, which we shall discuss farther on.

In the organization of the Actinocrinidæ, Melocrinidæ, Eucalyptocrinidæ, Rhodocrinidæ, Glyptasteridæ and Reteocrinidæ, the interradials form even more important parts than in the two groups above mentioned. That here the plates of the ventral side form a continuation of the interradials at the dorsal side, is clearly indicated in genera whose arms are given off in clusters, or in which the rays are formed into lateral extensions. In such species, the interradial series are not disturbed by so many radials, nor by interaxillary plates, and the interradials decrease in size gradually all the way from the first interradial up to the proximals. In species, however, in which the arms are arranged in a continuous ring, the interradials decrease in size more or less from the poles toward the periphery. This decrease in the size of the plates toward the equatorial regions is easily explained by the extravagant increase of arms in those species, and by the nature of the interradial plates, which, as stated, are accessory pieces, filling up spaces. An occasional interruption of the series, therefore, is no proof that the two sections represent different elements.

In some genera the interradials of the ventral side are exceedingly small, without definite arrangement, and they cover the surface radially and interradially. This is frequently the case in the Silurian genera, *Glyptocrinus*, *Periechocrinus*, *Melocrinus* and *Reteocrinus*. Their ventral covering resembles so closely the disk of certain Comatulæ, that it might appear as if this multitude of irregular plates, which sometimes decrease in size toward the periphery, and extend out to the free rays, could not be true vault pieces. In proof, however, that this is the case, we refer to Mr. St. John's carefully prepared diagram of *Glyptocrinus ramulosus* Billings, drawn from a specimen in the Canada Survey Museum, and kindly loaned to us by Prof. Whiteaves. Of the specimen only one-half of the calyx is preserved, and this is imbedded in rock, exposing only the inner floor. *Glyptocrinus ramulosus* is the largest species of the genus, and this facilitates the study of the plates. Like all other species of *Glyptocrinus* it has a large number of irregular interradial, interaxillary and interbrachial plates, which meet laterally over the arm openings, and are continued to the summit, leaving no line of demarkation between the plates of the two hemispheres. In the direction of each arm opening the floor is distinctly grooved, and these grooves or depressions, which diverge from the centre to the arm furrows, evidently lodge the ambulacra. That the grooved plates are not covering pieces, is shown by the fact that they have the same irregular arrangement as the other plates. The whole structure reminds us of *Physetocrinus*, and we have no doubt that the vault in those two genera was built essentially on the same plan. We find this further confirmed by the fact, that in the Canada specimen the inner faces of the interradial and interaxillary plates—but not any of the radial ones—are provided with short nodes, such as are found in many Actinocrinidæ, and which serve there as pillars or partition walls between disk and vault.

In the Crotalocrinidæ, which include *Crotalocrinus* and *Enallocrinus*, the whole ventral surface, in what appear to be the best-preserved specimens, is composed of strong, convex plates, without definite arrangement. In these specimens there is no central piece, nor proximals, nor traces of ambulacra (Icon. Crin. Suec., Pl. 7, fig. 3 *a*; Pl. 8, figs. 6, 7, and Pl. 25, fig. 2); there are, however, other figures of Angelin, apparently of a closely allied species (Ibid., Pl. 17, fig. 3 *a*), in which the plates paving the ventral surface are much more delicate, and consist of a central plate, large proximals, and several rows of covering pieces, without the intervention of either anambulacral or interradial pieces. It would be difficult with the utmost stretch of our imagination to recognize in the former figures either proximals or central piece, which, as admitted by Carpenter, are present in all these Crinoids, and we think there can be little doubt that the two sets of figures represent different parts of the animal, the one the disk, the other the vault, and that the one covered the other. A similar opinion was evidently entertained by Zittel (Handb. d. Palæont., i, p. 357), who stated that *Crotalocrinus* possessed five "grosse Oralplatten, bald unter der Decke, bald äusserlich sichtbar." According to our interpretation, the calyx of the Crotalocrinidæ extends ventrally to the oral pole, and the ambulacra, central piece and proximals are subtegminal, covered by interradial plates, which extend out to the lower rows of covering plates and side-pieces (Icon. Crin. Suec., Pl. 7. fig. 6, and Pl. 25. fig. 15). A similar condition probably prevailed in the Ichthyocrinidæ, with which the Crotalocrinidæ have close affinities.

In the Ichthyocrinidæ, interradials have been observed only at the dorsal side, where they are subject to many irregularities. In some of the genera they are always present, in others entirely absent; while there are still other genera and certain species, in which they are occasionally undeveloped dorsally. The interradials of the Ichthyocrinidæ are united by ligamentous articulation among themselves, and also laterally with the radials, as shown by the presence of deep fossæ at the sides of the plates (Pl. 5, fig. 5). The mobility in the test, resulting from this structure, led us formerly to state that the ventral covering, which is so rarely preserved, "perhaps" consisted of a "soft or scaly integument." The word "soft" was ill-chosen, and did not express our real meaning, we should have said, as we did in other places, "pliable." There is nothing to indicate a membranous surface structure, but the pavement evidently was pliable in conformity with the condition of the test at the dorsal side. In *Onychocrinus exsculptus*, the only Ichthyocrinoid in which portions of the ventral covering have been observed, Lyon and Casseday found in the radial regions rather large, alternately arranged plates (Amer.

Journ. of Sci., 1859, vol. xxix, p. 79), and in another specimen we found, interradially disposed, small imbricating plates connecting with larger pieces. Whether the latter, as we supposed, represent the summit plates, or Lyon and Casseday's alternating pieces, we could not make out satisfactorily. Carpenter took them to be "covering plates of the ambulacra, which perhaps were permanently closed as in the Platycrinidæ, or only temporarily so as in the Neocrinoids; while the small irregular plates, which form the interradial portions of the vault, correspond to the anambulacral plates of recent Crinoids. They pass downward into the interradials at the sides of the calyx, just as in the recent species and in the Liassic *Extracrinus*" (Chall. Rep., p. 181). We accept the first part of this explanation that these alternate plates probably correspond to the covering pieces of the Platycrinidæ; we even admit these plates to be morphologically identical with those along the disk of the Neocrinoidea. But we doubt if the interradial portions in *Onychocrinus*, or *Platycrinus* either, correspond to the anambulacral plates of recent Crinoids. The interradial plates of vault and disk are very distinct structures; the former constitute a part of the abactinal system, while those of the disk are actinal. Before we enter upon further discussion of this subject, we direct attention to the ventral structure of the Blastoidea and Cyathocrinidæ.

The Cyathocrinidæ were described by us as having no interradials, and until lately we considered this a fixed character of this group. The fact that the only plates interradial in position are located ventrally, seemed to us as sufficient evidence that they were actinal plates, and as such they seemed to be the representatives of the oral plates in the Neocrinoidea. We thought the same regarding the deltoids in the Blastoidea, which occupy essentially the same position in relation to adjacent parts as the above plates in the Cyathocrinidæ. Prof. Zittel, in his "Handbuch der Palaeontologie, i," like us, called the plates orals in all three groups, and this interpretation was afterwards accepted by Mr. Etheridge, Jr., and P. Herb. Carpenter, in their paper, "On certain points in the Morphology of the Blastoids" (Ann. Mag. Nat. Hist., April, 1882, p. 214), in which these writers state that in Blastoids the calyx is formed "by the basals, radials or forked pieces, and the deltoid pieces or orals."[1]

The latter statement seems to us an anomaly. It is impossible that those plates can be orals, and at the same time form part of the calyx. The orals in recent Crinoids have never been considered as calyx pieces, and hence, if the deltoids are orals, they do not belong to the calyx. That, however, they are calyx plates is indicated by their position and relations to other parts, and still more by their enormous variation in size among species of the same genus. If the deltoids were orals, the actinal system in the Blastoids, in forms like *Elaacrinus obovatus*, would occupy over three-fourths of the entire test, while in *Heteroschisma*, which has exceedingly small deltoids, these regions would be reduced to a small circum-oral space. The proportions of the actinal and abactinal regions in the test, respectively, were looked upon by Prof. L. Agassiz as determining the different outlines of the various "orders" of Echinoderms, which he ranked according to the greater preponderance of the one over the other, and this, if true, proves conclusively that the deltoids are not actinal plates, and, therefore, are not orals, but must be interradials. The same argument, however, cannot be applied to the Cyathocrinidæ, in which the so-called orals are located ventrally, and from analogy with recent Crinoids should be actinal plates.

By carefully removing the arms in some of our best specimens of *Cyathocrinus*, we succeeded in exposing the ventral surface in several species, and were enabled to observe its structure in various stages of preservation. In a specimen of *Cyathocrinus Gilesi* (Pl. 4, fig. 2), from the Burlington and Keokuk Transition beds, we found *in situ* the five large interradial plates, the so-called orals, all connected laterally, and each one provided along its upper face with a conspicuous central node. In another specimen of the same species (Pl. 4, fig. 3), these interradials were partly covered along their surface by numerous irregular pieces, but so as to leave the central node exposed, the face at a level with the small tegminal pieces. In two specimens of

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[1] We are pleased to state that Dr. P. H. Carpenter, whom we had acquainted with the modification of our views regarding these plates, now fully agrees with us that neither those of the Blastoidea nor Cyathocrinidæ are orals (see Chall. Rep., p. 162).

Cyathocrinus multiradiatus from Crawfordsville, of which the one is figured (Pl. 4, fig. 6), the entire surface of the interradials, and also the circum-oral space, is covered by minute plates, except at one end (see figure) where the plate underneath is exposed to view. The structure is similar in *Cyathocrinus iowensis* from the Lower Burlington limestone (Pl. 5, fig. 7), but there the plates closing the peristome consist of eight considerably larger pieces, placed around a central one, arranged in pairs, of which each pair corresponds in form and position to one of the four large proximals in other genera.

In the above specimens, the so-called orals are covered along their sutures by well-defined ambulacra, lined by side-pieces and covering plates, and these connect laterally with the small tegminal plates which we have described. That all surface plates in these species are perisomic, nobody will doubt after consulting our figures, and that the plates supporting them are interradials and not orals, is proved by the fact that they surround the peristome, but do not cover it, and are succeeded by numerous other plates.

This, however, was not the structure of the Inadunata generally, or even of all Cyathocrinidæ. Angelin figures from the Silurian of Sweden (Icon. Crin. Suec., Pl. 23, figs. 10 *b*, 11), two specimens under the name of *Cyathocrinus alutaceus*, in which the interradials (orals) were exposed, and not covered by plates. They have a central piece, surrounded by four large proximals, and there are, alternating with them, five conspicuous radial dome plates, with numerous irregular pieces along the posterior or anal side, which join the central plate, and extend outwards, forming a short protuberance, composed of small pieces. There are at the surface no traces of ambulacra, and the whole structure ventrally is almost identical with that of certain forms of *Platycrinus;* while the dorsal side of the species shows clearly the characters not only of the Cyathocrinidæ generally, but the detail structure of the genus *Cyathocrinus*. The total absence of ambulacra upon the surface proves that in this species the disk was subtegminal, covered by the plates which have been heretofore called orals, but which are identical with the first interradial plates of *Platycrinus*, and with the first interradials of *Actinocrinus* and other Camarata. The structural identity with all these plates proves that the interradials of the Cyathocrinidæ, and the deltoids of the Blastoidea, are abactinal plates, that they constitute a part of the calyx; and it proves further, which is equally important, that some of the Palæocrinidæ have abactinal plates along their ventral side. That *C. alutaceus* cannot be retained in the same genus with the Carboniferous forms is self-evident. The two are morphologically in a very different condition, and we should propose for the former a new generic name if we had before us specimens in place of figures.

Carpenter fully accepts the views previously held by us, that in the Camarata all interradials located dorsally are abactinal plates, and those at the ventral side actinal. It should be stated, however, that we had communicated to him, in time for the Challenger Report, the modifications our views had undergone on this point. We make this statement to show that Carpenter's interpretation of the plates was not based upon our—as we believe—erroneous observations, but was the result of his own studies. Carpenter even goes further than we ever did. He asserts that the plates, which we took to be the actinal representatives of the interradials, in some groups, are anambulacral plates, and form a part of the disk.

His interpretations of the interradials in the Platycrinidæ are not always harmonious. If we understand him correctly, he regards the first interradial piece as a calyx plate (Chall. Rep., p. 40), but all succeeding ones as perisomic, "much more substantial, however, than in Neocrinoids, and forming part of the solid covering, but not a true vault or *tegmen calicis*" (Chall. Rep., p. 179). On the same page he states further: "Although believing that the vault of a Platycrinoid corresponds collectively to the orals, interradials, ambulacral and anambulacral plates of Neocrinoids, I do not wish to assert that the Platycrinidæ either had an external mouth or open ambulacra on the disk." On page 178, however, he states that the "series of four or six interradials, corresponds generally to the single large interradial of *Cyathocrinus*." It is not clear to us, how the same pieces can be anambulacral, *i. e.* disk plates, and at the same time "correspond generally" to a true interradial plate. He supports his theory by pointing to the alternating pieces, the so-called "covering plates," which in most of the Platycrinidæ appear along the radial portions of the ventral surface, and which he believes are always subtegminal in *Actinocrinus*. He says: "I do not myself think that the vault of a Platycrinite was exactly of the same nature as that of an Actinocrinite, *i. e.*, that it covered in the whole of the visceral mass and ambulacra on its upper surface. For if the alternating dome plates represent the covering plates of recent Crinoids, then all the periphery of the dome, outside of the apical dome plates, must be the real ventral surface of the body, and not a *tegmen calicis* as in *Actinocrinus*." And he states further, on page 179: "There is some point on the actinal side of every Crinoid where the food grooves leave the oral system, covering up the peristome in which they originate, and are only closed by the covering plates at their sides." This is quite true as to the Neocrinoidea, in which the calyx is limited to the dorsal side, but not altogether in the case of the older Crinoids, in which the calyx, as we believe, takes up the greater part of the ventral surface, and the covering pieces frequently are embodied among abactinal plates. In the Platycrinidæ the disk is subtegminal, although portions of the covering pieces appear along the surface, but these, in place of lining the sides of the food grooves, are incorporated between the interradials, resting between them as solidly as the summit plates, and cover the food grooves as tightly, as the interradials do in *Actinocrinus*.

Carpenter agrees with us that the radials above the first are fundamentally arm plates, which, in the growing Crinoid, by the increase of interradials, were incorporated into the calyx. During the process of incorporation, by the widening of the equatorial zone, the ambulacral vessels and food grooves of the incorporated arm plates, gradually were lifted out from the arm-furrows, and stretched out along the disk in the form of tubes, being enclosed from above and below by plates. These ambulacral tubes in most of the Actinocrinidæ are altogether subtegminal, and located at a distance from the inner floor of the vault, until on approaching the arm bases they not only come in contact with, but raise up the interradial plates and push them aside, exposing to view the upper rows of tube plates, the so-called covering pieces, which are thence continued along the arm furrows.

In the Platycrinidæ, the conditions are essentially the same as in the Actinocrinidæ, but most generally the covering-plates of the tubes penetrate the vault before they pass into the arms. This takes place either along the outer edges of the proximals, or beyond the succeeding ring of interradials. In either case, however, the covering-plates join laterally with the interradials, and accommodate themselves, more or less, in form and size, to the surrounding plates, so much, indeed, that frequently they attain the same rigid form as the true vault pieces (Pl. 7, figs. 5, 7, 8). Sometimes, however, as in the case of *Marsupiocrinus cœlatus*, the alternating plates retain their original form and delicate structure, while in the same genus, in *Marsupiocrinus Tennessea* (Pl. 8, fig. 7), they are as rigid as the interradials.

For proof that our descriptions of the alternating plates, and the ambulacral tubes generally, are based upon actual observation, we refer to the casts of *Dorycrinus* (?) (Pl. 4, fig. 5), *Strotocrinus* (Pl. 4, fig. 4), and *Platycrinus* (Pl. 5, fig. 9), in all of which the ambulacra, at some distance before entering the peristome, are covered up in the cast and are visible upon the surface only at or near the arm bases. The cast of *Platycrinus*, which we have illustrated, shows beautifully the alternate arrangement of the covering plates, which pass out from beneath a belt of large interradials. Looking at this figure we do not see how Carpenter can any longer maintain that *Platycrinus* possessed no tubular skeleton, and that the upper interradials are anambulacral plates. The specimen will also convince him that there are in this genus upon the surface of the cast no "elevated rounded ridges, almost like strings overlying the surface," as he imagined (Chall. Rep., p. 179), and which, he thought, represented "the open food grooves of recent Crinoids." Among the twelve or more casts of *Platycrinus* which we examined from Mr. Rowley's collection, not one bears that string-like structure, and in all of them the ambulacral tubes are placed around the peristome at a distance from the vault. That even in the Actinocrinidæ those strings which we noticed upon the casts do not represent organs connected with the food grooves, will be shown elsewhere.

Among Actinocrinidæ, and probably in other families, the covering plates sometimes penetrate the interradials in a similar manner as in the Platycrinidæ, and this is so even in the genus *Actinocrinus*. *Actinocrinus stellaris*, from the Mountain limestone of Belgium, has a row of alternating plates covering the food grooves, a character not well shown in De Koninck's figures; although the arrangement of the plates is very regular in the specimens, and almost identical with that of certain species of

Platycrinus. They form a ridge of strong tuberculous plates, and are almost as prominent as the apical or summit plates of this species, while the interradials, from the first to the last, are scarcely convex. The same structure is also found in *Steganocrinus concinnus* (Pl. 8, fig. 4). In *Carpocrinus ornatus*, however, the alternate plates retain, more or less, the character of other perisomic pieces.

Wherever covering plates in the Camarata are exposed, they are invariably placed on a level with the interradials, not upon their surface, and the ambulacra are essentially in the same condition as those of the Actinocrinidæ, only the interradials do not close over them, but are pushed aside. The case, however, is very different in the higher form of *Cyathocrinus*, in which not the covering plates alone, but the whole tubular skeleton and the entire disk is exposed.

The discovery of anambulacral plates upon the surface of the interradials is morphologically of the utmost importance, as throwing light upon the phylogenetic as well as the ontogenetic development of the older Crinoids and their relation to the Neocrinoidea. If a resorption of these interradial plates, as we believe, took place in the Poteriocrinidæ, then the dividing line between the older and later Crinoids becomes so narrow, that it is difficult to decide where the one terminates and the other begins. A resorption of the interradial plates in palæontological times is in accordance with the embryological development of recent Crinoids. Carpenter is inclined to believe (Chall. Rep., p. 40), that the interradial plates, which Sir Wyville Thomson (Philos. Trans., 1865, p. 540) observed in the early larval stages of *Antedon rosacea*, and which he takes to be primary interradials, "eventually undergo resorption like the orals and the anal plate."

In the Neocrinoidea, with the exception of *Thaumatocrinus*, *Guettardicrinus*, and one or two species of *Apiocrinus*, the interradials are represented by indistinct plates, and are only temporarily developed. In the Palæocrinoidea, however, the interradials are permanent, and in some groups so extravagantly developed that they constitute the greater part of the calyx. It is very remarkable that we find the most profuse development of interradials among Silurian genera, which tends to prove that a largely developed interradial system represents a lower grade of organization in these Crinoids, especially as these plates increase numerically in the individual by growth. In the Crotalocrinidæ they cover the entire peristome, including the central piece and proximals. In the Reteocrinidæ and Glyptocrinidæ they extend from the basals to the central piece. In *Actinocrinus*, *Melocrinus* and *Platycrinus*, from the first radial to the proximals, exactly as in the early *Cyathocrinus*, only that in the latter the interradials consist of a large single plate, in the others of numerous small ones.

If it were true that the deltoids of the Blastoidea, and their representatives, the interradials of the Cyathocrinidæ, were orals, the first interradials of all Camarata would be oral plates, and all higher orders upward growth of the orals. That this is not the case is clearly shown by the fact that all these plates, from the first to the last, are calyx plates, *i. e.*, abactinal; while the orals of the Neocrinoidea are actinal, being developed around the left peritoneal tube.

That the interradials and their associates, the interaxillaries and interbrachials, dorsally and ventrally, are abactinal plates is further shown by the presence of perisomic plates underneath the vault, which, wherever they have been observed subtegminally, extend from the first interradial to the end of the central piece (Pl. 2, fig. 8). The disk of the Palæocrinoidæ, therefore, begins from beneath the first interradial, and rests, as in the Neocrinoidea, against the first primary radial, thereby making the first interradial, in the true sense of the word, a vault plate.[1]

According to Carpenter, the Ichthyocrinidæ and some of the doubtful Silurian forms, such as *Reteocrinus* and *Xenocrinus*,

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[1] The term "vault" has been heretofore applied by most writers to all plates of the ventral side. In this sense it is actually a misnomer. If the term is used at all, it should by right include all interradial, interaxillary and interbrachial plates, dorsally and ventrally, and these might be very appropriately designated as vault plates, to distinguish them from the perisomic or disk plates, which are placed beneath the others, and follow their direction. But fearing that the introduction of a new term, or giving a different interpretation to the same term, might produce confusion, we retain it as a convenient and short mode of expression for all plates of the ventral side that are not perisomic. It is therefore a merely conventional term. Carpenter applies it to all actinal plates of the dome, with the exception of the perisomic ones, in which he includes all interradials of the ventral side which he takes to be actinal.

appear to occupy an intermediate position between the heavily vaulted Platycrinidæ and the more thinly plated recent forms.

We have shown already that neither the small irregular plates in *Glyptocrinus*, nor any of the interradials of *Platycrinus*, are perisomic plates, and this in itself is a strong proof, that the structure, which occupies relatively the same position in the allied genus *Reteocrinus*, cannot represent a totally different thing. Carpenter leaves us in doubt whether the so-called disk of *Reteocrinus* and *Xenocrinus* begins at the basals, where those minute irregular pieces commence, or at the equatorial zone, as he believes it does in *Glyptocrinus*. It seems to us, if he had not meant the whole interradial series, he would not have made a comparison of these parts with those of the Liassic *Extracrinus* and recent forms without interradials, but would rather have selected *Thaumatocrinus*, in which interradials are present. He also indicates it by his remarks on the fixed pinnules of *Reteocrinus*, which, as we know, are located dorsally, and which he says (Chall. Rep., pp. 39, 40) are soldered together by the minute irregular plates, which pass insensibly upwards into the plates of the so-called vault, and further: "This condition recurs constantly in the Liassic *Extracrinus*, and in the recent Pentacrinidæ and Comatulæ; and I see no reason to believe that the minute interradials of *Reteocrinus* are in any way different from those of the Neocrinoids. But I regard them as perisomic plates, continuous with those of the disk above, which was in no sense a vault like that of the Actinocrinidæ."

According to this, if we understand him correctly, the calyx in the Reteocrinidæ consisted only of basals, underbasals and radials, which latter throughout their full length were enclosed by perisomic plates. This would be a very peculiar condition for one of the earliest known Crinoids, if we admit that the Palæocrinoids are developed from a lower morphological level than the Neocrinoidea. In support of it Carpenter has no other proof than a superficial resemblance in the form of the plates. There is nothing to show that any of the plates were perforated, there is no external mouth, no food grooves, nor plates that could possibly be considered as covering pieces. All the plates dorsally and ventrally, even those extending to the free rays, have the same irregular arrangement. The ventral surface of *Reteocrinus* is almost identical with that of *Glyptocrinus decadactylus*, which

S A. Miller (Cincin. Soc. Nat. Hist., Dec., 1883), decribes as follows: "It is composed of numerous polygonal plates. Those in the central part are the larger ones, and each of these bears a central tubercle, which is sometimes prolonged so as to be designated a spine. Toward the margin, or rather following the undulations toward the intertertiary areas, the plates are smaller and possessed of slight convexity. They unite in the depressions in the intertertiary areas with the plates of the calyx, or rather the interprimary radials graduate through the intersecondaries and intertertiaries to the plates of the vault without any line of separation. The plates become smaller as they approach the inner face of the arms, over the swelling undulations of the vault, and continuing to decrease in size, form a somewhat granular, continuous integument, that covers the ambulacral furrows. This continuation of the vault up the inner side of the arms, has been observed for a distance of an inch above the vault, and, no doubt, extended as far as the arm furrow itself."

We have carefully examined Miller's original in Dr. R. M. Byrne's collection, and can attest the correctness of his description. The decrease in the size of the plates toward the periphery, which evidently led Carpenter to consider those plates as an outgrowth from the oral side, is readily explained by the enormous accumulation of plates from the interradial, interaxillary and interbrachial series, which terminate soon after entering the ventral side, or else diminish in width. That the vault in *Glyptocrinus* and *Reteocrinus* extends over the full length of the arms, as suggested by Miller, and that only their large pinnules had open food grooves, is at least doubtful, although it may be possible, as such is the case in the allied genus *Melocrinus*, in which, however, the pinnule-like arms are provided with extra pinnules.

Carpenter attaches considerable importance to our incidental remark, "that the peculiar depressed state of the interradial and interaxillary areas of *Reteocrinus*, the irregularity in the arrangement of their plates, suggests the possibility that those parts were adapted to expansion by the animal." And he makes use of this as an argument in favor of his theory that the ventral plates of *Reteocrinus*, like those of the Ichthyocrinidæ, represent "the plated perisome of the Neocrinoids." That the test of *Reteocrinus* was in any way pliable, has been given up by us entirely, nor do we believe that the pliable test of the Ichthyocrinidæ bore any relation to the disk of recent Crinoids, but we believe, as strongly as ever, that their ventral surface was covered by a vault. A vault paved by small irregular pieces, and folded like the disk of recent Crinoids, with elevations following the food grooves, is found not only in *Glyptocrinus* and *Reteocrinus*, but also among the later Actinocrinidæ. The surface elevations, which form natural grooves at the inner floor, represent more or less open galleries, which in other forms are produced by a thickening of the plates along the inner floor. Miller's description of the vault of *Glyptocrinus* would apply equally well to *Physetocrinus reticulatus* which, as we know from actual observation, has a vault and a well-developed disk underneath. An open disk represents a higher form in the developmental history of the Crinoids, than a closed one. This is shown by *Cyathocrinus*, in which the vault is gradually replaced by the disk, and it is very improbable that the Reteocrinidæ, which did not survive the Lower Silurian age, attained a higher organization than most of the Carboniferous Actinocrinidæ.

According to Carpenter (Chall. Rep., p. 172), "the vault of *Actinocrinus* has been developed on the left larval antimer, in exactly the same way as the apical or abactinal system is developed on the right; but the oral system, instead of being limited to five oral plates, as in Neocrinoids, reached a very extensive development, so that in its completest form it represents such a parallel to the apical or abactinal system as is to be met with in no other Crinoid." A similar view was expressed by us when we wrote Part II of this Revision, but we believe the same thing might be said of other Actinocrinidæ and all Platycrinidæ and Rhodocrinidæ.

Carpenter, as we have stated, applies the term "vault" to all actinal plates covering the disk and tentacular vestibule, and in most of the Actinocrinidæ he regards all interradial plates of the ventral side as the representatives of the interradials at the dorsal side. However, in a few Actinocrinidæ and in the Platycrinidæ, Rhodocrinidæ and allied groups, he restricts the vault to the central piece, proximals and radial dome plates if such are present, and all other ventral plates he takes to be perisomic. In the Cyathocrinidæ and Blastoidea he limits the vault to the summit plates; but their interradials, although located ventrally, are said to be abactinal. These interpretations, if correct, would suggest, either that the condition of the ventral surface is of comparatively little value for classificatory purposes, or that certain forms, which have heretofore been described under *Actinocrinus*, are structurally very different, and should be referred to remote groups. It would further prove, if the upper interradial plates in *Platycrinus* were anambulacral pieces—because some of the covering pieces are interposed between them—that the higher interradials of *Actinocrinus stellatus*, which are in the same condition, are perisomic, and *vice versa* those of certain Platycrinidæ vault plates; indeed, that the very same plates which in the young Platycrinoid represent vault pieces, are perisomic in the adult.

Carpenter will admit that the minute temporary interradials, which Sir Wyville Thomson observed in the larva of *Antedon*, are the homologues of the large and permanent calyx interradials in the Cyathocrinidæ. In this group, in which the rays are free from the first radial, the interradials, for want of any other lateral support, join with each other, and thereby attain their ventral position; while in the adult Actinocrinidæ and Rhodocrinidæ, which have numerous radial and interradial plates, the first interradials naturally had to be located dorsally. The increase of interradial plates took place gradually in the growing animal, and from that we may reasonably suggest that these Crinoids at one time in their larval state possessed but five single interradials, which met over the disk ventrally, as in the case of *Cyathocrinus alutaceus*. At that time the young *Actinocrinus* was essentially in the condition of a young *Antedon* in which the interradials had made their appearance, however the interradials of the Palæocrinoid were more fully developed. If now *Allagecrinus* and *Haplocrinus*, as suggested by Carpenter, represent palæontologically a very early stage of the larva of *Antedon*, we should like to know something about the condition of the interradial plates in those genera. Are they as yet contrary to all other Palæocrinoidea altogether unrepresented, or here already resorbed by the animal? Both genera have five plates, which occupy the very same position as the interradials of *Cyathocrinus alutaceus*, and *Cyathocrinus Gilesi* (Pl. 4, fig. 2). Why should these be orals, when there is another structure covering the tentacular vestibule, which may represent them, and which, on the other hand, would be totally unrepresented in the *Antedon* larva and in all other Echinoderms?

The phylogenetic evidence indicates clearly that the interradial element takes a most prominent part in the composition of the Palæocrinoidea, and we hope we have proved that these plates were much more extravagantly developed in their earlier types. In Silurian genera they extended over the whole peristome, or the greater part of it. Gradually the summit plates made their appearance, evidently pushed out from beneath, afterwards the covering pieces of the ambulacra, and at last also the anambulacral plates. Even in the Cyathocrinidæ, in which the ventral structure attained a higher form than in any other group, with the exception, perhaps, of the Poteriocrinidæ and Encrinidæ, interradials are not only present, but they occupy the greater portion of the ventral side, and even in those genera in which, perhaps, they were resorbed before the Crinoid reached maturity, they had been previously well developed. Under the weight of this evidence, is it probable that *Haplocrinus* and *Allagecrinus*, which are said to be "permanently in the condition of a very early larva" (Chall. Rep., p. 157), alone among all Palæocrinoidea, should have no interradial plates, and that the plates which occupy their position in these two genera are "oral plates?" We, at least, wish to be excused if we doubt it. Upon palæontological grounds we expect to find in the younger stages of the Palæocrinoid the oral system feebly, the interradial system extravagantly developed, while, according to Carpenter's interpretation of the plates, in the Palæocrinoid larva, the entire ventral surface from the radials up would be oral, *i. e*, actinal.

From an embryological standpoint also, Carpenter's interpretation meets with very serious objections. If *Haplocrinus* represents, as he asserts, a very early stage in Crinoid ontogeny, before the opening of the tentacular vestibule to the exterior, we should like to know how the central piece, the so-called orocentral of Carpenter, made its appearance in the Palæocrinoid. It is not very probable that this plate was present in the early larva, or it would certainly be represented in the larva of the Neocrinoid at the time the oral pyramid was closed. Carpenter claims that it was even unrepresented in *Allagecrinus*, and that the oral pole was closed only by oral plates. This would suggest that it was introduced either by means of a partial resorption of the "oral" pyramid, or by the opening of its plates. The former is exceedingly doubtful, while the latter is clearly not the case in

Haplocrinus nor other Palæocrinoidea, for the proximals which Carpenter takes to be the representatives of the orals, are permanently closed, with the exception of *Coccocrinus*, in which the "orals" are said to be parted, but in which the central plate is wanting.

Another difficulty is offered by the fact that the so-called "oral" plates are pierced by the anal opening, a structure which certainly has no parallel among recent Crinoids.

Allagecrinus was described by Etheridge and Carpenter (Ann. and Mag. Nat. Hist., April, 1881) as without central piece, and the latter has since informed us, that he could not identify any such plate on re-examining the specimens. This, however, does not prove that it was wanting, for we must bear in mind that *Allagecrinus Austinii* is an almost microscopic form, not larger than a coarse grain of sand. The central piece was overlooked by the European naturalists, in the much larger *Haplocrinus*. Goldfuss, however, observed in (*Eugeniacrinites*) *Haplocrinus mespiliformis* (Petref. Germ., i, p. 214) "ein rundes Knöpfchen im Scheitelpunkt," and it is very significant that Etheridge and Carpenter also found in *Allagecrinus* "at the central end of one or more of the plates faint tubercles," for which, according to their own statement, "they can find no explanation." Whether these represent the tubercles which we discovered upon the face of the interradials in *Cyathocrinus multiradiatus* (Pl. 4, fig. 2), we are of course not prepared to assert with certainty, but it is worthy of note that Carpenter regards the latter "as the conical openings in *Granatocrinus Norwordi*,"[1] and it is very possible that they are the same thing in all three groups, which would prove better than anything else, that the plates bearing them are not orals but interradials. The tubercles in *Allagecrinus* (compare Ann. and Mag., ser. 5, vol. 7, Pl. xvi, figs. 3 *b*, 4, 5 and 7 *b*), are evidently of structural value, but as there is but one figured, although the description speaks of one to each plate, and this is located laterally in one specimen and centrally in the other, all interpretations by us must necessarily be more or less problematical. We are inclined, however, to believe that the lateral one (fig. 5), in analogy with *Haplocrinus*, represents the anal opening, *i. e.*

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[1] This suggestion was made by Dr. P. Herb. Carpenter in his letter of December 26, after sending him our figures, and he kindly permitted us to make use of it in our writings.

the larger tubercle in *Granatocrinus*, and the central one, if it exists at all, the central piece; but whether this plate is exposed or not, we believe it was represented in the Crinoid, and if it was not inserted between the interradials, it was subtegminal, underneath them.

In the later stages of *Allagecrinus*, according to Carpenter and Etheridge (p. 285), the so-called "orals" are placed "at the centre of the dome, in close contact laterally, so that no opening is visible, but their basal angles are more or less truncated, leaving a superficial gap between every pair of plates, which corresponds in position with the articular facet on the subjacent radial." "The interior of this gap, however, is filled up by the deeper portion of the oral plates." This structure, we admit, indicates that possibly at a more advanced stage of the Crinoid, the plates had separated laterally, similar to the orals in the recent *Holopus*. This, however, which we believe was really the case in *Coccocrinus*, does not prove that the plates of the two groups are homologous, as similar modifications take place among the interradials in the Palæocrinoidea, or as we should say, take place in the earlier Crinoids exclusively in the interradials, while the tentacular vestibule remains perfectly closed. In the case of *Allagecrinus*, the opening out of the plates toward the arm bases, indicates, in our opinion, that the Crinoid is approaching the stage of a Platycrinoid, in which the covering plates part the interradials and enter the vault; previous to the later Cyathocrinoid stage, in which the whole ambulacral skeleton covers the interradials. *Coccocrinus* represents a transition form between the two former, the interradials being separated from one another, forming open clefts with the ambulacra at their bottom.

The ventral side of *Coccocrinus rosaceus* in the best-preserved specimens consists of ten plates, all strictly interradial in position, arranged in five series, which are not in contact laterally nor centrally, leaving five rather conspicuous clefts and a central opening. The outer plate of each series is smaller, the inner resting upon the truncate face of the other. The inner plate at the azygous side is larger, and the anal opening excavated along the suture between the two plates, extending as deeply into the inner as into the outer plate. There are no special anal pieces, neither dorsally nor ventrally.

There is no difference of opinion as to the outer plates, which all recognize as interradials; the inner ones, however, were designated by Roemer as "kleine interradiale Stücke, welche von dem Mittelpunkte der Scheitelfläche zu den Armen verlaufen." Schultze called them "Scheitelstücke," Zittel and De Loriol "orals," and all speak of open ambulacral furrows leading to the arms, and of an external mouth. The latter two writers refer the genus to the Haplocrinidæ, Schultze to the Platycrinidæ. Carpenter (Chall. Rep., p. 163), regards *Coccocrinus*, "like the recent *Holopus*, to be permanently in the condition of a Crinoid larva in which the orals have not yet moved away from the radials, though separated from one another." In the interpretation of the plates he agrees with Zittel, De Loriol and Allman.

A similar interpretation was given by us in our generic description in Part II, when we took the plates of the inner ring to be identical with the so-called "orals" of *Cyathocrinus*, but this has been abandoned after finding the latter plates to be interradials, and they are now regarded by us as secondary interradial plates. When we adopted Zittel's interpretation, we were misled by the superficial resemblance to the oral pieces in the recent genus *Hyocrinus*, overlooking the fact that the latter rest within a belt of perisomic pieces, in place of interradials in the former. *Coccocrinus bacca*, as seen by Roemer's figure (Fauna West. Tenn., Pl. 4, fig. 5 *c*), has three interradials arranged transversely as in the Platycrinidæ, the outer ones resting against the secondary radials. The presence of higher interradials in this species is sufficient to prove satisfactorily that the genus *Coccocrinus* is no Haplocrinite, and that it does not even go with the Inadunata. It is possible that *Coccocrinus rosaceus* had exceptionally but one interradial within the first row, but as a member of the Camarata it must have possessed higher interradials, like other Palæocrinoids in which the interradials come in contact with the higher radials, contrary to the Inadunata, which have, as a rule, a single interradial plate.

We doubt if even Carpenter, although he is inclined to accept the upper series of interradials in *Platycrinus* as anambulacral plates, will go so far after examining our diagrams, as to include among these the lateral plates of the proximal row, either in *Platycrinus* or *Coccocrinus*, which he overlooked in both genera. *Coccocrinus* is certainly not in the same morphological condition as *Holopus*, even admitting, which we do not, that the upper interradial plates were orals. In the latter genus, the orals rest against the radials, and the ambulacra are exposed only along the arms. In *Coccocrinus*, however, the so-called "orals" abut with their outer ends against the interradials, and the clefts from the "orals," in place of entering the arms, are continued between the interradial plates.

In Part II, p. 58, we asserted that the clefts along both plates were probably filled in the animal by alternate (covering) pieces, and the summit openings by dome plates; although regarding at that time the inner circlet of interradials as oral pieces. We admit that Carpenter is right in asserting that the existence of covering plates between the orals is contrary to the structure of recent Crinoids, and at variance with the nature of oral plates generally; but considering, as we do now, that the inner as well as the outer plates are interradials, this objection loses its force, since covering plates are found between interradials in most of the Platycrinidæ. Yet the case of *Coccocrinus* is somewhat different from that of an ordinary Platycrinoid, which together with covering pieces has well-developed summit plates, of which no trace has been found in any of the specimens of *Coccocrinus*. Carpenter thinks that in *Coccocrinus* the central piece was unrepresented, that its *five* inner interradials are homologous with the *six* proximals of *Platycrinus*, and that the tentacular vestibule with the mouth at the bottom was exposed to view. This interpretation is a natural consequence of his oral theory, and shows still more forcibly the difficulties of his position. Not only has he to admit a homology of five plates to six, but that in a Silurian genus mouth and food grooves were not covered. This assumption, which represents an enormous advance in the development of the group, not attained by any other Palæocrinoid, is alone sufficient to overthrow his whole theory, and this the more when applied to a genus which decidedly represents a low stage among these Crinoids. What is left to make *Coccocrinus* a Palæocrinoid? Even the asymmetry, which, according to Carpenter, is one of the best characters for separating the older and later Crinoids, is rather problematical, as it has no special anal plate.

Admitting that the inner plates in *Coccocrinus* are secondary interradials and not proximals, we have to account for the absence of these plates in this case. That the summit plates, which are so universally represented throughout this group, should be totally absent in this genus, seems to us not very probable. Yet the central opening which should contain them is so small, compared with the space taken up by them in *Platycrinus* and allied forms, that it seems almost impossible to have been occupied by seven or more plates. Besides, there is not a single instance known to us, in which either the summit plates or the covering pieces were obliterated in the specimen, leaving at the same time the interradials in position, as we find it in all these specimens. This leads us to the conclusion that in *Coccocrinus*, as in *Platycrinus*, the five interradial series had been separated laterally to their full length, but that the disk covered by the summit plates had not been raised to the surface as in that genus, leaving an open gap and lateral clefts permanently as in *Holopus*, with the exception, however, that in the latter genus the clefts are formed between the orals. According to our interpretation, *Coccocrinus* represents phylogenetically a transition form between *Culicocrinus*, in which the interradials are still closed and its summit plates and covering pieces subtegminal, and *Platycrinus* in which they are incorporated with the calyx. This is the only explanation which meets all difficulties, and brings these genera, with regard to the distribution of the plates, under the same rule with the other Palæocrinoids.

The genus *Symbathocrinus* is morphologically a much higher form than either *Coccocrinus* or *Haplocrinus*, not only because it had better developed arms, but also well developed summit plates. Its summit had never been observed until we removed the arms in very perfect specimens, and succeeded in laying bare the whole ventral surface. It consists of eight plates, four large proximals, which, together with three other plates, along the azygous side, form a closed ring around a very conspicuous central piece, and these again are enclosed by ten or more smaller pieces, which rest upon the highly elevated articular facets of the radials.

These outer plates (there may be one or two additional ones toward the azygous side) are smaller than the proximals; five of them are placed radially, the others interradially. In the first specimen which we dissected, and which was sent to Dr. Carpenter for study, the lateral sutures between the smaller plates could not be distinguished. That plates were interposed between the radials and proximals (his orals) was clearly shown, and was also noticed by him in his letter. We were, therefore, somewhat surprised when we found them ignored in his discussion, and observed his statement that "the so-called apical dome plates rest directly upon the upper edges of the articular faces." We regret this the more, as we should like to know whether he regards them as calyx or perisomic plates. In our opinion they cannot be perisomic, as five of them have a strictly radial position. Nor do we believe that the five radial openings which we at first thought we observed along the upper angle of these plates, at their juncture with the proximals, are ambulacral or arm openings, as Carpenter suggests. We are inclined to take them for mere depressions along the suture, as it is very improbable that the ambulacra in proceeding to the arms passed over these plates. We regard the five radial pieces as radial dome plates, and the alternate ones as interradials. Carpenter also omits to state whether the "orals" in *Symbathocrinus* consist of five or six pieces. That there are more than five is clearly seen in the specimen which he examined, although the exact number could not be ascertained. Other specimens, however, which we have since prepared (Pl. 4, figs. 9, 10), prove clearly that there are seven pieces. This is morphologically of the utmost importance, as showing that the summit structure of *Symbathocrinus* is altogether different from that of *Haplocrinus* or *Rhizocrinus*, with which Carpenter identifies it, and it is more like that of *Platycrinus*. We shall return to this when we take up the oral plates.

As a result of the foregoing observations, we draw the following conclusions, viz.:—

1. Interradials are represented in all groups of the Palæocrinoidea. They were early developed in the larva, attained at once large proportions, and persisted through life or were resorbed on approaching maturity.

2. They extend invariably to the proximals, or even cover them completely.

3. They are more extravagantly developed in the earlier groups, not always in number, but by extending over comparatively larger space.

4. In all groups in which the arms are free from the first radials, they are represented by only five single plates, and these are located ventrally. Groups with two or more radials have

two at least, and the number increases in proportion to the increase of the radials, by means of which the lower series attain gradually a dorsal position.

D. *The Anal Plates and Anal Tube.*

It has been a general practice to regard all plates of the azygous interradius as anal plates. From a strictly morphological standpoint this is not correct, as comparatively few of these plates are connected with the anal aperture, although all of them are more or less affected by it. Properly speaking, in analogy with recent Crinoids. there is but one true anal plate, and the succeeding pieces are either interradials, or they constitute parts of the anal tube, which, in the growing animal, by the increase of interradials, were incorporated into the test. The latter plates, as representing parts of the calyx, which serve the same purpose as the true anal piece, might be very appropriately distinguished as "higher" anal plates, but unfortunately in many groups it is almost impossible to separate them from the interradials. A discrimination, however, should be made wherever it is practicable.

In the Pentacrinoid larva of *Antedon rosacea*, according to Dr. W. B. Carpenter (Philos. Trans. Royal Soc. London, pp. 726–747), the anal plate makes its appearance almost contemporaneously with the first radials, and stands on a level with them. It is at first a rather irregular plate, which somewhat later takes an elliptic form, and is gradually lifted out from between the radials, and developed into a conspicuous funnel, which disappears at the end of Pentacrinoid life, being removed by resorption.

The earlier stages of the anal plates in the Palæocrinoidea are only known from phylogenetic evidence, but this shows that the modifications which they undergo in palæontological times correspond closely with those of the growing Pentacrinoid. In the Inadunata, which have closer analogies with the Neocrinoidea than the other two groups, and which like them have but a single anal plate, the latter can be traced from its first appearance in the Silurian to its total resorption in the Carboniferous and Trias, and the various conditions of development, as thus represented, form excellent characters for generic distinction. Among the earliest Inadunata, however, we find a transition state which either is unrepresented, or has not been recognized in the Pentacrinoid. We refer to the development of the anal plate from the so-called azygous piece. That a plate which takes such an important part in the phylogeny of this group should be altogether unrepresented in the young Neocrinoid, seems to us somewhat doubtful, the more so as the Neocrinoidea are in all probability the palæontological successors, if not the linear descendants, of the Inadunata. Possibly the undivided azygous plate, as represented in *Baerocrinus*, has been overlooked in the early larva, and this would not be surprising, as the plate occupies the position, and has very nearly the form of an ordinary first radial.

In our chapter on the radials we have already alluded to the azygous piece, and expressed our conviction that its gradual resorption gave origin, not only to the right posterior radial, but also to the anal plate. We have shown that in *Haplocrinus*, a close ally of *Baerocrinus*, the fifth radial is somewhat rudimentarily represented by a small trigonal piece occupying the right upper corner; that this genus, as yet, had no anal plate, the left corner of the azygous piece being still intact; that in *Hybocrinus* the left side of the plate was taken up by a small anal, and the azygous piece proportionally diminished in size; that in the succeeding stages, which are typified by *Iocrinus*, *Dendrocrinus*, *Homocrinus*, the size of the anal plate gradually increased as the azygous piece diminished; and that at last in *Cyathocrinus* the latter plate was entirely removed, and the anal plate took the position of that in the larva of *Antedon*. These modifications were introduced, as a general rule, in geological succession, but not always uniformly, for in some groups the development went on more rapidly than in others. Such a rapid development took place in *Cyathocrinus*, which existed already in the Silurian, although attaining its maximum representation in the Carboniferous; while in most of the Poteriocrinidæ, which eminently belong to the Carboniferous, the very opposite is observed. The most remarkable deviation in this respect is shown by the symmetrical Silurian genus *Codiacrinus*, which apparently has neither azygous nor anal plate.

The final resorption of both plates is best shown in the Poteriocrinidæ. In *Poteriocrinus*, *Eupachycrinus* and *Zeacrinus*, the azygous plate is comparatively well developed, but completely pushed out of the radial position which it had previously occupied. In these genera the anal plate is small, and the first plate of the tube forms a part of the calyx. The allied *Graphiocrinus*, however, has no azygous plate, and the posterior basal, which is somewhat elongate, supports upon its truncate upper end only an anal plate. In *Ceriocrinus*, which is in a similar condition, the anal plate is partly lifted out from between the radials, and extends half way beyond the articular faces of these plates. In *Erisocrinus*, the anal plate is not only smaller, but rests wholly upon the radials, beyond the limits of the dorsal cup. Finally in *Encrinus*, this plate seems to have been entirely removed in the adult. We have a specimen of *Encrinus liliiformis* only an inch in length, including the arms, which contains between the arms a row of four conspicuous, slightly convex plates, the upper one triangular, which we regard as plates of an anal tube. This discovery is of some importance, as it tends to prove that *Encrinus* is not a Neocrinoid, but a highly-developed Poteriocrinoid.

In the Silurian *Triacrinus* and *Pisocrinus*, which we arrange under the Symbathocrinidæ, we find dorsally no anal plate, but simply an azygous piece. This supports both posterior radials, which are less than half as large as the two antero-lateral ones, and join laterally. In the Carboniferous genus *Symbathocrinus*, however, the azygous plate is wanting, the radials are almost equally developed, and these support a small anal piece. In the allied *Stortingocrinus* and in *Stylocrinus* (*Symbathocrinus* of Miller and Schultze), although exclusively Devonian genera, we find neither azygous nor anal plate, but *Phimocrinus*, like *Symbathocrinus*, possessed a large anal aperture between the highly extended articular facets of the radials, and may have had an anal plate. Whether the summit plates of the two former genera had reached the advanced state of *Symbathocrinus*, or were yet in the condition of *Haplocrinus*, cannot be ascertained from any of the specimens, but it may well be doubted. In *Haplocrinus* the anal opening is pierced through one of the interradials, and the same may be the case in *Stortingocrinus* and *Pisocrinus*. In *Coccocrinus* and *Culicocrinus*, the anus is located between the first and second radials, piercing the one as much as the other; in *Platycrinus* above the first interradial, being separated from the proximals by a special anal plate.

It has been stated that the Inadunata possess no higher orders of anal pieces, and that the plates succeeding the first, form a part of the tube. They do not all, however, have the tube well developed, and in some of them it is altogether unrepresented. *Haplocrinus* has a simple anal opening, and herein deviates from most of the other genera of this group. The Hybocrinidæ and *Cyathocrinus alutaceus* have only a short protuberance, composed of small plates.

The simplest tube is found in *Catillocrinus* and *Calceocrinus* (Pl. 5, figs. 15, 16), in which it consists of a single row of very large solid plates, transversely curved like an arm-joint, with a semicircular groove along the ventral side. This groove, which extends from the base of the tube to its distal end, is open in all our specimens. A somewhat similar tube occurs in *Symbathocrinus*, in which the proximal plates at the posterior side are considerably thicker than those upon the other sides.

More important from a morphological standpoint, is the ventral tube of the Heterocrinidæ, Anomalocrinidæ and some Silurian Cyathocrinoid genera in which the anal piece, as in *Catillocrinus*, is succeeded by a row of heavy curved plates, which on the dorsal side pass up to the end of the tube. These plates are bordered laterally by several rows of delicate pieces, pierced by pores or slits along their sides, the whole forming a sac-like appendage. It is very evident that this row of dorsal plates is identical with that of *Catillocrinus* and *Calceocrinus*, and also that the ventral side of the tube in the latter two genera was closed by plates in a similar way.

A still higher form is represented by the later Cyathocrinidæ, which have no such row of dorsal plates, the entire sac being composed of delicate pieces. Most of these are perforated with pores, with the exception of the proximal rows of plates dorsally, which are solid, and also frequently those crowning the distal end; while those facing the ventral side are more or less perforated. Among the earlier Poteriocrinidæ, the sac is large, either cylindrical, club-shaped, conical or balloon-shaped, and it often extends beyond the tips of the arms. In the later Poteriocrinidæ, however, the sac dwindles down to a short cone, even in the asymmetrical *Eupachycrinus*, and it has apparently no pores, at least not dorsally.

In most of the Camarata the anal plate is placed between the first radials, and occupies the lower portion of the dorsal cup. In the Rhodocrinidæ, in which the first interradials alternate with the first radials, the posterior interradial takes the functions of the anal plate, and the second order of interradials, which consists of two pieces, generally contains the second anal with additional plates above. The anals, as a general rule, are arranged longitudinally, but the row is often interrupted by intervening interradials. In *Reteocrinus*, in which the interradial series consists of small irregular pieces, the posterior side is divided equally by a vertical row of large convex anals, arranged like the plates which constitute the dorsal side in the tube of *Catillocrinus*. The only essential difference between the two structures is that the plates in the latter form a free appendage, similar to that of *Thaumatocrinus*, while those of *Reteocrinus* and *Xenocrinus* are incorporated into the calyx.

All typical Actinocrinidæ, Glyptasteridæ, Barrandeocrinidæ, Acrocrinidæ and Hexacrinidæ have a special anal plate between their first radials, and in most of them the first posterior interradial is split into two halves to receive the second anal plate. However, in *Actinocrinus* and allied genera which we separated under Actinocrinites, the second anal is pushed up to the line of the secondary interradials, although the first interradial, as in the other groups, is divided. The splitting of the first interradial for the reception of an anal piece, to which we have alluded, is of the utmost importance for the study of the summit plates, as we find the same thing there repeated among the proximals.

In the Melocrinidæ the first interradials are undivided, and in most of them the lower anal plate is inserted between the two secondary interradials; in others, however, which have no anals within the dorsal cup, the anals commence at the equatorial zone. In the Platycrinidæ the first interradial of the posterior side is considerably larger, and evidently consolidated with the first anal plate. In the Calyptocrinidæ, finally, the whole calyx, dorsally and ventrally, is strictly symmetrical, the anus central, and the only asymmetry in their structure is found among basals and proximals.

The anal opening in all Camarata is located at the distal end of the tube, whether this terminates within the calyx or is extended into a proboscis, and its position is more or less lateral, except in the Calyptocrinidæ in which it penetrates the central piece. The plates composing the tube of the Camarata are abactinal, and form a part of the posterior interradial series; they are strong, rigid, without pores, are suturally connected, and their arrangement is irregular. This tube differs essentially from the ventral sac, which forms a part of the disk, and is composed of anambulacral plates, into which the plates of the abactinal tube are incorporated, in a similar manner as the higher radials and proximal pinnules are into the disk of the Neocrinoidea. Moreover, the ventral sac does not contain the anal aperture, which is generally located within the disk. For further consideration of this organ we refer to our chapter on the perisomic plates.

Among the Articulata, the Crotalocrinidæ and Cleiocrinidæ have an anal plate in lateral contact with the radials. The same is the case in the Ichthyocrinidæ, with the exception of *Ichthyocrinus*, which has dorsally no anal plate and generally no interradials. *Pycnosaccus*, *Calpiocrinus*, *Homalocrinus*, *Lecanocrinus*, *Gnorimocrinus* and *Mespilocrinus* have even an azygous piece, which is absent in *Anisocrinus*, *Taxocrinus*, *Onychocrinus*, *Forbesiocrinus* and *Lithocrinus*. An anal appendage has been observed only in *Crotalocrinus* and *Enallocrinus*, located ventrally, close to the periphery. In the former it consists of a tube composed of eight vertical rows of heavy quadrangular pieces, connected by suture. In *Enallocrinus* its form is unknown.

In Part I we described *Taxocrinus*, *Onychocrinus* and *Gnorimocrinus* as having a small lateral tube resting upon the first anal plate. To this Dr. P. H. Carpenter objected in his paper on *Thaumatocrinus* (Philos. Trans. Royal Soc., 1884, pt. iii, p. 928). He admitted "that the arm-like series supported the lower portion of the anal interradius," but doubted "that the plates had been hollowed out on their inner side for the reception of the hind-gut," which "undoubtedly opened to the exterior at a higher level through a regular anal tube, just as in other Crinoids." These objections are well founded, and we are now fully convinced that those plates were bordered laterally by interradial pieces as in *Reteocrinus*.

THE PLATES OF THE ACTINAL SYSTEM.

A. *The Summit Plates.*

The *summit plates* consist of the actinal plates, overlying and immediately surrounding the peristome. For these plates we have heretofore proposed the name "apical dome plates," but finding its application somewhat cumbersome, as the word "apical" is used in a different sense, we have abandoned it. The summit plates are represented in the Palæocrinoidea by the *central piece*, the six or more so-called *proximals*, and the *radial dome plates;* in the Neocrinoidea, by the *oral* plates alone.

The orals constitute important elements in the ontogeny of recent Crinoids. They appear at first in the form of a closed pyramid, composed of five triangular plates.

According to Dr. P. H. Carpenter (Chall. Rep., p. 71), "their rudiments appear in the free-swimming larva simultaneously with those of the basals, which are developed spirally round the right peritoneal tube; while the orals appear in a similar spiral around the left one. The skeleton is at first limited entirely to these two rings of plates, the edges of which meet around the equator of the growing cup, though they ultimately become separated by the appearance of the radials between them. At the base of the closed pyramid formed by the oral plates is the upper portion of the larval body, in the centre of which the opening of the mouth is formed. . . . At a certain period of development, the five valves of this oral pyramid gradually separate so as to open the mouth to the exterior, and allow the protrusion of the tentacles, while the floor of the original tentacular vestibule, with the mouth in its centre, becomes the peristome of the growing Crinoid." Afterwards the orals become "completely separated from the basals and radials by the equatorial perisome and are relatively carried inwards, while the second radials project somewhat outwards. . . . The orals are thus left as a circlet of five separate plates protecting the peristome in the centre of the upper surface of the disk." In all Pentacrinidæ and also in the Comatulæ, with the single exception of *Thaumatocrinus*, the orals eventually undergo a process of resorption, while in *Rhizocrinus*, *Hyocrinus*, *Holopus* and *Thaumatocrinus*, they persist through life.

Nothing is known of the orals in Mesozoic Crinoids.

That the orals, which assume such an early prominence in the ontogeny of the later Crinoids, should be unrepresented in palæozoic ones, seems scarcely possible. This has been conceded by various writers, but there is, as yet, much difference of opinion as to the plates which represent them.

The first writer who referred to oral plates in palæozoic

Crinoids was Prof. Allman. He suggested an analogy between the transition stage of *Antedon* and the permanent condition of *Haplocrinus*, *Coccocrinus*, *Stephanocrinus* and *Lageniocrinus*. In these genera he took the plates covering the ventral surface to be the orals. We have already shown that the ventral pyramid in *Haplocrinus* and *Coccocrinus* is composed of interradials and not of orals, and the same may be said of *Stephanocrinus;* while the so-called orals in *Lageniocrinus* are radial in position, and evidently arm pieces.

The next writer on this subject was Prof. Zittel, who thought these plates were present in *Haplocrinus*, *Coccocrinus*, *Symbathocrinus*, in the Cyathocrinidæ, Hybocrinidæ and Crotalocrinidæ. That the so-called orals in the Cyathocrinidæ and Hybocrinidæ are interradials can no longer be doubted; while the orals of Zittel in *Symbathocrinus* prove to be merely articular extensions of the radials, which, in their form, somewhat resemble the orals of recent Crinoids. The so-called orals in the Crotalocrinidæ are identical with the proximals (nobis), and will be discussed in connection with them.

De Loriol substantially accepts Zittel's classification, and also his interpretation of the plates.

Dr. P. H. Carpenter, in the Challenger Report, no longer regards the large interradial plates in the Cyathocrinidæ and Blastoidea as orals, but, as before, he applies the term to the interradials of *Allagecrinus* and *Haplocrinus*, and to the inner ring of interradials in *Coccocrinus*. He also designates as orals the *six* proximals surrounding the central piece, and calls the latter the "orocentral." He further states that orals were "represented in the vault of all Palæocrinoidæ, whether simple or complex, although they are sometimes very greatly reduced." Carpenter's views agree essentially with those of Zittel, only that he extends the term to the proximals in all cases, while Zittel applies it exclusively to those of the Crotalocrinidæ. According to his description, the vault in the Platycrinidæ is paved with well-developed "Centralplatten," and in his general remarks on the Actinocrinidæ he speaks of "seven Scheitelplatten," surrounded by a greater or smaller number of radial and interradial plates.

As for ourselves, we have described orals in *Haplocrinus*, *Coccocrinus*, and in the Cyathocrinidæ; but, as already stated, later investigations have convinced us that the so-called orals in all three groups are calyx interradials. At no time, however, have we held these plates to be structurally identical with the proximals.

Before attempting to determine the identity and relationship of the oral plates in the older Crinoids, it will be necessary to give a full description of the different plates which constitute their summit.

The central piece, as a rule, is the largest plate of the ventral side. It is not only the centre of figure, but also the centre of radiation, and as such occupies the same position ventrally as the basals occupy on the dorsal side. It is frequently nodose, even spiniferous, but always more or less convex, and has a concavity upon its inner floor, toward which all organs from the arms concentrate. The central piece is surrounded variously by from seven to twelve other plates; four of these are larger than the others, interradial in position, and each one rests upon, and connects with, one of the four regular interradial series. Toward the posterior side there are three smaller plates (Pl. 7, figs. 2, 5, and Pl. 8, figs. 7, 8), rarely two (Pl. 7, figs. 6, 7, 8), which similarly connect with the azygous interradius. The three smaller pieces are frequently separated from the larger ones at each side by a good-sized plate, radial in position (*Xr* in Pl. 7, figs. 3–10, and Pl. 8, figs. 1, 3); sometimes, however, they unite laterally with the larger ones. This is the case in the simpler forms, such as *Symbathocrinus* (Pl. 5, fig. 12), and in *Cyathocrinus alutaceus*. In very complex genera, and especially among the huge forms of the Actinocrinidæ, the four larger plates are also separated by radial structures, generally by three plates longitudinally arranged (Pl. 8, figs. 1, 3, and Pl. 4, fig. 4), of which the inner ones abut against the central piece, the outer ones against the second radial and against the sloping sides of the four large proximals. In species in which the latter are laterally connected, which is much more frequently the case, there is but one radial plate, and this takes the position and functions of the third one. In species with a single radial, this rests at the three anterior rays within the angles formed by the four large proximals; while the plates of the two posterior rays are often laterally inserted between the larger and smaller proximals, abutting against the central piece. These two posterior radials were thought by us, and, we suspect, also by P. H. Carpenter, to represent a bisected proximal, and the two or three plates which they enclose were supposed to be anals or plates of the anal tube—a mistake easily explained by the fact that the plates stand in line with, and join the four large proximals, and have very near their size. We discovered our mistake when we found that in all internal casts the radiation follows the median line of the plates, and not the suture, as in the case of the proximals. The disturbance in the arrangement of the two posterior radials is evidently due to the anal structures, which pushed these plates out of their regular position. In species with a large subcentral anal tube, the position of these radials is so completely altered that they are sometimes actually placed within the semicircle of the four large proximals. Such is the case in the specimen of *Teleiocrinus* (Pl. 4, fig. 4), in which the anal appendage is almost central. In this specimen, all three anterior rays have three primary radials, while the two posterior ones have four. The inner plates serve as a kind of axillary for the ambulacra of the postero- and antero-lateral rays, which are undivided for some distance, giving off underneath a branch to the outer radials. The presence of a fourth radial is rather an exception, and, indeed, three radials are found, as far as we know, only in the larger species of the Actinocrinidæ. In species in which the covering plates pass out to the surface of the vault, the radial dome plates are frequently either wanting in the three anterior rays, or they are exceedingly rudimentary and very irregular in form, while those of the posterior rays are generally intact (Pl. 7, figs. 3, 9, 10). But in some species the posterior radials are partially or totally resorbed (Pl. 7, fig. 8), and the covering plates pass out directly from beneath the central piece. In *Melocrinus* and *Cyathocrinus alutaceus*, in which the anal structures are comparatively narrow, the central piece being generally surrounded by only six plates, of which two face the posterior side—all five radials are placed outside the ring of proximals; but we have a specimen of *Melocrinus Konincki* in which, exceptionally, the plate of the right postero-lateral ray is placed in line with the proximals. Another interesting departure from the general rule is found among the larger species of *Dorycrinus*, *Megistocrinus* and *Agaricocrinus*, in which the central plate is isolated from the proximals by a belt of small pieces. Not even the proximals are connected with the radial dome plates, nor with one another, and each summit plate has a totally isolated position. In the smaller species and younger specimens, however, all summit plates are connected, showing that those small inserted plates result from excessive growth, and are introduced to increase the capacity of the visceral cavity.

Higher orders of summit radials exist in comparatively few genera. We must admit that the descriptions which we gave of these plates, although correct as to certain species, cannot be applied to the Palæocrinoidea generally, nor even to all Actinocrinidæ. Many of them have but a single radial, and the plates which we took to be radials in most of them, prove to be interaxillaries and interbrachials, which often attain a larger size than the surrounding plates. A very conspicuous case of this kind is *Dorycrinus*, in which the large spiniferous plate above each ray is not a primary radial as we had supposed, but an interaxillary, for the bifurcation of the ambulacral tube takes place beneath the preceding plate. The misconception of these plates in this and other genera led us to suppose that the arrangement of some of the summit plates was more or less disturbed in all species with a large number of arms, while in fact we had searched for plates which are unrepresented. The arrangement of the summit plates, as a rule, is very regular, and only disturbed by the anal tube. They are readily recognized even in *Megistocrinus*, *Strotocrinus* and *Teleiocrinus* as seen by our diagrams (Pl. 8, figs. 1, 3, 5, and Pl. 4, fig. 4).

It has been stated that the proximals, in all cases in which they have been recognized by us, consist of more than five plates, generally of seven, and we have asserted, which has been accepted by Carpenter (Chall. Rep., p. 167), that the two outer plates at the azygous side are equivalent to, and take the place of a fifth large one, being separated from each other by anal plates or the proboscis. The structure is well shown by our diagrams, but in examining them it must be borne in mind that the plates marked *Xr* are radials, and not interradials as heretofore supposed. The more central the position of the anal aperture, and the larger the size of the tube, the greater is the disturbance in the general arrangement of the summit plates. This might be expected, but it is certainly very remarkable that the azygous proximal is divided also in species in which the position of the anal opening is lateral or dorsal, and totally outside the ring of proximals. Yet such is the case in *Megistocrinus Evansii* and in *Megistocrinus brevicornis*, in which the anal tube is extremely small, located beneath the arm regions, and separated from the proximals by from ten to twenty rings of plates. At the azygous side they have two well-defined proximals, separated by irregular small plates, in a similar manner as in other groups. If these pieces were orals, as asserted by Carpenter, it is difficult to understand why they should be divided in these species, especially if we take into consideration that the orals in all recent Crinoids, even in the asymmetrical *Thaumatocrinus*, consist of five undivided plates.

There is not a single instance known among recent Crinoids in which the anal opening penetrates the orals, not even in the early larva, in which the oral pyramid occupies the whole ventral surface. In the larva the opening is placed within the equatorial zone, beneath the orals, and the same is probably the case in *Holopus*, in which the orals retain permanently the condition of the larva. In the more advanced stages, the anal opening is carried inward by the gradually increasing perisome, but it remains outside the oral ring in all cases, whether the orals become absorbed as in *Pentacrinus*, *Bathycrinus* and *Antedon*, or are retained permanently as in *Rhizocrinus*, *Thaumatocrinus* and *Hyocrinus*.

In the face of such evidence it seems to us extremely hazardous to assert that in Palæozoic Crinoids the anus penetrated the orals, or was closely connected with them. But we must make this assertion if we are to accept the interradials in *Haplocrinus*, and the so-called proximals in other genera, as the representatives of the orals. We might account for a slight disturbance in the form of the plates in genera in which the anus, or its component parts, come in direct contact with the plates,[1] but in our opinion no explanation whatever can be given why in such forms as *Megistocrinus*, *Crotalocrinus*, etc., the posterior oral plate should be divided. For the same reason we cannot accept the five interradial plates in *Haplocrinus* to be orals. If *Haplocrinus* was in

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[1] There is a case in which the anus penetrates the central piece. In the Calyptocrinidæ in which the whole calyx—with the exception of the basals—is symmetrical, the anus is strictly central, and the proximals completely pushed out of position, the central piece is bisected, and the two halves, jointly with the proximals, form the sides of the anal tube.

the condition of the Pentacrinoid larva, as suggested by Carpenter, it should have its anal opening beneath the orals, and not pierced through the upper portion of one of them. The very fact that the anal structures are invariably connected with the proximals, proves to us that the latter are interradials, developed around the left peritoneal tube, in a similar manner as the calyx interradials around the right, and that, as such, they are homologous with the first interradial plate in the calyx, and not with the basals, as suggested by Carpenter. The interradials, and not the basals, enclose the anal plates; there is not a single instance known to us in which an anal plate enters the basal ring. The azygous side of the proximals is generally composed of three adjacent pieces transversely arranged, and a divided interradial, which encloses an anal plate, as in the case of the primary calyx interradials. Sometimes, however, the anal plate is lifted out, and the first row is occupied exclusively by a bisected proximal (Pl. 7, figs. 8–10), as in the apical system of *Actinocrinus*.

It has been observed by Goette (Vergleichende Entwickelungsgeschichte d. *Comatula mediterranea*, Arch. f. Microsk. Anat., 1876, Bd. xii, pp. 621–624), that there exists a complete homology between basals and orals, and that both were developed spirally, the former round the right, the other round the left peritoneal tube. Upon these important observations, with which we fully agree, Carpenter undertakes to build up his proof that the proximals are the orals of the Palæocrinoidea. He reasons as follows (Chall. Rep., pp. 169, 170): "The basals are primitively next to the abactinal centre in Urchins and Stellerids, and are only removed from it in the Crinoid by the growing stem; while the orals are next the actinal centre, no plate being developed there, however, in the recent Crinoid. Did it appear, it would only be in the way, and have to undergo resorption to a greater or less extent, just as the dorsocentral of many Urchins is more or less completely resorbed after the appearance of the anus."

The discovery of a dorsocentral plate in the larva of the Urchins, Starfishes and Ophiurids by Carpenter, Sladen and Lütken, which Carpenter thinks is represented by the terminal plate at the base of the larval stem in Comatula, is to our minds no proof, in the total absence of embryological evidence, that there was a similar plate at the oral side. The so-called "orocentral" is said to be present exclusively in Palæocrinoids, but there it is found in all of them. It is difficult to believe that a plate so prominent, and so universally represented among the older forms, should be unrepresented in the larva of recent Crinoids before the opening of the oral pyramid. Carpenter's argument, that if the plate was present in the larva it would be in the way, and have to undergo resorption, is certainly not a strong one, for he admits in the Urchins a partial resorption of the dorsocentral after the appearance of the anus, and similar resorptions are going on constantly in the growing Crinoid.

Carpenter's arguments respecting the orals are based essentially upon the existence of an orocentral plate, and if this cannot be proved, his whole oral theory must fall to the ground. In the recent Crinoids, he states: "The embryological evidence clearly indicates that the basals of the abactinal system are represented in the actinal system by the orals. The former are within the ring of radials and next to the dorsocentral; and it seems, therefore, only natural to regard the six proximal interradial plates, surrounding the central piece (orocentral) in the vault of a Palæocrinoid, as representing oral plates."

Admitting that the terminal plate at the base of the larval stem in the Comatulæ represents the dorsocentral of Stellerids and Urchins, a question which we will not discuss, and admitting further, that a similar plate existed dorsally in the young Palæocrinoid, which we have good reason to doubt,[1] we cannot make out the affinities that are said to exist between this plate and the central piece, the so-called "orocentral." The former is the outer end of a mere transitory appendage, which in the growing animal soon withers off, and which is attached to the outer face of the skeleton, forming no part of it. The latter is a permanent plate, which rests within the test and fills a conspicuous place in it. It is the most important plate in the

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[1] We have examined a large number of roots, and have in our collection five perfect Crinoids from the tips of the arms to the ends of the rootlets. In all of them the column runs out into numerous branches, which all come to a point, having no special terminal plate. It is evident that the majority of the older Crinoids, either must have lived in a kind of oozy ground, or they led a half-free life in the adult, using the root as an anchor. In the Lower Silurian only we find attached to corals or shells isolated disks, with a pit at the centre, which may represent the terminal plates of *Glyptocrinus*, but nothing like this has ever been found elsewhere.

summit, as it covers the mouth, and lodges underneath the annular vessel, which is the origin and centre of the whole ambulacral system. As such it has not only the position but performs the functions of the closed oral pyramid in the Pentacrinoid larva. Why, therefore, should the proximals be the orals, and the central piece represent something else that is totally unknown in Crinoid ontogeny, and among Echinoderms generally? The proximals, as a rule, surround the peristome, but do not cover it. The tentacular vestibule is closed by the central piece. This is well shown in our specimen of *Batocrinus Christyi* (Pl. 5, fig. 6), in which the perisomic plates extend up to the central piece. Other specimens (Pl. 4, fig. 4, and Pl. 8, figs. 1, 2, 5) show that the radiations pass out from beneath the central piece, and not from beneath the proximals. If there had been such a thing as an "orocentral," it is difficult to understand how this plate could have entered the "oral ring," unless it was developed in the early larva, as the proximals remain permanently closed. The Palæocrinoids, as a rule, have a central piece, but they do not all have proximals, and it is very significant that the proximals are absent in the earliest Silurian genera, and are most conspicuous in the later and higher types. *Heterocrinus juvenis* is evidently in the same morphological condition as *Haplocrinus*. The ring of plates, which Carpenter no longer considers orals in *Cyathocrinus*, encloses a central piece without proximals, and in all probability the same is the case in *Hybocystites* and the Hybocrinidæ generally. The Reteocrinidæ possess only a small central piece, but have no proximals. Are the orals here resorbed, and also the interradials? That would, indeed, suggest a very peculiar condition for a Lower Silurian genus.

The basals, as pointed out by Carpenter, are the most important plates in the calyx. They lodge within their cavity, bounded by the radials, the chambered organ, which is the centre of the nervous and vascular system, and from the basals the axial canals pass out to the radials and arms. In the summit, the central plate occupies, in relation to the radials, the same position as the basals. It is the only summit plate that is represented in every Palæocrinoid, and it lodges underneath the most important organs of the oral system. In view of these facts, and admitting that the orals are the homologues of the basals, there can scarcely be a doubt that the central piece, undivided as it is, is the true homologue of the oral pyramid as represented in the Pentacrinoid larva.

It is true that the pentamerous nature of the orals is an objection to this interpretation, but we do not believe it a serious one, certainly not so great as is found in attempting to homologize six proximals with five orals.

Of the embryology of the Palæocrinoidea little or nothing is known except from phylogenetic evidence, and even this is limited, and gives information only as to the later stages in the almost fully developed Crinoid. In recent Crinoids, from their earliest stages, the orals are composed of five distinct plates, and it is very possible that the central piece, if representing the orals of the Palæocrinoidea, primitively consisted also of five pieces, which were fused together, and that the suture lines gradually were obliterated by deposition of new material at the outer surface, as in the case of the underbasals in *Agassizocrinus*. Who would have thought that in this genus the thick plate at the dorsal end represented five anchylosed plates, if the sutures had not been fortunately observed in some of the younger specimens? That a similar process probably took place at the outer face of the central piece, is somewhat indicated by the condition of the plate, which is always more or less conical or spiniferous, and wherever the point of the plate has been broken, the missing part is replaced by secretion of new deposit. It seems to us that in a group like the Palæocrinoidea, in which the tentacular vestibule was permanently closed, a gradual anchylosis of the five primary plates is deducible from analogy, and would be in entire accordance with prevailing rules in nature.

Such an anchylosis occurred in palæozoic times among the basals, and this is of considerable importance, as the basals are admitted by Carpenter to represent the orals. In the larva of *Antedon*, the basal ring is formed of five distinct plates, and the same number prevails in the adult throughout the recent Crinoids, if not throughout the Neocrinoidea generally. Among monocyclic Palæocrinoids, however, this number forms the exception, and occurs only in a few Silurian genera. Five are soon succeeded by four, three and two plates. Carpenter finds no objection to call all those plates basals, and to regard them, whether composed of two, three or five plates, as the representatives and homologues of the orals. Similar modifications occur in the number of underbasals, and among them Carpenter admits three and four plates; but when we find the underbasals in *Stemmatocrinus* evidently fused together to a single piece, he regards this as a stem joint.

Even the joints of the column are sometimes tri- or quinquepartite, from the top of the column to the end of the rootlets, and principally in Lower Silurian genera; nevertheless the stem joints of the Pentacrinoid larva, and those of the Neocrinoidea generally, are undivided throughout. Are we to consider the former as different elements from the latter because they are composed of three or five pieces? Or are we to regard the five plates collectively as the homologues of the undivided joints of recent and other Crinoids? In the latter case, why should not the dorsocentral, *i. e.*, the terminal plate of the column, be divided in one or the other species? That the plate is undivided in the Pentacrinoid larva, and in the few species of *Pentacrinus* in which it has been observed, is by no means a proof that it is so in all Crinoids.

It has been stated by Carpenter that "the basals are within the ring of radials, and next to the dorsocentral." This is no doubt frequently the case, but is not the universal rule. In the Rhodocrinidæ and Reteocrinidæ the interradials are placed between the radials, forming with them a ring of ten plates around the basals, while in the Acrocrinidæ the radials are totally isolated from the basals by a wide belt of plates, which, although not true interradials, may be fairly compared with them (Pl. 8, fig. 1).

At the oral side, the arrangement is fundamentally the same as in the calyx, as can be observed in species in which all summit plates are fully developed. Frequently, however, the first and second radials are orally unrepresented, when the third radials occupy the same position as their representatives in the calyx, which is the same as that occupied by the third summit radials of *Strotocrinus*, etc.

If the orals were represented by the proximals, the latter should be succeeded in all cases by the radials, and not be included in the same ring. There is not a single instance of Crinoids known to us where either a radial or an anal plate entered the basal ring, or where an anal plate entered the ring of orals, yet all of this must be encountered if we consider the proximals to be the orals. Moreover, in *Strotocrinus* and *Teleiocrinus* the two posterior radials would be placed inside the oral ring, the orals of *Megistocrinus* would enclose a large circlet of interradial pieces; while in *Reteocrinus*, *Glyptocrinus* and other Silurian genera, the orals would be altogether unrepresented. All these difficulties are removed if we regard the central piece as the representative of the oral pyramid, and the proximals as summit interradials. Basals and radials, interradials and anal plates are then found to occupy the same position orally as aborally, and even the small intercalated pieces in the dome of *Megistocrinus* are explained by analogous plates in the calyx of *Acrocrinus*. But on the contrary, if the proximals were the orals, it would follow that the orals were represented in the calyx by the proximal interradials, and not by the basals.

That the proximals, which are such prominent plates in the Palæocrinoidea, are unrepresented in the Neocrinoids, is fully explained by the fact that in the latter the interradials generally were imperfectly developed in the calyx, and hence their absence in that group cannot be considered a serious objection to our views.

We are convinced that neither the underbasals nor the dorsocentral are represented at the summit, especially not the latter. We cannot imagine what office such a plate could possibly have had at the oral side, considering that it constitutes a part of the column, and the Echinoderms at no time, or in any group, were attached at their oral side. That it is represented dorsally in the Stellerids and Urchins is natural, as it represents there in a wider sense the entire column of the Crinoid, but its presence at the oral side would be an anomaly.

It seems to us that a far less objectionable explanation of the central plate than that given by Carpenter, would be to regard it as a posterior oral. In this case the orals would be represented by five plates and not by six; the anus would be placed outside the oral ring, and the radial dome plates would occupy the same position towards the orals as the calyx radials toward the basals. But it would place the mouth underneath the posterior oral, and it offers no explanation of the central piece in *Haplocrinus*.

This view was, perhaps, taken by Zittel in the case of the summit plates of *Crotalocrinus* and *Enallocrinus*, in which the central plate has a somewhat elongate form, and which he described as having five orals. The summit plates in both genera are subtegminal, being covered completely by interradials, and the same was probably the case in the allied Ichthyocrinidæ, at least in their earlier forms. *Reteocrinus* and *Xenocrinus* were evidently in a similar condition, but it is not known whether they had summit plates beneath the interradials or not. *Glyptocrinus* and most of the Silurian genera of the Camarata had a central piece, but no proximals. In all Devonian Crinoids both plates are generally represented, but they do not attain their full development until the Carboniferous.

It has been asserted by us that the ventral plates in *Allagecrinus*, *Haplocrinus*, *Culicocrinus* and *Coccocrinus*, are calyx interradials and not proximals. In *Allagecrinus* and *Haplocrinus* there are five single plates occupying the same space as the whole series of interradials in other genera. In their simplicity, and in resting upon the radials and closing the peristome, these plates, no doubt, closely resemble the orals in the Pentacrinoid larva, but as calyx interradials they would occupy exactly the same position. There is, however, a very important difference in the structure of the two forms to which no attention has been paid. The orals of the larva and those of *Holopus* rest loosely upon the calyx; while the interradials of *Haplocrinus*, like all other interradials, are united with the radials by a close suture.

It has been proved from palæontological evidence, that in the earlier genera the interradials are more extravagantly developed than in later ones. In *Crotalocrinus* and *Reteocrinus*, the interradials cover the entire ventral surface; in *Glyptocrinus* and *Glyptaster* they extend to the central plate; while in the Carboniferous genera they recede gradually toward the periphery, and the central space is filled by large proximals, and often by radial dome plates. Considering these facts, is it safe to assert that in *Allagecrinus* and *Haplocrinus*, which are regarded as larval forms, interradials are entirely absent, and that all ventral plates are actinal? Is it not more reasonable to imagine that in these low forms the ventral side was covered by the one plate, in a similar manner as in *Crotalocrinus*, *Reteocrinus and Glyptocrinus* by the whole collection of plates? In the Neocrinoidea, from the larva to the adult, all ventral plates are actinal, but in all Palæozoic Crinoids, and we may say in all Palæozoic Pelmatozoa, the whole, or at least the greater part of the ventral side, is abactinal, and this we consider one of the best distinctions between the two groups. We do not understand how Carpenter can maintain that those plates are orals, and at the same time can retain *Allagecrinus* and *Haplocrinus* under the Palæocrinoidea. He must either refer them to the Neocrinoidea, or accept the so-called "Scheitelplatten" as interradials in their simplest form.

It seems to us that in *Allagecrinus* the interradials cover not only the disk but also the summit plates. *Culicocrinus* is in a similar condition, but has additional interradial plates. In the somewhat higher developed *Coccocrinus*, the interradials are separated from one another, forming lateral clefts and a central gap, evidently to receive the oral plate and the ambulacra, which, however, retain permanently the position which they occupied before the valves separated, and rest in the bottom part of the clefts. In *Haplocrinus* the interradials evidently separated in the growing animal, and the oral plate moved outward, but not sufficiently to bring it to a level with surrounding plates; while the ambulacra remained subtegminal. The interradials, instead of being formed into lateral clefts as in *Coccocrinus*, remained permanently closed by means of lateral growth, as shown by their beveled edges, which are formed into grooves.

From *Haplocrinus* to *Cyathocrinus alutaceus* and *Symbathocrinus* there is but one step. The latter two have proximals, the former not. The proximals, we think, were introduced in the Palæocrinoidea in a similar manner as the perisomic plates in the Neocrinoidea. The interradials by the increasing width of the calyx retreated in the growing Crinoid toward the periphery, thereby forming an open space around the oral plate which was gradually filled by the proximals and other dome plates. *Symbathocrinus* is a much higher form than *Haplocrinus*, as shown by the presence of proximals, by the ventral tube, and by the highly differentiated mode of articulation.

If it were true that the five interradials of *Haplocrinus* and *Allagecrinus* are homologous with the six proximals of *Symbathocrinus*, *Platycrinus* and *Actinocrinus*, and that these plates are orals, it would follow, inasmuch as all later and complex Palæocrinoidea have six plates, that the larger number represented the higher form. And further, that *Haplocrinus* and *Allagecrinus* had reached a degree of development such as attained only by

Neocrinoidea, but existing among them as a constant character through all stages of growth. In the Neocrinoid larva the orals are large, occupying the entire ventral side, or one-half of the entire test, and the conditions are not changed by the introduction of perisome in the adult. In the adult Palæocrinoid the actinal system of plates is restricted to a small space, and it is very improbable that the orals extended out to the radials in the earlier stages, or in such forms as *Haplocrinus* and *Allagecrinus*, which, as admitted by Carpenter, are in the condition of the Palæocrinoid larva.

All this tends to prove that the resemblance between the proximals and the orals in the adult Rhizocrinite or Thaumatocrinite, and the "Scheitelplatten" in *Allagecrinus* and *Haplocrinus* with the Pentacrinoid larva, is altogether superficial, and that the orals, if these are developed in Palæocrinoidea, which we think they are, can only be represented by the central plate.

A resorption of the summit plates may have taken place in the later Inadunata; throughout the Camarata they persisted through life.

B. *The Ventral Perisome.*

The ventral perisome covers the visceral mass or body, and together with the oral plates, forms the surface of the disk. It is composed of the "ambulacral" and "anambulacral" plates. The anambulacral plates are irregular pieces or limestone particles along the interpalmar areas, which consist of the anambulacral plates proper, and the so-called interradial plates of the disk. The former are pierced by numerous water pores, and occupy the spaces between the ambulacra; the latter are not perforated, and occur in the substance of the perisome, uniting the rays and their subdivisions. These interradials must not be confounded with the calyx interradials, which cover those of the disk. The ambulacral plates extend from the peristomial area to the extremities of the arms and pinnules, and consist of the so-called "Saumplättchen" or "covering plates," and the "adambulacral" or "side pieces" which support the former and border the outer margins of the ambulacra.

In the Pentacrinidæ, the perisome is always studded more or less with plates, and these often have a very solid appearance; while in the Comatulæ the entire perisome is sometimes almost, or totally, free from calcareous incrustations.

Among the earlier groups of the Neocrinoidea, the perisome is only known in the Jurassic *Extracrinus* and in *Marsupites*, in both of which it consists of small irregular pieces, forming a rather substantial pavement, which frequently encloses the lower pinnules. Among Palæocrinoidea, a perisome has rarely been observed, but it was preserved among several groups, and we have been led to the conclusion that the perisome was probably subtegminal in the Camarata, the Articulata, and the earlier Inadunata, but external in the later Fistulata, our former *Cyathocrinidæ*, which we make a branch of the Inadunata.

The perisomic skeleton of the Camarata is frequently preserved in *Batocrinus*, *Eretmocrinus*, *Physetocrinus* and *Dorycrinus*, in which it probably attained a more substantial form than in any of the other genera. It is there composed of rather distinct plates, placed parallel to those of the test or *tegmen calicis*, and arranged in a similar manner. Each plate of the outer test has a corresponding plate in the ventral perisome; the plates of the latter, however, are not connected by suture, but disposed loosely, leaving an open space at each angle, which was perhaps filled by membranous substance. In their usual preservation the plates are frequently dense, owing to incrustations of inorganic matter, but in their natural state they consist of a fine network, and resemble similar plates in recent Crinoids. They form a sort of internal lining, which extends from the second primary radials and first interradials, uninterruptedly, to the central piece, or near it, underlying the proximals and entering the anal tube. This structure is well shown in the specimen (Pl. 5, fig. 6), in which the sutures between central plate and proximals are visible. Most of the perisomic plates, along their median portions, are connected with the plates of the test by small pillars or partition walls, leaving between them open chambers, evidently for the free circulation of water. The water probably entered from without by means of the respiratory pores, which we described in Part I, p. 11, and which jointly may have performed the functions of a madreporite. There are, however, no pillars between the plates along the radial regions, which take the shape of closed galleries or corridors, formed by grooves along the inner floor of the test, and closed from below by perisome. These passages diverge toward the arm bases and contain the ambulacral tubes. The perisome of other genera was probably less substantial, and perhaps in some of them altogether membranous. We never observed anything like plates in the Actinocrinites, except in *Physetocrinus*, in which they are well developed. Of this genus we lately obtained a specimen which proved that the small tubercles along the ventral surface, figured by us in Rev. ii, Pl. 19, fig. 5, are not, as we then supposed, openings through the "vault," but impressions of the open spaces between the anambulacral plates. In *Actinocrinus* and allied genera we occasionally find little pillars or nodes along the inner floor, which sometimes suspend fragmentary plates, or portions of a filmy substance, and evidently are parts of the perisome. We found similar pillars along the floor of *Glyptocrinus ramulosus* (Pl. 9, fig. 2) underneath the interradial areas, but not beneath the plates overlying the ambulacra. The latter plates are folded as in *Physetocrinus*, and formed into natural grooves, which evidently harbored the ambulacral tubes.

The ambulacral tubes of the Actinocrinidæ rest upon the perisome, but rarely enter the plates of the vault, and do not become exposed until they enter the free arms. In the Platycrinidæ the structure is essentially the same, but the covering pieces frequently enter the calyx at—or close to—the proximals, and in this case often take the form of vault plates. In the young Crinoid, according to our interpretation, the ambulacral tubes were attached to, and rested primarily within the grooves of the lower arm joints, from which they were gradually lifted out when these became incorporated with the calyx and transformed into radials. It seems to us that, while this was going on, the radial regions of the vault were raised by the ambulacra, thereby producing elevations or folds along the vault of *Glyptocrinus* and *Physetocrinus;* while in *Platycrinus* the ambulacra in many cases penetrated the test.

The tubes are composed of four rows of plates, alternately arranged, of which two constitute the floor, the two others the upper side. The upper ones are the covering pieces, but we are not certain whether those at the floor are side pieces or form a sort of subambulacral plates. The covering plates where they entered the vault were suturally connected, but on entering the arms became movable. Side pieces have never been observed in the Camarata, but covering plates are found occasionally both in arms and pinnules, and were probably present in all of them.

We have noticed (Rev. ii, p. 31) narrow grooves upon the inner surface of the vault, which meet beneath the median part of the oral plate, and follow the subtegminal galleries which enclose the ambulacral tubes. The condition of these grooves can be studied most profitably from natural casts, in which they appear as string-like elevations along the ventral surface. They have been observed most frequently among the Actinocrinites, where they seem to be universally developed, while no traces of them are to be seen in the twenty or more casts of *Platycrinus* which we examined. That they do not represent the ambulacral tubes, is proved by the fact that these are always located at a distance from the inner floor, as beautifully shown in the casts (Pl. 4, fig. 5, and Pl. 5, fig. 9), and wherever we found the tubes intact, they occupy the same position. That the strings are in no way connected with the tubes, is further shown by the fact that they always meet in the centre, while the tubes form a ring around the centre, as also by the irregularity which they exhibit. It is shown by our figures (Pl. 4, fig. 4, and Pl. 8, figs. 1 and 3), that there are always two of them side by side, which at places connect, and again at others depart from one another, with irregular knots at each bifurcation. This structure could not be explained if the strings represented the inner cavity of the ambulacral tubes, as these are very regularly arranged. That the grooves are placed along the solid walls of the test, has led us to suppose that they were axial canals, and that these Crinoids possessed an orocentral nervous system like all other Echinoderms, but contrary to the Neocrinoidea, in which the nervous system, as now generally admitted, is connected with the chambered organ within the basal cavity. Our interpretation becomes more plausible when we consider that in the Camarata the radials are never pierced by canals, and it would be difficult to understand how these ponderous arms could have moved without axial cords, unless their movements were altogether passive. That the canals have been observed only in certain groups, may be explained by supposing that in many cases they probably rested against the wall, without piercing the floor.

That the perisome, wherever found in place, extends all the way from the top of the first interradials to the central piece, is very interesting, and shows a complete resemblance between the ventral perisome of a recent Crinoid, and the body beneath the vault of an Actinocrinoid. A total resorption of all interradial plates, dorsally and ventrally, and also of the proximals, would reduce an Actinocrinoid, or Platycrinoid, essentially to the condition of a Neocrinoid that has its lower arm joints connected by perisome. The fact that the perisome is continued underneath the proximals, and extends to the central piece, tends to prove that the latter, and not the proximals, represents the oral pyramid, as these plates *surround* the peristomial area but do not cover it (Pl. 1, fig. 6). It further proves that the interradial plates of *Platycrinus*, *Glyptocrinus* and *Reteocrinus* cannot be partly plates of the calyx and partly perisomic, but must be either the one or the other. If the Reteocrinidæ had lived in Carboniferous times, and the Actinocrinidæ in the Lower Silurian, there might be a possibility that in the former the interradials, dorsally and ventrally, as well as the summit plates, had been resorbed; but as they comprise one of the earliest known groups, this interpretation need not be considered, and we can only regard those plates as ill-defined interradials.

We find it difficult to believe that the so-called "interradials" of *Guettardicrinus*, and *Apiocrinus roissyanus* and allied species, are homologous with the calyx interradials of an Actinocrinoid; but regard all those pieces as enormously developed perisomic plates. That they are somewhat heavier pieces and more regularly arranged than those plates usually are, is not sufficient to make them calyx plates, as they evidently adapted their conditions to surrounding parts, and are therefore thick plates from necessity, in order to fill the deep edges of adjoining radials. De Loriol, in the Paléont. Franc. on p. 272, describes them in *Apiocrinus roissyanus* as follows: Pièces interradiales nombreuses, très inégales, elles varient dans chaque espace interradial dans le nombre et l'arrangement. Presque toujours la série commence par une pièce unique, hexagone ou heptagone, qui est la plus grande, quelquefois fort grande. . . . Au-dessus il y a deux, trois, et même quatre pièces plus petites, irregulières, polygonales," etc. This description does not apply to calyx interadials, among which the first plate is always very regular, and the first row never consists of two plates, nor the second variously of two, three or four pieces. This irregularity seems to have puzzled Carpenter, for, on p. 183 of the Challenger Report, he suggests that perhaps the "smaller interradials were perisomic plates."

Why not the first plate also? We seriously doubt if those plates enclose the perisome as the interradials in *Actinocrinus*, or were covered by perisome as in *Cyathocrinus*, and hence believe they are not calyx but perisomic plates, which, like the smaller pieces of *Eutracrinus*, united the lower arm divisions. We take the same view of the so-called interradials and interaxillaries of *Uintacrinus*, which merely attained the outer form of calyx pieces, but are true disk plates, and on approaching the ventral side passed into anambulacral pieces instead of harboring or supporting a perisome. The case is altogether different in *Thaumatocrinus*, in which the interradials are placed within the ring of first radials, and as such form, like the anal plate, a primitive part of the calyx. The Crotalocrinidæ present a different perisomatic arrangement from the Actinocrinidæ. The interradials frequently commence in the equatorial zone, and extend over the whole ventral surface, even oral plate and proximals being subtegminal. Their perisome, which was figured by Angelin in *Crotalocrinus rugosus* (Icon. Crin. Suec., Pl. xvii, fig. 3 *a*), is composed exclusively of covering plates. The proximals are long and narrow, and abut with their outer edges against the deflected upper ends of two radials, leaving radially five angular spaces, which are occupied by the ambulacra. These ambulacra, of which the covering plates are visible, bifurcate like those of other groups, but their subdivisions, in place of being separated by anambulacral plates, join each other laterally, and, together with the summit plates, fill the entire ventral surface. The total absence of anambulacral pieces in this genus is a most remarkable feature, but may perhaps be explained by the presence of hydrospires. There are, however, no spiracles nor pores through any of the plates, except along the anal tube, which is perforated along its walls.

The vault of the Crotalocrinidæ extends quite a distance into the free rays, as shown by Müller's and Angelin's figures (Icongr., Pl. 6, figs. 6 and 7, also Pl. 25, figs. 15 and 25, and Akademie der Wissenschaften, 1853, Pl. 13, fig. 10). That those plates are not ambulacral pieces is proved by the fact, that they cover the Saumplatten, and have a different style of ornamentation. Those figures further prove, that the ventral covering was pliable, or the arms could not have assumed that horizontal position, and be folded in other specimens. This is of some importance as demonstrating that a pliable vault may enclose another flexible integument and contain the food grooves underneath, which was seriously questioned by Carpenter (Chall. Rep., p. 182). He evidently overlooked *Crotalocrinus*, for we doubt if he could have taken the small covering plates (Icongr., Pl. 17, fig. 3 *a*) for the representatives of the large rigid plates of figs. 6 and 7 on Pl. 6, or the irregular pieces around the oral pole to be summit plates.

Crotalocrinus and *Enallocrinus* have close affinities with the Ichthyocrinidæ, not only in that both have a flexible skeleton, but they frequently possess no interradials dorsally, and they all have the same peculiar arm structure. In speaking of a pliant vault we do not mean a surface "formed of connective tissue with numerous interradial plates imbedded in it," as supposed by Carpenter (Chall. Rep., p. 182), but a continuous integument of plates connected by ligament in place of suture, sometimes with imbricating plates. We postulated the prevalence of this structure in the vault of the Ichthyocrinidæ from the construction of the dorsal plates, which could not be movable unless the ventral side was pliant also. Our views are confirmed by the vault structure of *Crotalocrinus*, and we think the disk ambulacra of *Ichthyocrinus* were arranged in a similar manner, and covered by a similar vault.

A very different perisome is found in the higher types of the Cyathocrinidæ, which is not subtegminal, but exposed upon the surface of the interradial plates. This form is found only in genera in which the ambulacral tubes rest upon the upper edges of the interradials. It is not restricted alone to the later genera, but occurs in several Silurian forms. Angelin has figured such a disk in *Cyathocrinus lævis* (Iconogr., Pl. 26, figs. 2 and 3), and *Gissocrinus punctuosus* (ibid., Pl. 29, fig. 75 *d*), but we think the structure was not correctly understood. In all cases the five interradial plates are completely covered by small perisomic plates, of which those at the four regular sides are not pierced with water pores, while those toward the ventral sac are generally profusely perforated. In some cases we found the summit plates in process of resorption. In *Cyathocrinus iowensis* (Pl. 5, fig. 7), the larger proximals appear in the form of eight irregular pieces, their edges rounded off; while in *Cyathocrinus multibrachiatus* (Pl. 4, fig. 6) only fragments of the plates are scattered over the perisome.

The disk ambulacra were probably differently constructed from those of the arms (Pl. 4, figs. 6 and 7). The specimens indicate that the plates of the former were suturally connected, while those along the arms were movable. All Cyathocrinidæ, so far as observed, have side-pieces which support Saumplättchen; and these rest upon two series of subambulacral (?) plates, which form the floor of a tube as in the Actinocrinidæ.

The "ventral sac" of the Fistulata was always regarded by us as functionally and structurally distinct from the "anal tube" or "proboscis" of the Camarata. We held the former to be an essential part of the body, and perisomic in its origin; the latter as a mere prolongation of the azygous interradius, and constructed of abactinal plates.

To understand the two structures, we must bear in mind that in the growing Actinocrinoid the capacity of the calyx adequately increased with the growth of the body, and hence was at any time capable of holding the visceral mass. In the Fistulata, however, in which all brachials remain permanently free, and the calyx is not enlarged in proportion to the visceral mass, the posterior side of the disk forced its way out through the anal opening, and formed the so-called ventral sac, which has always a narrow neck along the base. According to our interpretation the ventral sac is an enormously developed interpalmar area supported by the anal plate, and as such reminds us of the asymmetrical disk in the recent genus *Actinometra*, in which the anus is central and the mouth marginal.

In most of the Fistulata, the ventral sac is perforated with round or slit-like openings, transversely arranged, which enter the outer margins of two adjoining pieces, but never penetrate the inner portions of the plates like the water pores of the Neocrinoidea. The openings either extend over the whole surface of the sac; or are arranged in longitudinal rows—porous plates alternating with solid ones;—or the terminal end is composed of large solid pieces, frequently spiniferous; or as in the Carboniferous species of *Cyathocrinus* the entire tube is composed of solid hexagonal plates, and the porous or anambulacral plates are restricted to the small area usually occupied by the smaller proximals. In the Poteriocrinidæ, the anambulacral plates extend over the greater part of the ventral sac, but in the Catillocrinidæ and Calceocrinidæ they are limited to one side of it. The two latter groups possess a series of large anal plates, arranged horizontally, and these form a proboscis with a furrow at its ventral side. This proboscis was incorporated into the sac in a somewhat similar manner as the lower arm joints and pinnules into the disk of the Neocrinoidea. In this structure the two groups have close analogies with the recent genus *Thaumatocrinus*. In that genus, however, the row of anal plates does not enter the perisome, but forms an independent solid appendage in the shape of a cone, which apparently has no functions, as the anal opening is persomic, and we regard this peculiar appendage as a remarkable instance of atavism.

It is probable that in the latter Poteriocrinidæ and Encrinidæ, the interradials and summit plates became finally resorbed, and the perisome was more or less restricted to the ventral disk, as in these genera the sac dwindled down to a small conical tube, which probably disappeared in *Encrinus* before reaching maturity.

That the openings along the ventral sac are not genital openings, as suggested lately by Trautschold, need not be discussed, as most of the Fistulata have well-developed pinnules, and these are not prehensile organs as supposed by him, but are continuations of the arms which contained the genital glands. Neither is it true that the ventral sac is frequently present or absent in the same species. It existed in every individual, but is rarely preserved in the fossil, and is often obscured by the arms.

Nothing is known from actual observation of the perisome of the Ichthyocrinidæ, and little if anything of the construction of the ventral side in any of their genera. The interradial plates of the dorsal side have been described by us as movable, somewhat irregular in form and arrangement, and upon this, principally, we based our conclusion that the plates of the ventral covering were movable, in some cases perhaps squamous. In *Onychocrinus* only there has been observed by Lyon and us indistinct traces of a ventral covering, but too imperfect to give much information either as to the real nature of the plates, or as to their arrangement. Carpenter regards all interradials of the dorsal side as calyx plates, and all those succeeding them and located ventrally as parts of the disk. We admit that the latter may have a superficial resemblance to the small, irregular and movable perisomic plates of *Extracrinus* and other Neocrinoidea to which he alludes. But we do not understand why a flexible calyx, with a flexible vault, may not enclose a soft or even a plated disk such as we find in *Crotalocrinus* and *Enallocrinus*. The thinness and irregularity of the plates is no valid argument against it. We find such plates ventrally in *Glyptocrinus* and some species of *Physetocrinus*, and there are plates of the same nature dorsally in the Reteocrinidæ. On the other hand we find massive and more or less regular plates dorsally in *Apiocrinus*, which Carpenter considers to be perisomic. To our minds the case of *Extracrinus* is by no means parallel to that of the Ichthyocrinidæ, as that genus is destitute of calyx interradials. If his argument were correct, then all the plates of the Ichthyocrinidæ and Reteocrinidæ should be considered as perisomic. In that case the perisomic portions of the Crinoid would predominate so enormously that nothing would be left for the abactinal part except the base, and species of *Reteocrinus*, which so good an observer as S. A. Miller considered as congeneric with *Glyptocrinus*, would constitute a distinct order. And we would have the anomaly that the earliest known forms of Crinoids would be in this respect examples of the highest organized types, and most closely allied to the recent Crinoids.

In support of his view, Carpenter has no other proof than this superficial resemblance. There is no evidence of the existence of external food grooves, which must follow if these plates are perisomic. The same reasons that led us to regard the smaller interradials in *Apiocrinus*—massive as they are—as perisomic plates, compel us to consider all plates of the Ichthyocrinidæ, interradial in position, as belonging to the same element, and either all perisomic or all calyx plates.

If the plates in question were perisomic, it would obliterate the last distinguishing feature between Neocrinoids and Palæocrinoids, and we should like to know upon what points Carpenter would separate the Ichthyocrinidæ and Reteocrinidæ from the Neocrinoidæ. We admit that the direct proof of our views as to the ventral structure of the Ichthyocrinidæ is as yet wanting, but in this respect Carpenter is no better off, and it seems to us that the weight of argument from analogy is in our favor.

THE RELATIONS OF THE PALÆOCRINOIDEA TO THE NEOCRINOIDEA.

The name "Palæocrinoidea" was proposed by one of us in 1877 (Amer. Journ. Sci., vol. xiv, p. 190), but not properly defined until 1879 (Rev. i, p. 30). At that time we also proposed the name "Stomatocrinoidea," and made both groups subdivisions of the "order" Crinoidea, of equal rank with Blastoidea and Cystidea. To the Palæocrinoidea we referred the earlier brachiate Crinoids in which *mouth and food grooves are subtegminal* or hidden from view; to the Stomatocrinidæ the Mesozoic and recent Crinoids in which *mouth and food grooves are exposed upon the disk.* Both groups were admitted by Carpenter and Etheridge, Jr., in 1881, but they changed the name Stomatocrinoidea into "Neocrinoidea" because, as they stated, our name was "long and cumbersome," and they were "by no means sure that some of the Palæocrinoids had not an external anal opening." We might, no doubt, successfully controvert the right of Carpenter and Etheridge to change our name, which had priority, and which was sufficiently defined to be recognized, until they proved satisfactorily that the name-giving characters were inconsistent or incorrect. This view of the case was evidently taken by De Loriol, who in his late work (Paléont. Francaise, tome xi, p. 43) placed both names in equal rank. We hold there is not a single Palæocrinoid known in which either mouth or food grooves are exposed, nor a "Stomatocrinoid" in which they are closed, and this we still regard as one of the best distinctions between the two groups. We, therefore, wish to have it understood that, in accepting Carpenter's name, we do not give up our original position, but yield to the preferable name.

The Crinoidea were subdivided by Joh. Müller into "Crinoidea Articulata" and "Crinoidea Tessellata," the latter including the Inarticulata and Semiarticulata of Miller. Müller's definitions of his groups were extremely vague, but we may conclude from the names and from the genera which he referred to them, that they were based upon a supposed difference in the mode of union of the first radials with the plates which they bear. Among the Tessellata, however, we find *Poteriocrinus* which has highly developed articular facets, not only between radials and brachials, but also at the bifurcations of the arms. Zittel, who adopted Müller's divisions, defined the calyx plates of the Tessellata as "Unbeweglich durch einfache Näthe verbunden;" those of the Articulata as "durch gelenkartig ausgehöhlte und gewölbte oder ebene Nathflächen verbunden." But nevertheless he refers to the Tessellata the Ichthyocrinidæ, in which the radials are united with one another by ligament and frequently by muscles also, as seen by the articular faces of *Forbesiocrinus nobilis* (Pl. 5, figs. 3 and 4), and we have seen similar faces in *Ichthyocrinus* and *Taxocrinus*. Among the later Poteriocrinidæ there are also several genera with fossæ along the lateral faces of the radials, which indicate a certain degree of mobility even among the plates of the calyx. On the other hand, the higher radials of the Apiocrinidæ, which Zittel refers to the Articulata, are as solidly united among each other directly, or by means of intercalated plates, as in any so-called " tessellate " Crinoid. All of this tends to prove that a division based upon the mode of union between the plates is totally impracticable, if intended to separate the palæozoic from the later Crinoids, as done by Zittel. We think, however, it affords important data for establishing subdivisions of the Palæocrinoidæ, among which we recognize Articulata and Camarata, the former having their plates connected by articulation, the latter by suture.

The distinctions between the Neocrinoidea and Palæocrinoidea, according to Carpenter (Challenger Report, pp. 149–154), are the following:—

1. In the Neocrinoidea, underbasals are rarely represented; in the Palæocrinoidea, frequently.

2. In the Neocrinoidea " by far the greater number of genera have five equal and similar basals, with five equal and similar radials resting upon them." Exceptions to this rule are found in *Hyocrinus*, which has three basals, and *Holopus* and *Eudesicrinus* in which the radials are not symmetrical; " but this want of symmetry is not due to the intercalation of any anal plate as in nearly all Palæocrinoids."

3. In all Neocrinoidea, with the exception of *Thaumatocrinus*, " the primary radials are in contact with one another by the entire length of their sides; or more rarely, as in *Guettardicrinus*, *Uintacrinus* and *Apiocrinus roissyanus*, their distal angles are cut away so as to receive the lower part of the first interradial. This feature, which is common enough in the Palæocrinoidea, is rare in the Neocrinoidea."

4. Most of the Neocrinoidea have no interradial plates in the calyx, but when present " they are not limited to any special side of the calyx, but are equally distributed all round it, so that there is no distinction of the anal side, *Thaumatocrinus* excepted." In the Palæocrinoidea, however, " the pentamerous symmetry of

the calyx is almost always disturbed by a greater or less modification of the plates on the anal side."

5. In the Neocrinoidea "the basals are pierced by interradial canals or grooves, which lodge the cords proceeding from the angles of the chambered organ," whence they pass into the radials. None of them have permanently imperforate radials as so many Palæocrinoidea, the latter group remaining in an embryonic condition.

6. In the Neocrinoidea, with the exception of *Metacrinus* and *Plicatocrinus*, the axillary is the third of the primary radials; while in the Palæocrinoidea the first radials themselves may be axillary or any other plate beyond the first.

7. The arms of the Neocrinoidea, with the exception of one or two species of *Encrinus*, are uniserial, those of the Palæocrinoidea frequently biserial.

8. The mouth and food grooves of all adult Neocrinoidea are exposed to view; in the Palæocrinoidea, with but few exceptions, closed by plates.

In most of these points we agree with the English scientist, but in some of them we think modifications should be made, and there is one point to which he did not give the importance which we think it deserves.

We agree with Carpenter that underbasals are rarely observed in Neocrinoids, which, as we have stated elsewhere, are built upon the plan of dicyclic Crinoids. The angles of the column are directed interradially, the cirrhi radially; while the opposite is the case in *Actinocrinus*, *Glyptocrinus*, *Belemnocrinus*, *Heterocrinus*, etc., which are known to be monocyclic, and we conclude from this structure that all Neocrinoidea, or at least most of them, in their larval state may have possessed rudimentary underbasals hidden by the column.

Among Neocrinoidea, *Thaumatocrinus* is the only genus in which calyx interradials are evident, and it is very doubtful to us whether even these plates, which rest within the ring of the first radials, really are the homologues of the first interradials of the Actinocrinidæ, Platycrinidæ or Cyathocrinidæ. The interradials of *Thaumatocrinus* were covered in the larva by the oral pyramid; while those of the young Palæocrinoid form the whole of the ventral surface. The so-called "interradials" of *Guettardicrinus*, *Apiocrinus roissyanus*, and *Uintacrinus* we take to be perisomic plates, and we cannot understand how Carpenter can admit interradials in *Apiocrinus roissyanus*, and not in *Apiocrinus Meriani* (De Loriol, Pal. Franc., tome xi, Pl. 40), *Apiocrinus Rathieri* (Ibid., Pl. 50) and *Apiocrinus murchisonianus* (Ibid., Pl. 53). But it is still more remarkable that in *Apiocrinus roissyanus* Carpenter considers only the first row, and not the succeeding ones also, as calyx plates. The latter are equally solid, suturally connected, and rest like the first plate, between the primary radials.

In our opinion Carpenter lays too much stress upon the asymmetry of the calyx in the Palæocrinoidea, which he attributes to the intercalation of an anal plate. If the asymmetry of the basals was due to that cause only, genera such as *Eucalyptocrinus*, *Coccocrinus*, *Mycocrinus*, *Dolatocrinus* and *Corymbocrinus*, which have no anal plates in the calyx, should have very regular basals, while in fact *Eucalyptocrinus* has the same basal arrangement as *Melocrinus*, *Dolatocrinus* as *Hexacrinus*, *Corymbocrinus* as *Abacocrinus*, the last named of which all possess anal plates. It is also well known that in *Platycrinus* and the Blastoidea, and all other genera with three unequal plates in the basal ring, the smaller plate is always located to one side, not posteriorly, and it is difficult to understand how in *Haplocrinus* the asymmetry of the calyx could be attributed to an anal plate, or to the anal opening, when the latter penetrates the very top of the so-called "orals." We admit that the dorsal cup is more frequently asymmetrical in Palæocrinoidea than in Neocrinoidea, but exceptions are so numerous that we cannot attach to this point the importance that Carpenter does, who considered the symmetry, or want of symmetry, to be the best distinction between the two groups. We believe the condition of the mouth, and that of the oral surface generally, is of much greater importance, and proves to be a more constant character than any of those to which attention has been directed. Carpenter thinks *Coccocrinus* forms an exception to this rule, which he regards to be in the condition of the Neocrinoid genus *Holopus*, and that consequently its mouth was exposed. If this were true, we should not hesitate a moment to refer that genus to the Neocrinoidea, as nothing would be left to make it a Palæocrinoid, not even the asymmetry.

Carpenter denies that interradials are present as a rule in

Palæozoic Crinoids, and he, therefore, does not attach to these plates the value which we think they deserve. According to our interpretation they are present in all Palæocrinoids, but absent or incompletely developed in the Neocrinoidea. By means of the interradials the two groups differ essentially in their larval state; the whole ventral surface of the Neocrinoid larva is covered by the orals, but in the Palæocrinoid larva the interradials physiologically take their place, and the orals or their equivalent is subtegminal. The indistinct calyx interradials, which appear for a short period in the Pentacrinoid larva, became resorbed before taking any prominent part in the formation of the calyx, while the interradials of all Palæocrinoids are well defined and permanent plates. It is possible that the interradials of the Encrinidæ were similarly resorbed shortly before the Crinoid reached maturity, but they were evidently well developed in their earlier life, as we may judge from their affinities with the Cyathocrinidæ and Poteriocrinidæ, and this, principally, has induced us to refer them to the Palæocrinoidea.

We propose the following definitions of the two groups:—

PALÆOCRINOIDEA Wachsmuth.

Crinoids with irregularly pentamerous calyx; plates united by suture or articulation. Base monocyclic or dicyclic. Basals and underbasals variable in number. First radials rarely in lateral contact all around, two of them often separated by an anal plate, and sometimes all of them by interradials. The succeeding plates of the rays are free or become incorporated into the calyx. Arms more frequently biserial than uniserial. There is always at least one interradial to each side which is located ventrally, but when there are a number of them, dorsally and ventrally. The interradials extend to the summit plates or cover them, occupy the greater portion of the ventral surface, and either form a vault over the perisome or support the perisome; in either case, however, mouth and disk ambulacra are completely closed. The summit plates are substantially a repetition of the plates in the calyx. They consist of an undivided plate which represents the basals; of the proximals or interradials and anals; and frequently of radial dome plates.

NEOCRINOIDEA Carpenter.

Crinoids with regularly pentamerous calyx, without interradial or anal plates (*Thaumatocrinus* excepted). Underbasals rarely well developed, being either rudimentary or absent. Basals five, exceptionally three. Radials perforated, and generally united to succeeding plates by a muscular articulation. Rays simple or dividing; the lower arm joints frequently connected laterally by perisome. The first axillary plate generally the second joint after the first radial; arms uniserial. Ventral surface completely occupied by actinal structures, either simply membranous or paved with irregular plates; traversed by the ambulacra, which have open food grooves. Orals five; always represented in the larva, but frequently resorbed in the adult; at first in lateral contact, but afterwards separating so as to open out the tentacular vestibule, and expose the mouth.

CLASSIFICATION.

The "Stalked" Echinoderms, by which we understand the Crinoidea in their widest sense, have been regarded by some writers as constituting an independent class, by others as an "order" of the class Echinodermata. The latter view, which has been adopted by most of the later European systematists, was somewhat modified in the classification of Dr. P. H. Carpenter, who ranks the Stalked Echinoderms under the name "Pelmatozoa" as a "branch" of the "phylum" Echinodermata, and he makes the Crinoidea—*sensu str.*—and the Cystidea and Blastoidea, full classes, of equal rank with the Holothurians, Echinoids, Asteroids and Ophiurids.

The name Pelmatozoa, as stated by Carpenter (Chall Rep., p. 193), was introduced by Leuckart in an essay published in 1848, and more fully discussed in 1865, in his "Bericht über die wissenschaftlichen Leistungen in der Naturgeschichte der niederen Thiere." In the latter paper he subdivides the Echinodermata into three groups: the Pelmatozoa, to include the Stalked Echinoderms, *i. e.*, Crinoidea in the broadest sense; the Scytodermata, to embrace the Holothurians; and the Echinozoa, under which he placed the Urchins, Starfishes and Ophiurans.

That the Stalked Echinoderms and Holothurians are more distinct from each other, and from the three groups for which Leuckart proposed the name Echinozoa, than these are among themselves, cannot be denied, but it is questionable whether it is necessary or even desirable to express this in the classification, any further than by placing in juxtaposition the nearest allied groups. Too many subdivisions encumber the classification, and as long as the Scytodermata and Echinozoa of Leuckart are not accepted, we think it unnecessary to establish a branch for the Pelmatozoa. In principle, however, we agree with Carpenter, and admit that the "Pelmatozoa" differ very essentially "in the presence of a stem, and in the consequent departure from the ordinary habits of an Urchin, Starfish or Holothurian. Whether sessile or provided with a stem, the Crinoid lies on its aboral surface instead of creeping about mouth downwards in search of food" (Chall. Rep., p. 193), and they differ also in having no locomotor organs in connection with the ambulacral system (Ibid., p. 188). All this, however, we think is sufficiently expressed by giving the Pelmatozoa the rank of a class, and placing them at the end of the list.

In our opinion there is no doubt that J. S. Miller proposed the name Crinoidea to designate exclusively the brachiate Crinoids, for he stated in his description (A Nat. Hist. Crin., p. 7), that "there proceed from the upper rim of the cup-like body five articulated arms, divided into tentaculated fingers," and among the species which he refers to them there is neither a Blastoid nor a Cystid. Unfortunately, however, later writers have used the name in a twofold sense, designating thereby the class and one of its subdivisions, until lately Zittel, in his Handb. der Palæontologie, to remedy this, proposed the name "Eucrinoidea" for the "Brachiata" *i. e.*, Crinoidea, *sensu str.*, and "Crinoidea" to take the name of the class, an arrangement which has since been accepted by De Loriol. To conform to Miller's idea, the new term should have been given to the class, and not to the subdivision. But as Leuckart had already proposed the collective name "Pelmatozoa," which has priority, and is a more appropriate term than Crinoidea, Zittel's scheme need not be discussed.

Carpenter has placed the Blastoidea and Cystidea on a level with the Crinoidea, making all three distinct classes, a rank to which we think they are not entitled. The three groups, according to our views, are mere modifications of the same plan which, so far as known, originated in the Cystidea, and of which the Blastoidea and Crinoidea are mere offshoots. The latter group, but especially the Blastoidea, are linked together with the Cystidea by such easy transitions, that among the earlier types it is difficult to draw any clear line of demarkation. We are unable to point out a single character that is not found exceptionally in one of the other groups. We do not except the calicine pores or the pectinated rhombs, which are regarded as characteristic of the Cystids, nor the lamellar tubes beneath the ambulacra, which were thought to be restricted to the Blastoids. Even jointed arms occur in many Cystids, and in some of them they are connected with the radials in a similar manner as in the Crinoidea.

We do not wish to enter upon a discussion of the structural peculiarities of the Cystidea and Blastoidea, and, if we allude to them here, it is only to illustrate their close affinities with one another, and with the Palæocrinoidea. *Asteroblastus*, judging from the calyx, is a Cystid, but it has Blastoid ambulacra, Blastoid pinnules, associated with ambulacral and calicine pores. The same structure occurs in (?) *Agelacrinus Pusirewskii* Hofmann. On the other hand, the Blastoid genus *Codaster* has neither spiracles nor ambulacral pores; its hydrospires open out like those of certain Cystidea, and they do not underlie the ambulacra, but are placed alongside of them. *Codaster* was referred by Billings and Zittel to the Cystidea, but is now generally recognized as a Blastoid. *Stephanocrinus* has been variously described as a Crinoid, Blastoid and Cystid. As admitted by Carpenter, it has probably no hydrospires, and so far as known no calicine pores nor pectinated rhombs, but it possesses long Crinoid-like brachial appendages. *Caryocrinus*, which has been very generally regarded as a Cystid, has segmented pinnule-bearing arms like a Crinoid, and these are attached to the radials, but it has calicine pores, and numerous hydrospires along the inner floor of the calyx. *Porocrinus* has a calyx and arms like a Cyathocrinoid, but calicine pores like a Cystid. *Hybocystites* was described by Wetherby as a Cystid; by Carpenter as a transition form between Crinoids and Blastoids, but nearer the latter; while we consider it a Crinoid. Its arm structure is that of a Cystid, but it has apparently neither calicine pores, rhombs, nor lamellar tubes. The Crotalocrinidæ and Eucalyptocrinidæ probably have hydrospires within the calyx, *Cupressocrinus* and *Symbathocrinus* probably hydrospires underneath the ambulacra, and both have segmented arms.

These few examples, to which others might be added, will sufficiently show that neither the Blastoidea and Cystidea, nor the Crinoidea proper, form primary divisions like the Urchins, Starfishes or Ophiurans, but constitute subordinate groups of the

Pelmatozoa. Carpenter admits on p. 191 the close affinities between the Cystids and Blastoids, but the Crinoidea he takes to be a well-defined group "by having segmented arms attached to the radials, contrary to the Cystids and Blastoids in which there are either no arms at all, or structures of an entirely different nature from those of the true Crinoids." We have already directed attention to *Caryocrinus* and *Porocrinus* as having well-developed arms, similar to those of *Hybocrinus*, and also calicine pores. If we were to make the division between Crinoids and Cystids upon the arm structure, and did not make the calicine pores the principal distinction between those groups, we would also have to place among the Crinoidea *Comarocystites*, which has not only segmented arms but even pinnule-like appendages. Neither could we leave out *Glyptocystites* and *Pleurocystites*, in which the arms are long and lined with well-defined covering plates.[1]

Burmeister (Zoonomische Briefe, Leipzig, 1856, vol. i, p. 243) divided the "Crinoidea" into Anthodiata, among which he included the Cystidea and Blastoidea, and "Brachiata" with Tessellata, Articulata, Costata and the genus *Holopus*. This arrangement, leaving out the Costata, which probably are not Pelmatozoa at all, seems to us a very good one, and we find it convenient to adopt his divisions as "subclasses," substituting, however, for Burmeister's name Brachiata, Miller's older name Crinoidea. This enables us to discriminate between Palæocrinoidea and Neocrinoidea on the one side, and Cystidea and Blastoidea on the other, which, as we have stated, are more distinct from one another than the groups which we place under them. To make the Anthodiata and Crinoidea separate classes, on a level with the Urchins, would give to them too much importance. We doubt if Carpenter will claim them to be anything like as distinct groups as the Ophiurids and Starfishes, which by some systematists were regarded as mere subgroups of the

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[1] The Cystidea have never been properly defined. They form in our opinion an assemblage of several groups of equal rank with the Blastoidea. S. A. Miller pointed out in the Cincinnati Journal of Nat. Hist., Dec. 1882, the Lichinocrinoidea and Agelacrinoidea as orders of the Crinoidea; the latter name, however, must be changed to "Edriasterida," as this has priority. It was proposed by Prof. Huxley in his classification of animals, London, 1869, p. 130 (Carpenter).

Stellerites. These, however, differ essentially in their mode of development, which can hardly be claimed for the Anthodiata and Crinoidea. We can only say of them that, as a rule, in the former the organs generally were contained within the calyx, whereas in the Crinoidea the generative and respiratory apparatus is almost entirely confined to the arms, and probably neither Blastoids nor Cystids had appendages united by paired muscular bundles. The Palæocrinoidea form parallel groups with the Blastoidea, both being descendants of the Cystidea; while the relations of Palæocrinoidea and Neocrinoidea are similar to those of Palæocrinoidea and Cystidea, and Cystidea and Blastoidea; but the Neocrinoidea, although they are of later descent, are equally well defined. In making these four groups orders of the Anthodiata and Crinoidea respectively, we place at the head of the list the Cystidea, as being the typical form, the Blastoidea next, and at the opposite end the Palæocrinoidea and Neocrinoidea.

In correspondence with Dr. Carpenter he has admitted that his classification tends to give an expression of well-marked differences between Crinoids, Cystids and Blastoids, which, as he stated on p. 191 of his Report, do not exist between the two latter, and we are authorized to state that he concurs with us in re-establishing Burmeister's Anthodiata and Brachiata, as we have practically done, the former to include as "orders" the Cystidea and Blastoidea, the latter the Palæocrinoidea and Neocrinoidea. We believe, therefore, that there is very little difference between us on this point.

Various other classifications have been proposed by different writers, for which we refer to the Challenger Report, pp. 186–196. The following classification will be adopted by us, viz.:—

Phylum, ECHINODERMATA.

Class, PELMATOZOA.

Subclass I, *Anthodiata.*	Subclass II, *Crinoidea* (*Brachiata*).
Order 1, CYSTIDEA, ETC.	Order 3, PALÆOCRINOIDEA.
Order 2, BLASTOIDEA.	Order 4, NEOCRINOIDEA.

Class, PELMATOZOA.

Definition.[1]—Echinoderms which are fixed either permanently

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[1] This and the succeeding definition is taken from Carpenter (Chall. Rep., pp. 186), with a slight alteration in the first one which is indicated by italics.

or temporarily by the middle of the aboral surface. A jointed stem containing a neurovascular axis is usually present, but may be lost when maturity is reached; or in the case of a few sessile forms, remain altogether undeveloped. The apical system consists of a dorsocentral plate, basals and radials, with the frequent addition of underbasals and interradials. These plates form a cup, which either simply supports or more or less completely encloses the visceral mass, and often bears jointed appendages, the arms and pinnules.

An oral system, to some extent a repetition of the plates in the apical system, consisting of basals, radials and interradials, covers the peristome, but may be altogether resorbed, or be restricted to basals only. The anus either is located within the calyx, and surrounded by abactinal plates, or forms a part of the oral surface.[1]

The water vascular ring does not communicate directly with the exterior, and the lateral branches of the radial vessels (when present) are respiratory, but not locomotor in function.

Subclass, *Crinoidea.*

Definition.—Pelmatozoa, in which the radial plates of the calyx bear more or less branching arms. These consist of segments which are articulated by means of muscles and ligaments, and in most cases bear similar jointed appendages, the pinnules. The nervous system consists (1) of a central organ situated in the calyx, and fibres extending from it through the skeleton of the stem, arms and pinnules; (2) of a circumoral ring and radial extensions which are in close relation with the ciliated epithelium of the ambulacral grooves. These are more or less extensively distributed on the ventral surface of the disk, arms and pinnules; and are bordered by groups of tentacles which alternate on opposite sides. When they are absent, the radial water vessels give off no tentacular branches. The water vascular ring opens by five or more water tubes into the body cavity, which itself communicates with the exterior by a corres-

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[1] Carpenter's version: "An oral system, consisting of a central plate (orocentral) and five orals, is developed above the peristome of the larva to a very variable extent, and may be either altogether resorbed, or reach a high degree of importance by the appearance of additional plates so as to form a vault or *tegmen calycis*. The anus is situated on the oral surface, which may be bare, or more or less covered by calcareous plates."

ponding number of water pores. The mouth is central, except in a *few genera*, and the anus subcentral or excentric. The genital glands are lodged in the lower parts of the arms, but are usually fertile only in the pinnules.

THE SUBDIVISIONS OF THE PALÆOCRINOIDEA.

Among the Palæocrinoidea we recognize three great divisions, which on the whole correspond to our former groups, Sphæroidocrinidæ, Ichthyocrinidæ and Cyathocrinidæ. These groups, which are divisible into definite subgroups, will be ranked by us as suborders of the Palæocrinoidea, and the subgroups as families. The three suborders, for which we have proposed the names *Camarata*, *Articulata* and *Inadunata*, are distinguished from one another principally by the mode of union among the calyx plates, and the condition of the arms as to whether their lower plates constitute a part of the calyx, and as such enclose the visceral cavity, or form parts of the free arms. These groups are not only well defined in nature, as shown by the fact that they are so readily recognized, but they are also most convenient for all descriptive and comparative work.

When we first defined the three groups (Rev., i and ii), we laid the greatest stress upon the construction of the ventral surface, which, as we stated, offered most excellent characters for their separation; but as the modifications which take place among them, to a large extent, result from the conditions of calyx and arms, we regard the structure of their ventral side as of subordinate rank. This necessitates a re-description of those groups, especially as our present views upon the ventral plates generally differ essentially from those previously held by us.

We have stated that the so-called "orals," upon which the "Cyathocrinidæ"—the Inadunata of our new classification—were at that time principally founded, are interradials, which attained their ventral position by being in lateral contact, in place of resting laterally against the lower arm plates. The construction of the ventral surface in the earlier Inadunata thereby became fundamentally identical with that of the "Sphæroidocrinidæ," except that the latter attained subsequently a larger number of interradials. In the later Inadunata the ventral structure is very different; indeed, so much so that the two sections according to our former views should have been distinctly separated. This we had contemplated, but we encountered great difficulties, as the two forms run very closely from one into the other. Even the ventral sac, the best distinguishing character, undergoes all possible modifications. It dwindles down to almost nothing in some of them, and its porous nature is sometimes very indistinctly developed or even unrepresented. We regard these modifications, as they occur in palæontological times, as representing various stages of development in the history of this group, and as good generic characters, but do not attach to them the importance we did before. We have, however, placed the genera in which a ventral sac is developed as a group by themselves, to separate them from those in which it is absent. The latter group, which represents the larval form, will be designated by us as "*Larviformia*" the former as "*Fistulata*."

Instead of the name Sphæroidocrinidæ, which is objectionable for several reasons, we propose to use *Camarata*, under which we have placed several additional groups. To the *Articulata* (nobis, not Müller or Miller), which we restrict to the *articulated Palæocrinoidea*, we refer the Ichthyocrinidæ and Crotalocrinidæ. If there is any objection to re-establishing Müller's name, which has been generally discarded, we might change Articulata into "Articulosa." We think, however, we are fully entitled to adopt the former, as the Crinoids which we refer to them are true Articulata in Müller's sense. We place the Camarata, which we regard as the typical form of the Palæocrinoidæ, at the head of the list, the Articulata next, and the Inadunata, which in some respects approach the Neocrinoidea, at the opposite end.

The CAMARATA embrace all Palæocrinoidea in which the plates of the test are solidly united by suture, and in which the lower arm plates are incorporated by means of interradial plates so as to form a part of the calyx. The underbasals are frequently undeveloped. The basals of monocyclic genera are variable in number, five being the exception. The primary radials consist generally of three plates to each ray, rarely of two or four. There is always at least one secondary radial, which may give off the free arms or support others, and frequently radials of higher orders. Interradials numerous, or not less than two; the first one resting upon the sloping upper sides of the first radials, or alternating with them. The interradials, together with the interaxillaries and anal plates, separate the rays and their subdivisions, and cover the greater part of the ventral surface up to the summit plates, or the whole of it including the latter. The free arms are simple or branching, and with a few exceptions biserial, uniserial only in their immature state, permanently only in a few Silurian genera. The articulation of the arms is primitive, and dorsal canals have never been observed. All have pinnules, which as a rule are closely folded together. The anus is surrounded by solid plates, suturally connected; its position is excentric, except in the Eucalyptocrinidæ.

The summit plates are largely developed, and consist in all Carboniferous, and in most of the Devonian genera, of an undivided oral plate, proximals, and frequently one or more radials; in most of the Silurian forms, however, of orals only, and even these may be covered by interradials. The disk is subtegminal, but sometimes the covering pieces enter the outer surface, when they take the condition of surrounding plates. The Camarata have small openings along the brachial zone, by means of which the water for respiration entered the body.

To the ARTICULATA we refer all Palæocrinoidea in which the test is pliable. The calyx extends to the lower arm joints, and the plates are united by articulation, and not by suture. Underbasals are always represented; they are small, being frequently covered by the column, and consist of either three or five plates. The number of primary radials varies from two to seven or more, and also the number of the higher orders is very variable. The radials of different rays are either in contact laterally or connected by the help of interradials. In the former case, frequently, a smaller number of radials alternates with a larger one, and the plates of one ray rest with their upper sloping sides against the lower sloping sides of their fellows of adjoining rays, or *vice versa*. When the radials are separated by interradials, these either extend to the basals, or rest against the upper sloping sides of the first radials. In some cases, however, the interradials are restricted to the ventral surface. The form of the calyx varies from almost strictly pentamerous to bilateral symmetry, but it sometimes becomes irregular, owing to the interposition of an azygous plate. Some species have no anal plate dorsally. The radial and arm plates are united horizontally by muscles and ligament, or perhaps in some cases by ligament only. The lateral face of the radials and those of the interradials are provided with deep ligamental fossæ. The arms are closely folded together, and sometimes connected laterally by a membranous substance. The ventral surface, so far as known, is composed of interradial plates; it forms a pliable vault, which extends to the free rays, and probably covers not only the disk, but also the summit plates. The Crotalocrinidæ have no anambulacral pieces, but possess hydrospires within the calyx.

The INADUNATA are subdivided into *Larviformia* and *Fistulata*. They include all Palæocrinoidea in which the arms are free from the first radials. Their calyx is comparatively small; composed exclusively of basals, frequently underbasals, five radials, five interradials, and one or two azygous plates. The proximal ring of plates, whether basal or underbasal, is composed of five, or less frequently, three plates. The radials are laterally connected except at the posterior side, where they are separated by an azygous and anal plate, if these have not been resorbed. The presence of the azygous plate gives to the calyx a very irregular outline. The interradials are located ventrally; they rest against the upper ends of two adjoining radials, and join along their lateral margins.

The ventral covering of the LARVIFORMIA consists of comparatively few pieces, among which generally the combined muscle plates form a conspicuous part. The central space is covered either exclusively by interradials, or these enclose an oral plate, which in some of the higher forms is surrounded by proximals. The disk is subtegminal in place of being extended into a lateral sac. The anal opening either penetrates the interradials, or is placed intermediate between two radials or their appendages. Respiration took place by pores along the arm furrows, which probably communicated with hydrospires.

In the higher organized FISTULATA the perisome is partly or wholly exposed, the interradial plates either cover the perisome, or this partly covers them. In the latter case the summit plates may be resorbed, in the former they are largely represented; but in either case portions of the disk penetrate the calyx posteriorly by passing out through the anal opening. These portions form either a balloon-shaped or a tubular sac, composed of well-defined plates, closed at the end, but perforated over the surface by pores along the suture lines; the pores penetrating the lateral edges of the plates. Respiration took place by means of the pores along the perisome.

PHYLUM, *ECHINODERMATA.*

CLASS, **PELMATOZOA.**

SUBCLASS, **Crinoidea.**

ORDER, PALÆOCRINOIDEA.

SUBORDER, CAMARATA.

The Camarata embrace the Platycrinidæ, Actinocrinidæ and Rhodocrinidæ, which in Part II we grouped together under the name Sphæroidocrinidæ, and also the Acrocrinidæ and Calyptocrinidæ, which are here described.

In a paper on *Glyptocrinus* and *Reteocrinus*, Amer. Journ. Sci., vol. xxv, April, 1883, we intimated on p. 267, that we might find it advisable to place *Glyptocrinus*, *Reteocrinus* and allied genera in a family by themselves. This had been done by Zittel, and has since been adopted by S. A. Miller, under the name of Glyptocrinidæ. Zittel included in this family *Glyptocrinus*, *Glyptaster*, *Thylacocrinus*, *Cupulocrinus*, *Lampterocrinus*, *Eucrinus* and *Sagenocrinus*, genera all having well developed underbasals, with the exception of *Glyptocrinus*, in which they were said to be rudimentary. Miller's Glyptocrinidæ contain *Archæocrinus*, *Cupulocrinus*, *Glyptaster*, *Lampterocrinus*, *Reteocrinus* and his proposed genus *Gaurocrinus*, all having underbasals, and *Glyptocrinus*, *Xenocrinus* and his *Compsocrinus* and *Pycnocrinus*, which he described as having but one ring of plates below the radials.

The presence of underbasals has been very generally considered a good family distinction, and it has always been a question of doubt with us whether we were justified in departing from this rule by placing *Glyptocrinus* and *Xenocrinus*, in which underbasals were said to be absent or indistinctly developed, in the same group with *Reteocrinus* and *Archaocrinus*, in which those plates form a more or less important part. The genera which Miller has grouped together, and a few more, agree remarkably in general aspect, but they differ not only in the matter of underbasals, in the number of basals, but also very materially in the disposition and form of their interradial plates.

Glyptocrinus was originally described as possessing no underbasals. Hall afterwards discovered minute pieces enclosed by the ring of plates which he had previously designated as basals, and which he now called subradials, taking the small inner pieces for the true representatives of the basals. The presence of these small pieces was also acknowledged by Meek and ourselves, but Meek hesitating to call them basals, applied the name "subbasals;" while we took them to be rudimentary underbasals, and as such they have been described in Part II of the Revision, and in our April paper.

We have stated elsewhere, that in all Crinoids having basals only, the column, when pentagonal, has its angles directed radially, the radii of the pentapetaloid or five rayed columnar canal interradially, and that the opposite is the case in all species, throughout all Palæocrinoidea in which underbasals are present. Applying this rule to *Glyptocrinus* and allied genera, we find that every species referred by us to *Glyptocrinus*, is without underbasals, and that all those, with one or two exceptions, which we placed under *Beteocrinus*, have underbasals. The exceptional species are *Glyptocrinus Richardsoni* Wetherby, of which we speak later on, and Meek's *Glyptocrinus Baeri*, which we found to be a *Xenocrinus*, having four basals and a subquadrangular column; but, like *Xenocrinus* and *Mariacrinus*, a pentangular axial canal, its angles directed strictly interradially. By carefully grinding off the base in *Gl. decadactylus*, and in several other species, we have become satisfied that the pieces which have been designated by Hall, Meek and ourselves heretofore, respectively, as basals, subbasals, and rudimentary underbasals, form no part of the calyx, but constitute the uppermost portion of the column, which in this genus rests within a remarkably deep, funnel-shaped concavity.

Among the species arranged by Miller under *Glyptocrinus*, and which were said to have no underbasals, are *Glyptocrinus Richardsoni* Wetherby, and *Gl. Pattersoni* Miller. In Rev., Part II, and subsequently in our paper in the Amer. Journal, these species were placed under *Reteocrinus* Billings. In neither one of them have underbasals been observed, although these plates may be present, hidden beneath the column, as in the case of many Rhodocrinidæ and Poteriocrinidæ. The species differ, however, very materially from *Gl. decadactylus* and allied species without underbasals in the distribution and position of their interradial plates, which are irregularly arranged, and rest upon the five basals, exactly as they do in *Reteocrinus stellaris* and in *R. O'Nealli*, which, contrary to the other species, have well developed underbasals. The case is similar in *Xenocrinus penicillus* Miller, only that in this species underbasals are known to be absent, and they have four in place of five basals. Any difference in the number of basals has been generally considered a good generic distinction, and this makes *Xenocrinus*, undoubtedly, a good genus. But in which group shall we place it? Together with *Reteocrinus* or *Glyptocrinus?* Together with species in which the interradials rest upon the basals, and which have well developed underbasals, or with species destitute of underbasals, and with their interradials, as in *Glyptocrinus*, resting upon the first radials?

In Part II we maintained that, as a rule, the presence or absence of underbasals should be considered of more than generic importance, and this we made the principal distinction between Actinocrinidæ and Rhodocrinidæ. We pointed out, however, that in these families there are several genera, among the earlier types, which are closely connected by transition forms, and shade almost imperceptibly from one into another. We even thought it possible that species of the same genus might possess underbasals in a rudimentary way, while those plates might be totally absent in others. This is not confirmed by our later investigations, but it is nevertheless by no means an easy task to separate some of the earlier genera upon this character, as there are frequently other important features by which they are much more closely connected with other groups. In proof of this we need only refer to *Glyptocrinus Richardsoni*, provided this really possesses no underbasals, as Miller asserts, and to *Reteocrinus O'Nealli*, in which they are very conspicuous. As the two species are almost identical in every other respect, it would seem doubtful policy to refer them to distinct families upon this character alone. S. A. Miller evidently experienced the same difficulty, for his Glyptocrinidæ include genera of both forms. Zittel, De Lorial, and all preceding writers, make the presence of underbasals a full family distinction, and all their Glyptocrinidæ and Rhodocrinidæ are said to have underbasals.

Diversities in the distribution of the interradial plates of the calyx have been generally taken to be of minor morphological importance; but at the same time they have been considered good characters for distinguishing genera. S. A. Miller alone has placed in the same genus species, which in this respect show the greatest possible contrast. It is, however, rather singular that he applies this rule only to the "Glyptocrinidæ," while in other groups he considers such difference to be at least of generic importance, and what is more singlar, he even constructed thereon a whole family. His Melocrinidæ differ from his Actinocrinidæ mainly in having all five interradial spaces arranged almost uniformly, and they generally have four basals. That Miller did not make the number of basals the distinctive character, is very evident, or he would have arranged his *Xenocrinus penicillus* and "*Compsocrinus*" *Harrisi* among the Melocrinidæ. On the contrary, he placed these species under distinct genera; while he referred *Glyptocrinus decadactylus* and *Reteocrinus Richardsoni* to the same genus, although these two differ in exactly the same way as the two former species.

One is curious to know upon what ground Miller based his Glyptocrinidæ. Not upon the underbasals, nor upon the relative number of basals; neither upon the ridges along the radials, for these are absent in *Cupulocrinus* and *Lampterocrinus*, and certainly not upon the ornamentation, which he asserts does not hold good even among those genera. They are united by no single character, and since it has been clearly proved that *Glyptocrinus* has no underbasals, this genus no longer falls within the Rhodocrinidæ, which were fundamentally based upon the presence of those plates, and must be referred to the Actinocrinidæ. That *Glyptocrinus* was in many respects closely allied to the Actinocrinidæ, subdivision Melocrinites, has been shown already in Part II, and several species were at first described under *Glyptocrinus*, which we have since referred to *Mariacrinus*. Among these is *Gl. Harrisi*, for which Miller lately proposed the genus *Compsocrinus*. The generic definition of *Compsocrinus* is partly based upon inaccurate observation, for the interradials of all five sides rest upon the edges of the first radials, and not one of them upon a basal, as figured by Miller in his diagram pl. 11, fig. 4, a.

It has been stated in Part II, p. 185, that the interradials of all known Actinocrinidæ, except sometimes those of the azygous side, rest upon the first radials, and this is the case in *Glyptocrinus* and "*Compsocrinus*." We find an apparent exception to this rule, if we make the absence of underbasals the controlling family character, in the genus *Xenocrinus*, and perhaps in *Glyptocrinus Richardsoni* and *Gl. Pattersoni*, in which underbasals have not been observed. The two latter species agree in all essential particulars with *Xenocrinus*, in which we include not only Miller's type, but also *Glyptocrinus Baeri* Meek. These two species, however, have four basals, while the two former ones have five. Equally close are the affinities with *Reteocrinus*, which has well defined underbasals. *Xenocrinus*, *Reteocrinus*, and *Glyptocrinus Richardsoni*, which we make the type of our new genus *Canistrocrinus*, agree in the following features: The plates of the five main rays and their branches are formed into tube-like ridges along the middle, with lateral extensions to meet the interradials. The interradial areas are deeply depressed; composed of numerous minute, irregularly arranged plates. They abut against the basals and isolate the first radials to their full length. The azygous interradius is divided by a conspicuous, rounded ridge, composed of strong, comparatively large plates, longitudinally arranged, which slightly decreasing in size, extend out to the subcentral anal opening.

Reteocrinus, *Xenocrinus* and *Canistrocrinus* constitute a natural, well defined group, and it seems to us impracticable to separate them upon the ground that some of the species possess underbasals. The lateral separation of the first radial plates distinguishes them from all Actinocrinidæ, and this, according to P. Herb. Carpenter,[1] "is a fact of considerable importance in Crinoid morphology; but in this very character they approach somewhat the Rhodocrinites, in which, as a rule, the first interradials all around meet the basals. Among the Rhodocrinites, however, the lower interradials are perfectly regular plates, their position is fixed, and they are succeeded by equally regular pieces. Whether such widely different plates, as here represented, can be compared with each other, is very doubtful, and this seems to have been the opinion of Carpenter, who intimates that the irregular small pieces of *Reteocrinus* can hardly be regarded as the complete morphological equivalents of the larger and more regular single interradials which occur in the Rhodocrinidæ." That these irregular interradial plates occur in none of the later groups of the Palæocrinoidea, but only in the very earliest Silurian types, and under decidedly similar conditions, in species with and without underbasals, points clearly to the conclusion, that those genera constitute a little group by themselves, and we think this justifies us in

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[1] On a New Crinoid from the Southern Sea by P. Herb. Carpenter, M. A., Philos. Trans. of the Roy. Soc., Part III, 1883.

recognizing them as a distinct family, which we propose to call *Reteocrinidæ.*

Now, having referred the genus *Glyptocrinus* in its typical form, and "*Glyptocrinus*" (*Compsocrinus*) *Harrisi* Miller, = *Mariacrinus Harrisi*, to the Actinocrinidæ or their allies, *Reteocrinus*, *Xenocrinus*, and our new genus *Canistocrinus* to the Reteocrinidæ, there remain for consideration among species with underbasals, or Rhodocrinidæ, as they were previously called, two other groups:

(*a.*) Species, in which all five primary interradials meet the basals, forming a ring of ten plates with the first radials.

(*b.*) Species, in which the first anal plate only rests upon the basals, the interradials upon the edges of the first radials. The first group comprises the genera: *Archæocrinus*, our new genus *Rhaphanocrinus*, *Lyriocrinus*, *Rhipidocrinus*, *Thylacocrinus*, *Anthemocrinus*, *Rhodocrinus*, and *Ollacrinus*; the second *Glyptaster*, *Dimerocrinus*, *Ptychocrinus* and *Lampterocrinus.* The former group agrees with our subdivision *Rhodocrinites*, except *Archæocrinus*, which we had previously arranged under Glyptocrinites; the latter corresponds with our former Glyptasterites.

It might be as well, perhaps, to let these groups remain as subdivisions of the Rhodocrinidæ; but, as it is desirable that the families proposed by various authors in the different classifications should be made to correspond as far as possible, we follow Zittel, and rank them as full families. The first, as embracing the typical genus, will be *Rhodocrinidæ.* Zittel's name, Glyptocrinidæ, however, cannot be used for the other group, since it is known that *Glyptocrinus* has no underbasals. We propose in its place the name *Glyptasteridæ*, *Glyptaster* being one of its most characteristic types.

These divisions are substantially in conformity with the views of Carpenter, expressed in his paper on *Thaumatocrinus*, p. 929. He approves Zittel's division into Glyptocrinidæ and Rhodocrinidæ, but acknowledges at the same time "that *Glyptocrinus* has decided affinities with the Actinocrinidæ." His views upon the irregular plates of *Reteocrinus* have already been quoted. The rounded ridges along the radials, as they appear in *Reteocrinus* and *Xenocrinus*, are more than mere ornamentations. They seem to have contained tubular passages which, perhaps, may represent the axial canals, while the more angular ridges of *Glyptocrinus*, *Glyptaster*, etc., must be considered simply as an ornamentation of the calyx. They represent, as stated by Carpenter, "a character of altogether minor importance as compared with the morphological difference between the lateral union and the isolation of the radials."

In Part II we have placed under *Actinocrinidæ* all Crinoids without underbasals, in which the interradial plates are connected by suture, and the basals support the radials, and frequently a large anal plate, but none of the regular interradials. This excluded the allied genus *Acrocrinus*, in which basals and radials are separated by a large number of accessory pieces. We excepted also the *Calyptocrinidæ* with *Eucalyptocrinus* and *Callicrinus*, which differ essentially in their vault structure, and the *Barrandeocrinidæ* for other reasons to be explained hereafter.

The Actinocrinidæ, as they were defined by us, comprise a well-defined natural group; and we find it difficult to subdivide them, unless it be upon the presence or absence of an anal plate in line with the first radials, *i. e.*, the bilateral symmetry of the one group as contrasted with the more or less pentamerous symmetry in the other. In making this division, we place the Stelidiocrinites and Melocrinites with their almost regular symmetry in the one group, and the Agaricocrinites, Periechocrinites, Actinocrinites and Batocrinites in the other, the former as *Melocrinidæ*, the latter as *Actinocrinidæ*.

Rœmer, Lethæa Geogn., 1855 (Ausg. 3), p. 228, distinguished Melocrinidæ from Actinocrinidæ, the latter on account of their larger azygous interradius, and having three in place of four basals. Zittel partly recognized these groups, but added to the Melocrinidæ *Scyphocrinus* Zenker (not Hall), *Corymbocrinus* and *Abacocrinus*, the latter with an anal plate upon the basals, thus proving that he made the number of basals the distinctive character. He divided our Actinocrinidæ into the families *Briarocrinidæ*, *Carpocrinidæ*, *Dimerocrinidæ*, *Actinocrinidæ* and *Polypeltidæ*.

Our *Platycrinidæ* were subdivided into Platycrinites and Hexacrinites, the one with strictly pentamerous symmetry in the calyx, the other bilateral. The two groups are easily recognized, and will be continued, but ranked as families.

The Platycrinidæ have been described by us and other writers as having a single interradial plate in contact with the radials.

This was based upon an incorrect understanding of the plates. That it is not the case in *Platycrinus* is readily seen by our figures on pl. 7. Even the most simple form has three interradials, horizontally arranged, all supported by the first radial plates, and we are convinced that three, or a greater number of plates, are found in all other Platycrinidæ, and all Hexacrinidæ. Wherever we have observed them, the middle plate is larger, and rests upon the juncture of two first radials, the outer ones upon their upper face, meeting laterally the higher radials. The larger number occurs in forms with flattened disc and wide, spreading rays.

The presence of three or more pieces in the first row, which evidently represent the first, second, and perhaps third ranges of interradials in other groups, is morphologically of considerable importance, as it seems to have produced, to a large extent, the structural peculiarities of the two families. It is evident that, owing to the great width of the interradial areas, the succeeding radials could make no connection with the higher interradials, and the rays thereby became isolated, and remained permanently in a more or less embryonic state. Three interradials seem to have been represented also in *Coccocrinus*, as shown in Roemer's figure 5^c of *C. bacca*, although they are not figured in his *Coccocrinus rosaceus.*

We also refer to the Camarata the genus *Barrandeocrinus.* It was made by Angelin, Zittel and De Loriol the type of a distinct family, and this seems to be warranted by its exceedingly strange form, produced principally by the construction of the arms and the arrangement of the plates at the ventral side, although the plates along the dorsal side are arranged similarly to those of the Actinocrinidæ.

The Camarata, according to our classification, fall into ten families:

A. RETEOCRINIDÆ. Base monocyclic or dicyclic. Basals 4 or 5. Radials folded into strong tubular longitudinal ridges along the median line of the plates. Interradial and interaxillary areas deeply depressed; resting upon the basals. They are composed of a large number of ill-formed immovable pieces, which continue to the ventral side, almost completely covering the interpalmar areas, leaving but a small oral plate at the centre. Azygous side wider: divided by a vertical row of rather large anal plates, which extend to the anal aperture. Arms single-jointed; pinnules strong. Anus subcentral. Column circular or angular.

B. RHODOCRINIDÆ. Base dicyclic. First radials separated from one another by the first interradials, with which they form a ring of ten plates around the basals. Interradial areas composed of well-formed plates, definitely arranged; azygous side scarcely distinct. The interradials in all earlier forms along the ventral side are arranged like those of the Reteocrinidæ, and the proximals are probably unrepresented; but in the later ones proximals are well developed. Anus subcentral. Column circular or obtusely pentangular.

C. GLYPTASTERIDÆ. Base dicyclic. First anal plate resting on the basals, but the first interradials not touching them. Succeeding interradials arranged as in the Rhodocrinidæ. Those upon the ventral surface are sometimes composed of larger plates than in the preceding groups. Anus subcentral. Oral piece and proximals well represented. Column circular or pentangular.

D. MELOCRINIDÆ. Base monocyclic. Basals 3 to 5. Neither anal nor interradial plates touching the basals; the latter in contact with radials only. Interradial areas composed of numerous plates; those upon the dorsal side large, regularly arranged, those along the ventral surface frequently small and irregular. Oral plate generally surrounded by proximals. Anus subcentral. Column circular, rarely angular.

E. ACTINOCRINIDÆ. Base monocyclic. Basals 3, rarely 4. First anal plate resting on basals, the first interradials upon the sloping sides of the first radials. The interradials together with the interaxillaries, anal plates and proximals, form a solid vault over the disk, rarely exposing any of the covering plates. Anus subcentral. Column circular.

F. PLATYCRINIDÆ. Base monocyclic. Basals unequal. Neither anal nor interradial plates touching the basals. First radials extremely large, forming with the basals almost the whole dorsal aspect of the calyx. Second radial small and short, and likewise the higher orders of radials, which in place of being connected by interradials, are formed into lateral branches or free appendages. Interradials three at least, generally more; all located more or less ventrally. The lower range contains no special anal plate. It consists of from three to five pieces, transversely arranged; the middle one larger, resting upon the sloping upper ends of two first radials; the outer ones abutting against the large primary and smaller succeeding radials. Oral piece large, generally surrounded by proximals, which are very prominent. Covering plates frequently exposed upon the surface. Anus subcentral. Column circular or oval.

G. HEXACRINIDÆ. Base monocyclic. Basals 2 or 3. First anal plate resting on basals, and similar in form to first radials; other plates arranged as in Platycrinidæ. Calyx with similar arm-like extensions. Column circular.

H. ACROCRINIDÆ. Base monocyclic. Basals 2, separated from the radials by a wide belt of small plates, which are arranged in rings around the basals, and occupy the greater part of the dorsal side. Radials 3×5, increasing in size upwards, all isolated laterally. Interradials in two rows; two plates in the lower series, one only in the upper, but the latter larger than the two others. Azygous interradius comparatively much wider, and composed of twice the number of pieces, in addition to the anal plates which form a vertical line. Column circular.

I. BARRANDEOCRINIDÆ. Base monocyclic. Basals 3. First anal plate resting on basals; the interradials upon the sloping upper sides of the first radials. Arms recumbent; united laterally by their pinnules, and together with these forming a solid integument around the calyx. Column circular, large.

J. EUCALYPTOCRINIDÆ. Base monocyclic. The dorsal side uniformly composed of 4 basals, 3×5 primary radials, 2×10 secondary radials, 3×5 interradials, and 1×5 interaxillaries, there being no anal plates. The ventral side consists of 5 large interradials, 5 similar interaxillaries, and 10 small trigonal interbrachial pieces, which form a ring around the dorsal cup, and are succeeded by the summit plates. The summit plates form a neck-like prolongation. They consist of 4 large proximals which constitute a ring by themselves, of two small proximals, and the oral plate. The latter is bisected and pushed to opposite sides by the anal opening, which is strictly central. The plates of the ventral side are formed into 10 compartments for the reception of ten pairs of arms. Column circular.

FAMILY I.—RETEOCRINIDÆ W. & Sp.

RETEOCRINUS Billings.

1881. W. & Sp., Rev. II., p. 191.
1883. W. & Sp., Amer. Journ. Sci., vol. xxv (April), p. 256–268.
1884. P. Herb. Carpenter, Phil. Trans. Royal Soc., Pt. III, 1883, pp. 919–933.

Syn. Glyptocrinus (in part), Miller; Journ. Cincin. Soc. Nat. Hist., vol. v, April, 1882.

Syn. Gaurocrinus Miller (in part). Ibid. vol. vi, December, 1883.

Reteocrinus is readily distinguished from the other Reteocrinidæ by its well developed underbasals, which extend beyond the limits of the column. From our former list we withdraw ***Reteocrinus Baeri***, which is a *Xenocrinus*, and *Reteocrinus* ***Richardsoni*** Wetherby, which we make the type of our new genus ***Canistrocrinus***.

One more species must be added:

*1883. **Reteocrinus magnificus** (S. A. Miller), **Gaurocrinus magnificus**, Journ. Cincin. Soc. Nat. Hist., vol. vi, p. 230, Pl. 9, fig. 2.—Hudson River gr.—Lebanon, O.

CANISTROCRINUS, nov. gen.

(κανιστρον, a willow basket; κρίνον, a lily.)

Syn. *Glyptocrinus* (in part) S. A. Miller, 1883, Journ. Cincin. Soc. Nat. Hist., vol. vi., p. 226.

Syn. *Reteocrinus* (in part) W. & Sp., Amer. Journ. Sci., vol. xxv, p. 266.

Generic Diagnosis.—In general aspect closely resembling *Reteocrinus*. The radial ridges strong, tube-like; the interradial spaces deeply depressed. Symmetry decidedly bilateral.

Underbasals perhaps indistinctly developed, more probably altogether absent. Basals five, truncated above for the reception of the lower series of interradials. Primary radials 3×5, of nearly equal size; the first and third similar in form. The ridges of the former branching downward toward the basals; those of the latter upward toward the secondary radials, which they follow until these turn into free arm-plates. Arms branching or simple; composed of single joints, which give off rather strong pinnules.

Interradial spaces composed of numerous small pieces without definite arrangement. The plates rest upon the basals, separating all five rays from the base up. With the increase of interradials and interaxillaries by age, which seems to have been going on continually in the specimen, more arm-plates, *i. e.* radials, were gradually incorporated into the calyx, involving the proximal pinnules, the plates of which are easily recognized from surrounding interradial and interaxillary pieces by being more prominent. Azygous interradius wider than the four others. It has an elevated ridge, composed of rather large anal pieces, which are longitudinally arranged and have somewhat the appearance of radials. The interaxillary areas are depressed, even deeper than the interradial ones, and they consist of similar plates. The ventral side has not been observed, but was evidently constructed as in *Xenocrinus* and *Reteocrinus*.

We place here the following species:

*1882. **Canistrocrinus Pattersoni** (S. A. Miller). **Glyptocrinus Pattersoni**, Journ. Cincin. Soc. Nat. Hist., vol. v (July). Pl. 3, figs. 2, 2 a. Ibid., vol. vi, Decbr. 1883, p. 226.—**Reteocrinus Pattersoni**, Wachs. and Sp., 1883, Amer. Journ. Sci., vol. xxv, April, 1883, p. 266. Utica Slate, Cincinnati, O.

*1880. **Canistrocrinus Richardsoni** (Wetherby). Type of the genus.—**Glyptocrinus Richardsoni**, Journ. Cincin. Soc., Nat. Hist., vol. ii, Pl. 16, figs. 1, 1 a. W. & Sp., 1881.—**Reteocrinus Richardsoni**, Rev. ii, p. 193; also Amer. Journ. Sci. vol. xxv, p. 266.—Miller, **Glyptocr. Richardsoni**, 1883, Journ. Cincin. Soc. Nat. Hist., vol. vi, p. 226. Hudson River gr., Clinton Co., O.

XENOCRINUS S. A. Miller.

(Pl. 6, fig. 2.)

1881. S. A. Miller. Journ. Cincin. Soc. Nat. Hist., vol. iv.
1881. W. and Sp. Revision ii, p. 184.
1883. W. and Sp. Amer. Journ. Sci., vol. xxv, p. 266.

Xenocrinus is closely allied to *Canistrocrinus*, from which it differs in having four in place of five basals, and a quadrangular column.

Generic Diagnosis.—Base monocyclic. Basals four, forming combined a shallow decagonal cup, which upon five of its sides supports the five radials, and alternately upon each of the five other sides a series of small interradial pieces. This arrangement gives to the basals, owing to their abnormal number, a very irregular form, no two of them being alike. The axial canal in this genus, notwithstanding it has but four basals and a quadranglar stem, is pentangular, its angles directed interradially. In all other respects, including the ventral covering, *Xenocrinus* agrees with *Reteocrinus* and *Canistrocrinus*, to which we refer for further particulars. We place in this genus also "*Glyptocrinus*" *Baeri* Meek, which we have heretofore referred to *Reteocrinus*, not knowing the construction of its basal portions. It has not only four basals, but fundamentally a quadrangular column, the more or less cylindrical outline being caused by knife-like lateral extensions along the joints; its cross-section shows the nucleus to be strictly quadrangular.

Geological Position, etc.—Hudson River group of the Ohio valley.

*1872. **Xenocrinus Baeri** (Meek). **Glyptocrinus Baeri,** Amer. Journ. Sci. iii (Ser. 3), p. 260; also 1873, Geol. Rep. Ohio, Paleont. I, p. 37, Pl. 2, fig. 1 a, b.—S. A. Miller, 1880, Journ. Cincin. Soc. Nat. Hist., vol. iii, Pl 7. fig. 4.—**Reteocrinus Baeri** W. & Sp., 1881, Revision ii, p. 193; also Amer. Journ. Sci., vol. xxv, p. 266.—**Glyptocr. Baeri** S. A. Miller, 1883, Journ. Cincin. Soc. Nat. Hist., vol. vi, p. 226.—Hudson River gr., Ohio valley.

1881. **Xenecrinus penicillus** S. A. Miller. Type of the genus. Journ. Cincin. Soc. Nat. Hist., vol. iv (April), Pl. 1, fig. 3, and ibid. July), Pl. 4, fig. 6.—Hudson River gr. Waynesville, O.

FAMILY II.—RHODOCRINIDÆ Roemer.

(Emend., Zittel; emend., W. and Sp.)

ARCHÆOCRINUS W. and Sp.

1881. W. and Sp. Revision, ii, p. 189.
1883. S. A. Miller. Journ. Cincin. Soc. Nat. Hist., vol. vi, p. 217.
Syn. *Lyriocrinus* (S. A. Miller not Hall), 1882, Journ. Cincin. Soc. Nat. Hist, vol. v.

Mr. Walter R. Billings informs us that all the species which we referred to *Archæocrinus*, possess a special anal piece placed between the interradials of the second series. In Part II, p. 190, we erroneously stated that the anal interradius could not be distinguished from the four others, and we are obliged to Mr. Billings for making this correction. We find it confirmed by some interesting specimens which we recently collected from the Trenton limestone near Knoxville, Tenn. Most of these specimens represent Miller's "*Lyriocrinus*" *sculptus*, which was supposed to come from the Niagara group, but which evidently came from a lower horizon. Our specimens were found associated with *Hybocrinus* and other characteristic *Lower* Silurian fossils. *Lyriocrinus sculptus* Miller, or, as we call it, *Archæocrinus sculptus*, is smaller than any of the Canadian species. It has but one secondary radial, and fewer and larger interradials both dorsally and ventrally, but otherwise agrees well with those types. It probably represents paleontologically a younger stage of that genus, for the arms are free from the first secondary radial. In *Lyriocrinus* the arms proceed upward in a straight line with the walls of the calyx, the arm openings are located ventrally and are arranged at nearly equal distances from each other; while in *Archæocrinus sculptus* the arms extend out laterally in the form of free appendages. In the former the interradials of the ventral side rest against the inner edges of the dorsal cup, the so-called "vault" being perfectly flat; in the latter the vault is elevated and the interradials along the ventral side are so closely intermingled with the dorsal ones, that no dividing line can be distinguished.

In *Archæocrinus desideratus*, which is a good typical form of the genus, there are twenty or more interradials beneath the horizon of the arms, and these are succeeded by a much larger number of minute pieces at the ventral side, all of which, from the basals up, decrease in size to the oral pole. There are no large plates to represent the proximal dome plates, and hence no orals if these were represented by the proximals as contended by Carpenter. The interradial and interaxillary spaces in the dome are depressed, thereby producing along the surface somewhat irregular ridges, which follow the direction of the subtegminal ambulacral tubes.

The depressed globular form and the wide interradial spaces of the calyx are characteristic features of *Archæocrinus*, which distinguish it readily from all other Silurian Rhodocrinidæ.

Some of our specimens of *Archæocrinus sculptus* have beneath the first interradial plate, resting upon the basals, two small additional plates. As these are present only in the larger specimens, and totally absent in the smaller ones, in some of them developed in a most rudimentary way, sometimes only in one or two of their rays, it is evident that they are the result of extravagant growth, and not true interradial plates. They seem to us equivalents of the small accessory pieces between basals and radials in *Acrocrinus*, in which they attain a much more profuse development, occupying the greater part of the calyx.

We note here the following additional species:

1881. **Archæocrinus desideratus** Walter R. Billings MS. (The description will appear in the Transactions of the Field Naturalist's Club of Ottawa.)

*1880. (?) **Archæocr. globularis** Nichols. and Ether., Silur. Fossils Girvan Distr., p. 329, Pl. 22, figs. 9-11.—Craighead limestone.

*1882. **Archæocrinus sculptus** (S. A. Miller), **Lyriocrinus sculptus,** Cincin. Journ. Nat. Hist., vol. v, p. 217, Pl. 3, figs. 6 a, b.—Trenton limest. Knoxville, Tenn.

Syn. **Lyriocrinus sculptilis** S. A. Miller. Name preoccupied.

RHAPHANOCRINUS nov. gen.

(*ῥάφανος*, a radish; *κρίνον*, a lily.)

Syn. *Glyptocrinus* Walcott (in part), not Hall, 1883, New Spec. of Foss. from Trenton gr. of N. York, p. 2. (Abstract from the 35th Rep. N. York State Museum Nat Hist., N. York.)

The species upon which the genus *Rhaphanocrinus* is proposed, was referred by Walcott, with some doubt, to *Glyptocrinus.* Like that genus, it has regularly arranged interradial plates, but these rest upon the truncate upper side of the basals, not upon the sloping sides of the first radials as in that genus; besides it possesses underbasals. The latter plates were not observed by Walcott; they are evidently small, and covered by the large column or hidden within the basal concavity. That underbasals were present, is clearly seen by the angular form of the first radials, and by the form, size and position of the basals.

Rhaphanocrinus is closely allied to *Archæocrinus*, from which it differs in having the arms constructed of a single series of quadrangular plates, and in having simple, in place of branching, arms. It also resembles *Dimerocrinus* in its general aspect, but is readily distinguished by the position of the interradial plates, and by having the arms constructed of a single series of plates. It differs from *Anthemocrinus*, with which it has probably the closest affinities, in the entirely distinct arm structure.

Generic Diagnosis.—Calyx short, truncate below; interradial spaces slightly depressed.

Underbasals small, not visible in a lateral view, and more or less hidden by the column. Basals large, hexagonal, the upper side truncate for the reception of the first interradials.

Primary radials 3 . . 5, large; the first and third nearly alike in form. Secondary radials two or more, quadrangular; gradually decreasing in height and passing into arm plates.

Interradials numerous: those of the ventral side smaller. Interaxillary plates few. Summit plates, and form of anus unknown.

Arms stout, long, simple; composed of a single series of quadrangular plates, which give off alternately strong pinnules. Column large; cylindrical.

The type of the genus, and only known species is:

*1883. **Rhaphanocrinus subnodosus** (Walcott), **Glyptocrinus** (?) **subnodosus**, 35th Rep. N. York State Mus. Nat. Hist., Pl. 17, fig. 3.—Trenton limest. Trenton Fall, N. Y.

LYRIOCRINUS Hall.

(W. and Sp., Revision II, p. 203.)

Not *Lyriocrinus* S. A. Miller, 1882, Journ. Cincin. Soc. Nat. Hist., vol. v, p. 217.

(?) SAGENOCRINUS Angelin, Rev. II, p. 201.

RHIPIDOCRINUS Beyrich, Rev. II, p. 205.

THYLACOCRINUS Oehlert, Rev. II, p. 207.

1879. *Thylacocr. Vanniosti* Oehlert, Extr. du Bull. Soc. Géol. de France (Ser. 3), vii, Pl. i, fig. 1; also 1882, ibid. vol. x, p. 359, fig. 1.—Devonian. St. Germain, France.

ANTHEMOCRINUS W. and Sp. Rev. ii, p. 208.

RHODOCRINUS Miller, Rev. ii, p. 209.

1882. *Rhodocr. coxanus* Worthen, Bull. i, Illinois St. Mus. Nat. Hist., p. 30; also Geol. Rep. Illinois, vii, p. 305.—Keokuk limest. Keokuk, Iowa.

OLLACRINUS Cumberland, Rev. ii, p. 213.

FAMILY III.—GLYPTASTERIDÆ W. and Sp.

PTYCHOCRINUS nov. gen.

(πτύξ a fold; κρίνον a lily).

Mr. S. A. Miller has arrayed a number of species under a proposed genus *Gaurocrinus*, which, like his *Glyptocrinus*, embraces a heterogeneous assemblage of forms. It contains species of *Reteocrinus*, *Glyptocrinus*, and a new form with good generic characters, in our opinion, for which we should be very glad to retain Miller's name, if he had not expressly taken as its type Hall's *Glyptocrinus O'Nealli*, which is a typical *Reteocrinus*. We are, therefore, obliged to adopt a new name, and propose *Ptychocrinus*, for the reception of his *Gaurocrinus splendens*, and *G. angularis*, together with Hall's *Glyptocrinus parvus*, which, evidently, according to Hall's figure (but not Meek's), has the same characters.

We cannot agree with Miller that Wetherby's *Reteocrinus gracilis*, in which ill-formed interradials separate the radials down to the base, and in which the basals are squarely truncated above and form the base of the interradial spaces, is a synonym of *Glyptocrinus angularis*, in which the "interradial spaces have a hexagonal plate resting between the upper sloping side of the first radials."

The three species differ from all established genera of this family in having their arms constructed of single joints. It might, perhaps, be doubted whether this is a good generic character, as all Crinoids with double-jointed arms are single-jointed in their younger stages; but finding three species with the same kind of arms, and these comprising the only known Lower Silurian species of this family, we are evidently justified in making it a generic distinction.

Generic Diagnosis.—In general form closely resembling *Glyptocrinus*. Radials with a fold-like, strong, tubular ridge along their median line; interradial spaces depressed.

Underbasals five, well shown in a side view. Basals five, large; all of them hexagonal. Primary radials 3 × 5; the first ones heptagonal, but the upper sloping sides facing the azygous side longer, forming a deep notch for the reception of a very large anal plate. Secondary radials three or more, which have the appearance of arm-plates, and gradually pass into free joints. They have strong arm-like pinnules, given off from alternate sides.

Interradials consisting of one plate in the first row, two in the second, and three in the third row. The azygous side wider; the first plate extending far down between the first radials, sometimes touching the basals, and there are three in place of two plates in the second series. Structure of the ventral side unknown. Column small; cylindrical.

*1879. **Ptychocrinus angularis** (Miller and Dyer), **Glyptoor. angularis**, Journ. Cincin. Soc. Nat. Hist., p. 5, Pl. 1, fig. 10.—1883, **Gaurocr. angularis** S. A. Miller, Journ. Cincin. Soc. Nat. Hist., vol. vi, p. 229.—Hudson River gr. Cincinnati, Ohio.

*1872. **Pt. parvus** (Hall), **Glyptocr. parvus**, Desc. New Crin., etc., Pl. 1, fig. 17 (without description), 24th Rep. N. Y. State Cab. Nat. Hist., p. 207, Pl. v, fig. 17; (?) Meek, 1873, Geol. Rep. Ohio, Pal. i, p. 36, Pl. 2, figs. 4 a b; (?)

S. A. Miller, 1883, Journ. Cincin. Soc. Nat. Hist., vol. vi, p. 224.—Hudson gr. Cincinnati, Ohio.

Meek's description of this species, upon which the Cincinnati paleontologists have tried to identify it, is based upon specimens which did not show its characters, and therefore cannot be relied upon. Hall's figure exhibits a well marked form, it shows plainly that it must have underbasals, and that a small anal plate extends down to the basals.

*1883. **Pt. splendens** (S. A. Miller), **Gaurocr. splendens,** Journ. Cincin. Soc. Nat. Hist., vol. vi, p. 230.—Trenton gr. Cape Girardeau, Mo.

GLYPTASTER Hall, Rev. ii, p. 193.

Additional species :—

1881. *Gl. Egani* S. A. Miller. Journ. Cincin. Soc. Nat. Hist., vol. iv (October), Pl. 6, figs. 4 a b.—Niagara gr. Chicago, Ill.

1882. *Gl. occidentalis* var. *crebescens* Hall. Eleventh Geol. Rep. Indiana, by Collett, p. 263.—Niagara gr. Waldron, Ind.

EUCRINUS Angelin, Rev. ii, p. 196.

DIMEROCRINUS Phillips, Rev. ii, p. 197.

Additional species :—

*1882. **D. waldronensis** (Miller and Dyer), **Cyathocrinus waldronensis,** Journ. Cincin. Soc. Nat. Hist., July (Abstr., p. 6), Pl. 4, fig. 9.—Niagara gr. (We have seen in the collection of Mr. Wm. Gurley, of Danville, a specimen which shows plainly the presence of dorsal interradials; and this feature, together with the double-jointed arm structure, proves, beyond doubt, that it is not a Cyathocrinoid).

LAMPTEROCRINUS Roemer, Rev. ii, p. 199.

Additional species :—

1879. (?) **L. parvus** Hall, Trans. Alb. Inst., vol. x (Abstr., p. 9).—Niagara gr. Waldron, Ind. (This may be a young specimen of **L. tennesseensis.** It apparently differs only in the much smaller size, and in having but four anal plates).

FAMILY IV.—**MELOCRINIDÆ** Roemer.

(Emend. W. and Sp.).

a. STELIDIOCRINITES.

(?) **BRIAROCRINUS** Angl., Rev. ii, p. 96.

This is one of the genera in which we cannot trace satisfactorily the family relations, being in some of the characters allied to the Ichthyocrinidæ.

STELIDIOCRINUS Angl., Rev. ii, p. 98.

Additional species:—

*1883. (?) **Stelidiocrinus argutus** (Walcott), **Glyptocrinus argutus**, 35th Rep. N. York State Cab. Nat. Hist. (Adv. Sheet, p. 1), Pl. 17, fig. 9.—Trenton limest. Trenton Falls, N. Y. This is certainly not a **Glyptocrinus**. To judge from the figure, it is closely allied to **Stelidiocrinus**, but may be the type of a new genus.

PATELLIOCRINUS Angl., Rev. ii, p. 100.

MACROSTYLOCRINUS Hall, Rev. ii, p. 102.

Additional species:—

1882. **Macrostylocr. fusibrachiatus** Ringeberg, Journ. Cincin. Soc. Nat. Hist., vol. v, p. 119, Pl. 5, fig. 4.—Niagara gr. Lockport, N. Y.

1880. **M. striatus, var. granulosus** Hall, 28th Rep. N. Y. State Cab., p. 129; also 11th Geol. Rep. Ind., p. 258.—Niagara gr. Waldron, Ind.

CENTROCRINUS W. and Sp., Rev. ii, p. 104.

b. MELOCRINITES.

GLYPTOCRINUS Hall, Rev. ii, p. 185.

1883. S. A. Miller. Journ. Cincin. Soc. Nat. Hist., vol. vi (December).
1883. W. and Sp. Amer. Journ. Sci. (April), p. 255.
1883. S. A. Miller. *Ibid.* (August), p. 105.
Not Etheridge and Nicholson, 1880, Silur. Foss. of Girvan Distr., p. 328.
Syn. *Pycnocrinus* S. A. Miller. Journ. Cincin. Soc. Nat. Hist., vol. iv.

Since the absence of underbasals is clearly proved, *Glyptocrinus* differs from *Mariacrinus* only in the number of basals, which is five in place of four. Miller has founded the genus *Pycnocrinus* upon a species which he had previously referred to *Glyptocrinus*. Through the liberality of Mr. Miller, for which we are under lasting obligations to him, we have been given the freest access to his beautiful type specimens, with liberty to use them for our descriptions. We are reluctantly compelled to say that in our opinion *Pycnocrinus* is simply a young *Glyptocrinus*. The genus was founded principally upon the absence of "secondary radials," and the arms were said "to arise free from the primary radials." This statement does not agree with our observations, as we find in two of the specimens a minute interaxillary piece, and at least one secondary radial. In the two others, which are even more immature, the third primary radials, in part, take the functions of the secondary radials, as seen by the surface ridges, which bifurcate along the middle portions of the plates. The plates succeeding them are still in a free state, and appear as arm-plates, but actually form extensions of the calyx, being not as yet connected by interradials and interaxillaries, as in the more adult specimens. A diversity in the number of secondary radials cannot be considered of generic value, at least not in a form like *Glyptocrinus*, in which, as Miller himself has shown us (Journ. Cincin. Soc., vol. vi, Pl. 11, fig. 1), the rays remain in an immature condition, more or less, even in the adult. The specimens referred to *Pycnocrinus* are so embryonic in their condition, that it would be speculation for us to assert to what species they belong, and we have concluded to leave them as doubtful species under *Glyptocrinus*.

The species now referred by us to *Glyptocrinus* have round columns, with the exception of *Glyptocrinus Fornshelli*, which Miller thinks may prove to be a distinct generic form; while those referred to *Reteocrinus*, with probably one exception, have pentagonal columns.

The species which were referred in Europe to *Glyptocrinus*, probably with the exception of *Glyptocrinus basalis* (?), belong to different genera. That species was figured without discription in Murchison's Siluria, p. 206, from a specimen with arms, and came from the Caradoc limestone. In this specimen, the plates of the calyx cannot be recognized, but the arms are those of *Glyptocrinus*. In the type specimen of McCoy, in which only the calyx is preserved, the interradials apparently touch the basals, which, if true, would exclude it from *Glyptocrinus*.

The specimens described by Nicholson and Etheridge, jun., under the name of *Glyptocr. globularis*, from the Craighead limestone and from Traive Glen. (Monogr. Silur. Foss. Girvan Distr. in Ayshire, 1880, pp. 328–30, Pl. 22, figs 9–11), probably belong to *Archæocrinus*. They evidently had underbasals, for the interradials rest upon the basals, and alternate with the first radial plates. Neither can the arms, fig. 12, on the same plate, which are composed of a double series of joints, be referred to *Glyptocrinus*.

We add the following species to our former list:

(?) 1854. **Glyptocrinus basalis** McCoy, Synops. Palaeoz. Foss., p. 57, plate I D, fig. 4, 1859, Murchison's Silur., p. 206.—Caradoc limest. Montgomeryshire, Great Britain.

1882. **G. miamiensis** S. A. Miller, Journ. Cincin. Soc. Nat. Hist., vol. 5, Pl. 1, fig. 1. Ibid., 1883, vol. vi, p. 224.—Hudson River gr. Waynesville, O.

1882. **G. sculptus** S. A. Miller, Journ., Cincin. Soc., vol. v. p. 13, Pl. 1, fig. 2; also Ibid., 1883, vol. vi, p. 224, Pl. 1, fig. 2.—Hudson River gr. Waynesville, O.

MARIACRINUS Hall, Rev. ii, p. 114.

Syn. *Compsocrinus* S. A. Miller, 1883, Journ. Cincin. Soc. Nat. Hist., vol. vi, p. 234.

Compsocrinus was described by Miller from a species which was said to possess a quadripartite base, supporting five radials and an anal plate; column quadrangular. Good specimens of "*Compsocrinus*" *Harrisi*, Miller's type, from the collection of Mr. Harris, who has the type specimens, show the number of basals to be four, as described by Miller; but the interradials at all sides rest upon the first radials, the posterior one not abutting against the basals as was asserted, and this makes *Compsocrinus* identical in structure with *Mariacrinus* as emended by us. If Miller's diagnosis had been correct, *Compsocrinus* would have been undoubtedly a good genus. Whether the column in other species of *Mariacrinus* is quadrangular, is not known.

*1881. **Mariacrinus Harrisi** (S. A. Miller), **Glyptocrinus Harrisi**. Journ. Cincin. Soc., vol. iv, Pl. 1, fig. 4.—**Compsocrinus Harrisi** Miller, Ibid., vol. vi, p. 234, Pl. 11, fig. 4.—Hudson River gr. Waynesville, O.

TECHNOCRINUS Hall, Rev. ii, p. 116.

MELOCRINUS Goldf., Rev. ii, p. 118.

1883. *M. Benedeni* (Dewalque MS.) Fraipont, Rech. sur les Crin. du Famenien de Belgique, Ann. de la Soc. géol. de Belg., Tome x, p. 60, Pl. 4, fig. 9.—Devon. superieur. Senzeille, Belgium.

1883. *M. Chapuisi* (Dewalque MS.) Fraipont, Ibid., p. 65, Pl. 5, figs. 5–7.—Devon. superieur. Senzeille, Belgium.

1882. *M. Clarkei* Williams, Proc. Acad. Nat. Sci. Phila., p. 31.—Genessee slate. Ontario Co., N. Y.

M. gerolsteinensis Steininger, 1853, Geogn. Beschreib. d. Eifel, p. 35, is not sufficiently defined for identification.

1883. *M. globosus* (Dewalque MS.) Fraipont, Rech. sur les Crin. du Famenien de Belg. Ann. Soc. géol. de Belg., Tome x, p. 61, Pl. 5, figs. 1–4.—Devon. superieur. Senzeille, Belgium.

1884. *M. inornatus* (Dewalque MS.) Fraipont, Ibid., Tome xi, p. 105, Pl. 1, fig. 1.—Devon. superieur. Frasne, Belgium.

1883. *M. Konincki* (Dewalque MS.) Fraipont, Ibid., p. 58, Pl. 4, figs. 6–8. Devon. superieur. Senzeille, Belgium.

1883. *M. mespiliformes* (Dewalque MS.) Fraipont, Ibid. p. 63, Pl. 5, figs. 8–10.—Devon. superieur. Senzeille, Belgium.

1882. *M. occidentalis* Oehlert, Bull. Soc. géol. de France (ser. 3), Tome x, p. 357, Pl. 8, fig 4.—Devon. inferieur. Near Sabré and La Flèche, France.

1883. *M. Oehlerti* W. aud Sp. *Melocrinus Verneuili* Oehlert (not W. and Sp., 1881). Described Soc. géol. de France (Ser. 3), Tome x, p. 358, Pl. 8, fig. 5.—Devon. inferieur.—Sabré, France.

1884. *M. obscurus* (Dewalque MS.) Fraipont, Ibid., vol. xi, p. 107, Pl. 1, fig. 2.—Devon. superieur. Chaud fontaine, Belg.

SCYPHOCRINUS Zenker, Rev. ii, p. 123.

(?) **HADROCRINUS** Lyon, Rev. ii, p. 222.

DOLATOCRINUS Lyon, Rev. ii, p. 124.

1884. *D. triadactylus* Barris, Proceed. Davenport. Acad. Nat. Sci., vol. iv, Pl. 2, figs 5–7.—Hamilton gr. Alpena, Mich.

1871. *D. ornatus* Meek, Proc. Acad. Nat. Sci. Phila., p. 57.—Corniferous. Columbus, O.

STEREOCRINUS Barris, Rev. ii, p. 126.

FAMILY V.—ACTINOCRINIDÆ Roemer.

a. AGARICOCRINITES.

CARPOCRINUS Müller, Rev. ii, p. 105.

NOTE.—In Rev. ii, p. 107, in place of *Carpocrinus elongatulus* read *C. elegantulus.*

(?) **LEPTOCRINUS** Angl., Icon. Crin. Suec., p. 3.

This genus was placed by Angelin under Platycrinidæ, but, if we understand the figure correctly, it is not only an Actinocrinoid, but even synonymous with *Carpocrinus*.

Additional species :—

1879. **Leptocrinus raridigitatus** Angl., Iconogr. Crin. Suec., p. 3. Pl. 20, figs. 18, 19, and Pl. 28, figs. 4, 4 a.—Upper Silurian. Gothland, Sweden.

DESMIDOCRINUS Angl., Rev. ii, p. 108.

AGARICOCRINUS Troost, Rev. ii, p. 109.

Additional species :—

1881. **A. crassus** Wetherby, Journ. Cincin. Soc. Nat. Hist., vol. v, p. 178, Pl. 5, fig. 1 a b.—Keokuk gr. Kentucky.

1881. **A. elegans** Wetherby, Journ. Cincin. Soc. Nat. Hist., vol. v, p. 179, Pl. 5, fig. 4 a b.—Keokuk gr. Kentucky.

ALLOPROSALLOCRINUS Lyon and Cass., Rev. ii, p. 113.

b. PERIECHOCRINITES.

PERIECHOCRINUS Austin, Rev. ii, p. 127.

S. A. Miller's late additions to this genus were made from natural casts, and there is the usual uncertainty as to their identification. We must consider them as doubtful species, until the external surface is known from casts or otherwise. Miller considers *Megistocrinus infelix* Winch. and Marcy, *Saccocrinus infelix* Miller, specifically distinct from *Saccocrinus Christyi* Hall, which Hall had doubted. He gives two more figures of the species, Journ. Cincin. Soc. Nat. Hist., vol. iv, Pl. 6, figs. 2 *a b*.

Additional species :—

*1881. **Periechocr. Egani?** (S. A. Miller). **Saccocrinus Egani**, Journ. Cincin. Soc. Nat. Hist., Pl. 4, figs. 4, 4 a.—Niagara gr. Chicago, Ill.

*1865. **Periechocr. necis?** (Winchel and Marcy). **Megistocrinus necis**, Memoirs Bost. Soc. Nat. Hist., i, p. 111, Pl. 2, fig. 15. S. A. Miller, **Saccocrinus necis**, Journ. Cincin. Soc. Nat. Hist., 1881, Pl. 4, figs. 3, 3 a.—Niagara gr. Chicago, Ill.

*1882. **Periechocr. pyriformis?** (S. A. Miller). **Saccocrinus pyriformis**, Journ. Cincin. Soc. Nat. Hist. (July), Pl. 3, figs. 3, 3 a.—Niagara gr. Chicago, Ill.

*1882. **Periechocr. urniformis?** (S. A. Miller). **Saccocrinus urniformis**, Journ. Cincin. Soc. Nat. Hist. (July), Pl. 4, figs. 2, 2 a.—Niagara gr. Chicago, Ill.

ABACOCRINUS Angelin, Rev. ii, p. 133.

CORYMBOCRINUS Angelin.

1878. Angelin, Iconogr. Crin. Suec., p. 18.
1879. Zittel, Handb. d. Palæontologie i, p. 373.
Syn. *Eucalyptocrinus* McCoy, 1855 (not Goldfuss).
Syn. *Clonocrinus* Quenstedt, 1876 (not Oehlert, 1879).

The genus *Corymbocrinus* was in Pt. ii erroneously referred by us to the Calyptocrinidæ. It resembles *Eucalyptocrinus* so remarkably in the construction of the calyx plates, its deep basal concavity, and the perfect symmetry that prevails throughout the interradii, that we took it to be a connecting link between Actionocrinidæ and Calyptocrinidæ, but nearer the latter through *Callicrinus*, which we thought to be intermediate between *Corymbocrinus* and *Eucalyptocrinus*. To this view even the branching arms formed no serious objection, as Angelin has figured in the

Iconographia, Pl. 9, fig. 13, a malformed specimen of *Eucalyptocrinus*, in which some of the arms divide half-way up to the top, and in a similar manner, as in *Corymbocrinus*. Prof. Lindström, of Stockholm, however, informs us that the plates along the ventral side differ essentially in the two forms, and that the genus, in his opinion, could not be arranged with the Calyptocrinidæ. The total absence of special anal plates, unites it with the Melocrinidæ, and in this we agree with Zittel, but not with Angelin, who separated *Corymbocrinus* and *Abacocrinus* from *Melocrinus*, and placed them in separate families. The two genera have a similar arm-structure, but differ essentially in the construction of the calyx, the one having a strictly pentamerous, the other a decidedly bilateral symmetry. More close are the affinities with *Polypeltes*, provided we understand that genus correctly. We are somewhat in doubt whether Quenstedt's name *Clonocrinus*, should not be adopted in place of *Corymbocrinus*, as it probably has priority, but Quenstedt gives no generic description, only mentioning the name in connection with a certain species.

Generic Diagnosis.—Calyx basin, or low cup-shaped; basal portions broadly and deeply excavated; plates of very uniform size, rather heavy, somewhat convex, rarely ornamented; symmetry regularly equilateral, except in the basals.

Basals four, unequal, forming a hollow cone, which is filled by the upper portions of the column.

Primary radials 3 × 5, all wider than high. The first plate larger than the rest, its lower (here inner) side forming a part of the basal concavity, its opposite side at right angles with the column, only a small portion curved upward. The second radials quadrangular or nearly so, much wider than high, frequently with convex lower edges, narrower than the first radials. The third radials are pentagonal. Secondary radials 2 × 2 × 5, comparatively large. Their upper series support two rows of transversely linear tertiary radials, arranged alternately like a double series of arm plates, but connected by interradial and interaxillary pieces, and hence forming parts of the body.

Arms long, bifurcating, gradually tapering to the distal ends; from their base up composed of a double series of very short but wide interlocking pieces. Pinnules long.

Interradials arranged longitudinally in rows of a single plate each. The first plate the largest in the calyx; ninesided; it extends from the upper sloping sides of the first primary radials to the first plate of the secondary radials. The second plate is much smaller, though yet comparatively large; it is hexagonal, and placed upon the first interradial and between the two secondary radials. There are two more interradial pieces above, which, like the two former, are longitudinally arranged. This arrangement is uniform in all five areas.

Interaxillary plates, one or two; the upper one cuneate, and inserted like the upper interradials between the tertiary radials. Construction of the plates of the ventral side unknown. The column is large, round, composed of low segments; articular faces provided with radiating striæ, except upon a small zone next to the periphery; central canal pentalobate.

Geological position, etc.—*Corymbocrinus* is only known from the Upper Silurian of England and Gothland.

Angelin refers to it the following species:

1840. **Corymbocr. corolliferus** Hisinger (**Cyathocr.** (?) **corolliferus**). Lethæa. Suec. Suppl. sec., p. 6, Pl. 39, fig. 3, a–e. Angelin, 1878.—**Corymbocr. corolliferus**, Iconogr. Crin. Suec., p. 18. Pl. 23, fig. 19.—Upper Silurian. Gothland, Sweden.

1878. **Corymbocr. grandis** Angelin. Iconogr. Crin. Suec., p. 18, Pl. 9, figs. 2, 3.—Upper Silurian. Gothland, Sweden.

1878. **Corymbocr. grandistellatus** Angelin. Iconogr. Crin. Suec., p. 18, Pl. 9, fig. 4, and Pl. 23, figs. 18–21.—Upper Silurian. Gothland, Sweden.

1878. **Corymbocr. laevis** Angelin. Iconogr. Crin. Suec., p. 18, Pl. 23, fig. 20.—Upper Silurian. Gothland, Sweden.

1878. **Corymbocr. Panderi** Angelin. Iconogr. Crin. Suec., p. 18, Pl. 9, fig. 5, and Pl. 23, figs. 17, 17 a, b.—Upper Silurian. Gothland, Sweden.

1855. **Corymbocr. polydactylus** McCoy (**Eucalyptocr polydactylus**). Apud. Sedgewick, Synops. Pal. Foss., p. 58, Pl. 1 D, fig. 2: also Salter, 1873; Catal., p. 120; Angelin, 1878.—**Corymbocr. polydactylus**, Iconogr. Crin. Suec., p. 18, Pl. 9, figs. 1, 6–12, and Pl. 21, fig. 17.—Upper Silurian. Gothland, Sweden.

NOTE.—It is possible that *Mariacrinus macropetalus* Hall, Paleont., N. York, vol. iii, p. 111, Pl. 3 A. fig. 1, is a *Corymbocrinus*, but it may be a *Callicrinus* in place of *Mariacrinus*, as which it was described.

(? POLYPELTES Angelin.

1878. Angelin, Iconogr. Crin. Suec., p. 27.
1879. Zittel, Handb. d. Paleont. i, p. 373.

The genus *Polypeltes* was described as being composed of "8 or more basals, 16 parabasals, 10 (?) × 1 radials (all axillary), numerous interradial and interaxillary pieces, and as having

10 × 12 primary arms." This formula was considered by Angelin and Zittel so distinct from that of any other known form, that both placed the genus in an independent family. We should follow their example, if we were satisfied as to the correctness of that description.

From the fact that Angelin gave the number of most of the above plates with doubt—he stated positively only the number of "parabasalia"—we infer that his specimens in the basal regions were not in a condition for critical examination. It is, moreover, apparent that an arrangement of plates, such as he described, is theoretically, as well as practically, impossible.

From the description it is difficult to ascertain which of the plates were intended as "basals" and which as "parabasals." In fig. 2, Pl. 9, of the Iconographia, there are represented close to the column two rings of plates; an upper or outer one, which is composed of 25 or 26 pieces, and close to the column an inner one, which, if any reliance can be placed in the figure (?), contains very nearly the same number, for the plates are represented as alternating with those of the upper ring. The former should contain the "parabasals," the latter the basals; but unfortunately the plates of both rings differ in number most conspicuously from the number attributed to "basals" and "parabasals" in the description.

Of all the plates to which the description alludes, the "ten (?) bifurcating radials" are most readily recognized, and we believe there are actually ten of these plates in the specimen. In the figure they occupy a position within the second ring, but along with other plates which are interposed between them. At the one side there is a small single piece, which we take to be an interaxillary plate; at the other are found two larger plates, evidently interradials, with possibly an additional anal piece at the posterior side. It is very probable that these 15 or 16 plates, which in groups of one, two, and three (?) are inserted laterally between the axillary radials, were taken in the description for "parabasalia," as otherwise those plates would be undescribed. If this is the case, the term has been incorrectly applied, as the name "parabasalia" has been given only to the ring of plates which lies beneath the radials, and between these and the underbasals. All plates which are laterally inserted between the radials, as in this case, are called interradials. It would be, however, equally inconsistent in principle to search for "parabasalia" among the plates of the first ring, for basals and "parabasals" are not placed beside each other, but the latter rest upon the ring of the former. We doubt if *Polypeltes* possessed any such plates as "parabasalia," at least not among the plates of these two rings. It is probable that the plates of the inner ring, like those of the outer, were partly radials and partly interradials, while the basals were hidden from view by the column. In support of this view it is well to compare the plates here exposed with those represented in allied genera.

According to description, the ten bifurcating radials are succeeded by two rows of from four to five plates, consisting of higher orders of radials; the upper series bifurcating, giving off another order of radials, and these the primary arms, which branch after becoming free. Comparing the different portions of the rays with the same parts in *Abacocrinus* and *Corymbocrinus*, we find the form of the radials, their proportionate size, and even the construction of the arms and their mode of branching, almost identical with those two forms, provided we compare the ten lower radials in *Polypeltes* with the ten rows of secondary radials in *Abacocrinus* and *Corymbocrinus*. The main difference is that the latter genus has but one bifurcation in the calyx above these plates, while the former has two, and consequently twice the number of primary arms, a difference only of specific value. From the fact that *Polypeltes* has an extra bifurcation, and twice as many primary arms as the other two genera, it might be asserted that it has exceptionally ten primary rays instead of five, and ten interradial spaces, but that is not the case. It has been stated that the ten radials are laterally disconnected, and separated on the one side by a single plate, and on the other by two larger pieces. The two larger ones are followed by numerous other plates, which, arranged in two rows, extend to the lower portions of the arms, and enclose these within the calyx, while the smaller plate at the other side stands perfectly isolated, surrounded on all sides by radials. That the former represent the plates of five interradial series, and the single piece an axillary plate, has been already stated, and this proves very clearly that *Polypeltes*, like other Crinoids, has but five main rays, that the ten axillary pieces in Angelin's figure represent 1 × 5 × 2 secondary radials, and that the specimen must have somewhere primary radials.

Beneath the interaxillary plate, the figure indicates the presence of two plates, separated laterally, which, combined, have the form and position of a bifurcating plate. That there is a mistake in the figure with regard to these plates, seems to us beyond question. There is evidently but one plate in the specimen, and this represents a primary radial, while the two plates at each side of it, as in the succeeding ring, are interradials. The figures do not extend beyond this ring, all lower plates being evidently hidden from view by the large column, and hence the exact number of primary radials and basals is not known, but this was undoubtedly similar to that of allied genera, and not so abnormal as given by Angelin.

If it has three primary radials and four basals, which seems to us most probable, and at the same time a distinct anal interradius, we should not hesitate to place *Polypeltes* as a synonym under *Abacocrinus*, while under the same conditions, but with only three basals, it agrees with *Megistocrinus*. However, should it be proved that the posterior interradius has no additional plates, but is constructed like that of the four other sides, *Polypeltes* should be placed under *Corymbocrinus*. Only a variation in the number of primary radials, if our interpretation is correct, will warrant a generic separation, but in this case the name should be changed, as it becomes meaningless.

We suggest that in *Polypeltes* (?) the basals and the greater part of the primary radials form a deep concavity, which, to a large extent, is filled by the column, as in the case of *Corymbocrinus*, *Megistocrinus* and *Eucalyptocrinus*. We found a very similar case in *Megistocrinus concavus* Wachsmuth, from Alpena, Michigan, in which the basals and first radials form the lateral walls of a deep concavity, and are entirely hidden from view. The second radials are partly exposed, and form, with adjoining pieces, a ring of twelve very even, strongly nodose plates, which consist of five radials, four regular interradials, and three anal plates. Nobody would suspect one of these specimens to be a *Megistocrinus*, unless he obtained access to the deep funnel which contains the missing plates.

We deem it unnecessary to give a special diagnosis of *Polypeltes*, as we think it will eventually be placed under *Abacocrinus* or *Corymbocrinus*. It has the same long, branching arms, composed of two series of narrow interlocking pieces, and, as in that genus, the lower portions of the arms are connected laterally for some distance by one or two rows of interbrachial pieces.

Angelin described under *Polypeltes* a single species :—

1878. ? **Polypeltes granulatus** Angelin. Iconogr. Crin. Suec., p. 27, Pl. 24, figs. 2, 3.—Upper Silurian. Gothland, Sweden.

MEGISTOCRINUS Owen and Shum., Rev. ii, p. 135.

We compared *Megistocr. ontario* Hall, and *M. depressus* Hall, with good specimens in our own cabinet and in the Canada Survey Museum, and find the former to be a young example of *M. abnormis* Lyon, the latter of *M. rugosus* Lyon and Cass.

Additional species :—

1879. **M. pileatus** S. A. Miller. Journ. Cincin. Soc. Nat. Hist. (December), Pl. 10, figs. 1 a b.—Corniferous limest. Columbus, O.—This must be closely compared with **M. rugosus** Lyon and Cass., with which it may be identical.

1885. **M. concavus** Wachsmuth. Proceed. Davenport Acad. Sci., vol. iv, p. 96, Pl. 1, figs. 5–7.—Alpena, Mich.

*1836. **M. globosus** (Phill.) **Actinocr. globosus**, Geol. Yorkshire, p. 206, Pl. 4, figs. 26–29, also McCoy, 1844, Synops. Carb. Foss. Ireland, p. 182; W. and Spr. **Rhodocr. globosus**, Rev. ii, p. 212.—Mount. limest. England.

1885. **M. nodosus**, var. **multidecoratus** Barris. Proceed. Davenport Acad. Nat. Sci., vol. iv, p. 100.—Hamilton gr. Alpena, Mich.

c. ACTINOCRINITES.

ACTINOCRINUS Miller, Rev. ii, p. 138.

Phillipsocrinus caryocrinoides McCoy, Synops. Carb. Foss. Ireland, p. 183, Pl. 26, fig. 5, is evidently an abnormal specimen of *Actinocrinus pusillus* or some other closely allied species.

Actinocr. dalyanus S. A. Miller, 1881, is a synonym of *Actinocr. proboscidialis* Hall, and it is from the Lower Burlington limestone, not from the Keokuk limestone, as supposed by Miller.

A. tholus Hall. It is possible that the form which Hall described under this name, and which we took to be a synonym of *A. glans*, is more than a mere variety. We found lately in one and the same locality numerous specimens agreeing well with Hall's description, every one having convex or even slightly nodose plates; while those of *A. glans* are generally smooth or merely convex, and the form of the body is somewhat more elongate.

Additional species :—

1860. **A. spinotentaculus** Hall, Suppl. Geol. Rep. Iowa, I, p. 86.—Lower Burlington limest.—Burlington, Iowa.

TELEIOCRINUS W. & Sp., Rev. ii, p. 146.

In the second part of the Catalogue of Amer. Pal. Foss., p. 268, Miller calls *Teleiocrinus* "a subgenus of doubtful utility." The fact is we proposed it as a full genus of the Actinocrinites and not a subgenus of *Strotocrinus*. We stated expressly, *Teleiocrinus* holds the same relation to *Actinocrinus* as *Strotocrinus* to *Physetocrinus*, which, curiously enough, are both accepted by Miller. Probably all these genera are descendants of *Actinocrinus*, and it is difficult to see how Miller can reject *Teleiocrinus* when he accepts *Strotocrinus*.

STEGANOCRINUS M. & W.., Rev. ii, p. 149.

AMPHORACRINUS Austin, Rev. ii, p. 151.

PHYSETOCRINUS M. &. W., Rev. ii, p. 155.

Additional species:—

*1881. **P. Copei** (S. A. Miller) **Actinocrinus Copei**, Jour. Cincin. Soc. Nat. Hist. (Decbr.), Pl. 7, figs. 2, 2 *a*.—This species, like all others which Miller described from New Mexico, came from the Lower Burlington limestone, and not from the Keokuk group.—Lake Valley, New Mexico.

STROTOCRINUS M. & W., Rev. ii, p. 158.

GENNÆOCRINUS W. & Sp., Rev. ii, p. 160.

d. BATOCRINITES.

BATOCRINUS Casseday, Rev. ii, p. 162.

Additional species:—

*1859. **B. grandis** (Lyon), **Actinocrinus grandis**, Amer. Journ. Sci., vol xxviii (September), p. 240.—Keokuk limest. Kentucky and Tennessee.—In the original description of this species, by mistake of the printer, the specific name was omitted. Lyon evidently intended to name the species **Act. grandis**, as that name is mentioned at the end of the description in discussing the geological position. We adopt this specific name, but place the species under **Batocrinus**. It has two arms extended from each arm base, a character only found among the Batocrinites.

ERETMOCRINUS Lyon & Cass.. Rev. ii, p. 170.

Additional species:—

E. varsoviensis Worthen, 1882, Bull. i, Illinois State Mus. Nat. Hist.. p. 30, and Geol. Rep. Ills., vol. vii, p. 306, Pl. 28, fig. 14. This species is synonymous with **E. originarius** W. & Sp.

DORYCRINUS Roemer, Rev. ii, p. 176.

Additional species:—

D. lineatus S. A. Miller, 1881, Journ. Cincin. Soc. Nat. Hist. (December), Pl. 7, figs. 3, 3 a, from New Mexico, is specifically identical with **D. unicornis** (O. & Shum.).

FAMILY VI.—**PLATYCRINIDÆ** Roemer.

(Emend. W. & Sp.).

CULICOCRINUS Joh. Müller, Rev. ii, p. 61.

This genus is known only from casts, and reasonable doubts may be entertained as to the correctness of Müller's figures. That the whole ventral side had been covered by only five plates, as described by Müller, seemed to us not very probable, and we suggested in our description that perhaps it had been composed of eight pieces: a central plate, 6 proximals and an anal piece, of which the sutures had been obliterated. Of late, however, we are inclined to abandon this view, as the plates in question are too large to be proximals, neither can they be orals, for the larger plate is pierced by the anal opening. It seems to us *Culicocrinus* represents morphologically a still lower form than even *Coccocrinus*, that its ambulacra were subtegminal, and probably also the oral piece, unless this is represented by the tubercle in the larger plate.

COCCOCRINUS Joh. Müller. Rev. ii, p. 58.

(Revised).

In our generic description it was incorrectly stated that *Coccocrinus* had but a simple interradial to each side. This was partly due to a misunderstanding of the plates. The first range consists of three pieces, as clearly shown in *Coccocrinus bacca* Rœmer (Silur. Fauna West Tenn., Pl. 4, fig. 5 c). The middle plate, the one we described, rests within the notch of two first radials, the other two against the upper face of one of them, and against the second and third radials. A fourth plate, which we previously described as an oral plate, but which we regard now a secondary interradial, abuts against the upper faces of the three former. The plates of adjoining interradii do not touch laterally, but are separated by a very regular linear cleft, which extends all the way from the central gap to the arm furrows. There are nowhere traces of ambulacra, which were probably hidden within the clefts, and partly covered by the interradials, instead of being placed, as we had supposed, on a level with them. A similar position was probably occupied by the central plate, which, in our opinion, formed the bottom part of the central space.

We have but little doubt that the conditions of *Coccocrinus rosaceus* were essentially the same as those of *C. bacca;* in the former, however, the outer interradials were not preserved, having been probably extended out to the free rays, as, more or less, in the case of all discoid species of *Platycrinus*. That they were present is indicated by the irregular width of the lateral clefts, which, as seen in the specimens, suddenly widen on approaching the arm bases, while they should rather grow narrower if representing the clefts between the orals in *Holopus*, as which they were regarded by Carpenter.

CORDYLOCRINUS Angelin, Rev. ii, p. 60.

MARSUPIOCRINUS Phillips, Rev. ii, p. 62.

Additional species :—

*1875. **M. præmaturus** (Hall), **Platycrinus præmaturus**, Geol. Rep. Ohio, Palæont. ii, p. 124, Pl. 6, figs. 3–6.—Niagara gr. Green Co., O.

PLATYCRINUS Miller, Rev. ii, p. 65.

Pl. discoideus Hall, 1858, not Owen and Shumard, 1850. = *Eucladocrinus pleuroviminus* White.

Additional species not noted before :—

1882. **P. monrœnsis** Worthen, Bull. i, Ill. State Mus. Nat. Hist., p. 30; also Geol. Rep. Ills. vii, p. 306, Pl. 30, fig. 9.—St. Louis limest. Monroe Co., Ill.—We have but little doubt that Prof. Worthen described here a young specimen of **P. bonœnsis** White.

1838. **Pl. coronatus** Goldfuss, Nova Acta, Leop. xix, i, p. 344, Pl. 31, fig. 8.—Carboniferous. Bristol, Engl.

Pl. bloomfieldensis S. A. Miller, syn. of **Platycrinus planus** O. and Shum.

Pl. poculum S. A. Miller. Too imperfect for identification.

Pl. vesiculus McCoy, Rev. ii, p. 76, read **Pl. vesiculosus**.

Pl. præmaturus Hall & Whitf. = **Marsupiocrinus præmaturus**.

EUCLADOCRINUS Meek, Rev. ii, p. 76.

COTYLEDONOCRINUS Cass and Lyon, Rev. ii, p. 77.

FAMILY VII.—HEXACRINIDÆ W. and Sp.

HEXACRINUS Austin. Rev. ii, p. 78.

Additional species :—

1884. **H. minor** (Dewalque MS.), Fraipont, Extrait des Ann. de la Soc. géol. de Belg., Tome xi. p. 110, Pl. 1, figs. 4 a and 4 b.—Devon. superieur. Senzeille, Belgium.

1884. **H. verucosus** (Dewalque MS.), Fraipont, Ibid., p. 108, Pl. 1, fig. 3.—Devon. superieur. Senzeille, Belgium.

1882. **H. Wachsmuthi** Oehlert, Bull. géol. de France (Ser. 3), Tome x. p. 355, Pl. 8, fig. 3.—Devon. inferieur. Sabré and La Fleche, France.

ARTHROACANTHA Williams.

1883. Williams, Proc. Am. Phil. Soc. (April), p. 84.
Syn. *Hystricrinus* Hinde, 1885, Ann. and Mag. Nat. Hist. (March), p. 158.

Prof. Williams proposed the name *Arthroacantha* in 1883, for a Crinoid of the *Hexacrinus* type with movable spines, of which he described and figured one species, *A. Ithacensis*, from the Chemung of New York. He also defined the characters of another species, from the Hamilton group, which had been named by Hall as *Platycrinus punctobrachiatus*, but not defined by him, except through the medium of a photograph privately distributed. To the latter species Williams gave the name *Arthroacantha punctobrachiata*.

In 1885, Dr. Hinde (Ann. and Mag. Nat. Hist., p. 158), proposed the name *Hystricrinus* for the genus defined by Williams, and described and figured a species, *H. Carpenteri*, from specimens derived from the Hamilton group of Ontario, Canada. He states that eminent authorities decided Williams' name to be invalid, by reason of its similarity to *Arthracanthus*, previously employed by Schmarda for a genus of Rotatoria. Examination of the question in the light of the Rules of the British Association, adopted in 1865, has led us to the conclusion that *Arthroacantha*, however injudiciously chosen to designate a genus of Crinoid, will have to stand. The tenth Rule (Am. Jour. Sci., July, 1869, p. 101) says: "A name should be changed which has before been proposed for some other genus in zoölogy or botany." It is evident from this that a proposed name may be ignored on account of identity with a prior name, but not by reason of mere similarity or resemblance in form, however close. It is the word itself which determines its standing, and not its signification or derivation. The question is one of authority, and not of propriety or expediency, and it will be seen that the committee who reported the above-mentioned rule to the British Associaton, took the same view as to its effect that we do (Am. Journ., July, 1869, p. 107). *Arthroacantha* is a different word from *Arthracanthus*, although of the same etymology. and of similar construction, and there are other names of recognized standing in natural history, which bear a closer resemblance to prior names than this.

Another bibliographic question arises as to the species of this genus. Hall made a good figure of the type, which he called *Pl. punctobrachiatus*, but his plates were not published. Williams, however, when establishing the genus gave a brief but very clear definition of the characters of Hall's type specimen (Proc. Am. Phil. Soc., 1883, p. 83), and proposed for it the name *Arthroacantha punctobrachiata*. On p. 86 he again defined its principal characters by comparison with *A. ithacensis*. The "definition" necessary to impart authority to a published zoölogical term implies a "distinct exposition of essential characters." (See Committee's Report on Rule 12, Am. Journ., 1869, p. 102.) This was given by Williams far better than has been done in a great many specific descriptions of well known Crinoids. It is our opinion, therefore, that *A. punctobrachiata* is a good species, and that it must be credited to Williams. Whether Hinde's species is identical with *A. punctobrachiata* we cannot undertake to determine without more direct comparison of specimens. We have examined specimens from the Hamilton group of Ontario, Canada, which undoubtedly belong to *A. punctobrachiata*, and it is not improbable that *A. Carpenteri* may prove to be the same thing.

Arthroacantha is closely allied to *Hexacrinus*, from which it differs in having three primary radials instead of two, and movable spines along the surface of the plates. That the spines, which are frequently found in close proximity to the plates, are not mere broken parts of the plates, but constitute independent structures, is clearly seen from Prof. Williams' specimens, which he was good enough to send us for examination. The nature of the spines was disclosed to us more satisfactorily in specimens of *A. punctobrachiata* from the Hamilton of Canada, in which not only the calyx, but also portions of the arms were preserved, and in which numerous detached spines lie upon the surface of the plates close to the tubercles from which they had been detached. That these spines, to some extent, were movable, is more than probable. They were evidently connected with the plates by elastic ligament, so as to yield when accidentally brought in contact with other objects, like the joints in a column, but we doubt if beyond this they represent, either functionally or structurally, the spines of the Echini.

These views differ somewhat from those held by Williams, who thinks it "not improbable that the original plates of *Lepidocentrus eifelianus*, described and figured by Johannes Müller, which were detached plates, associated with spines similar in nature to those just described and borne upon similar tubercles, were plates from the vault of a true Crinoid like *Arthroacantha*." And he remarks further, "we have here a possible clue to a relationship between true Crinoids and Perischœchinidæ.

There is in our opinion not the slightest doubt but that Müller's figures represent Echinoid plates, and that the spines which were found associated with them had the same functions as those of the true Urchins of later epochs; but we think that the spines of *Arthroacantha* form component parts of the plates taken separately, and as such we regard them as representing in a modified way the ordinary undivided spiniferous plates of other Crinoids. For this reason we cannot regard the movable spines of *Arthroacantha* of much more than of specific importance, but as the species also possess an additional primary radial, it may be well to separate them generically from species of *Hexacrinus* which do not have them. We allude to this more particularly, as Williams and also Hinde, was inclined to regard *Arthroacantha* as the type of a distinct family, a distinction, which, in our opinion, gives to the movability of the spines a degree of importance which it does from a morphological standpoint not deserve.

We also doubt if (?) *Arthroacantha Carpenteri* had whorls of cirrhi throughout the column, as supposed by Hinde. The columnar fragments which he figured on Pl. 4—if they belong to this species at all—evidently formed the lower portions of the stem, as shown by the size and the irregular arrangement of their branches, and as such are regarded by us merely as radicular cirrhi.

Generic Diagnosis.—In form and arrangement of plates closely allied to *Hexacrinus*. All plates of the dorsal cup, the arm plates, and all interradial and summit plates, covered with numerous, irregularly arranged tubercles, provided centrally with a small pit for the reception of a long acicular spine.

Basals three, large, pentagonal. Primary radials 3 × 5; the lower one very large; the two upper ones small.

The anal plate has nearly form and size of the first radials, and occupies a similar position. The interradials are numerous and either cover the ambulacra completely, or open out to expose the covering plates. All plates of the calyx, dorsally and ventrally, except the basals, are provided with one or more movable spines, also the oral plate and proximals, but not the covering pieces, which, however, as stated, are not always exposed. Anus subcentral.

Arms two from each ray, simple or branching, and giving off slender pinnules from each joint. The proximal arm plates are composed of single cuneiform pieces, but these gradually interlock and turn into two series of alternate plates. Column round.

Geological position, etc.—Arthroacantha has been found in the upper part of the Devonian, and of America only.

1883. **Arthroacantha ithacensis** Williams, Type of the genus. Amer. Philos. Soc., April, p. 83, with figures.—Hamilton gr. Near Ithaca, N. Y.

1882. **A. punctobrachiata** Williams, Trans. Amer. Phil. Soc. (April), pp. 83 and 86 (figured by Hall as **Platycrinus punctobrachiatus**).—Hamilton gr. Ontario, Can.

*1885. **A. Carpenteri** (?) Hinde (**Hystricrinus Carpenteri**), Ann. and Mag. Nat. Hist. (March), p. 162, Pl. 4.—Hamilton gr. Ancona, Ontario, Can. (Probably a *Syn.* of **Arthroacantha punctobrachiata** Williams.

DICHOCRINUS Münster, Rev. ii, p. 81.

Additional species :—

1860. **D. lachrymosus** Hall, Suppl. Geol. Rep. Iowa by Hall, p. 84.—Upper Burlington limest. Burlington, Iowa.—This species was erroneously referred by us to **Platycrinus**, and was said to be synonymous with **Pl. subspinulosus**, with which it agrees in the ornamentation of the plates. Fine specimens which we obtained lately, have convinced us that it is a **Dichocrinus**, and was correctly separated by Hall. It has a comparatively large number of interradial plates, a very conspicuous oral, and six large proximal plates. The anal aperture is lateral, somewhat protruding, placed at the upper edge of one of the first interradials, which is somewhat excavated. The radial dome plates are composed of small alternate pieces which we followed up to the second bifurcation of the ray. Arms given off from the third secondary radials, whence they branch once or twice again, always from the third plate.

D. coxanus Worthen, 1882, Bull. i, Illinois State Mus., p. 35, and Geol. Rep. Ill., vol. vii, p. 313, Pl. 27, fig. 7, we take to be a mere synonym of **Dichocrinus ficus.**

1882. **D. hamiltonensis** Worthen, Bull. i, Ill. State Mus. Nat. Hist., p. 35; also Geol. Rep. Ill., vol. vii, p. 313, Pl. 27, fig. 10.—Keokuk limest. Hamilton, Ill.

TALAROCRINUS W. & Sp., Rev. ii, p. 85.

Additional species:—

1882. **T. ovatus** Worthen, Bull. i, Illinois State Mus. Nat. Hist., p. 36; also Geol. Rep. Ill., vii, p. 314, Pl. 19, fig. 11.—Kaskaskia, gr. Monroe Co., Ill.

PTEROTOCRINUS Lyon & Cass., Rev. ii, p. 87.

FAMILY VIII.—ACROCRINIDÆ W. and Sp.

The Acrocrinidæ, so far as known, are represented by a single genus, and of this only three species have been described, two from the Chester (Kaskaskia) limestone, and one from the coal measures of America.

No attempt has ever been made to assign the genus *Acrocrinus* to its proper systematic position. Zittel and De Loriol in their classifications omit it entirely, and the descriptions by Yandell and Hall, which were from imperfect specimens, are indistinct and partly incorrect. Thanks to the kindness of Prof. Worthen, we have been able to examine a very perfect specimen of an undescribed species, which one of us described for volume vii of the Illinois Geological Report, and of which preliminary descriptions were published in Bulletin I, of the Illinois State Museum of Nat. Hist., p. 41. The specimen shows plainly that the base is bipartite, as Hall suspected, and not undivided, as stated by Yandell. Fortunately the other plates of the calyx were also in place, and in a condition to be critically examined.

Acrocrinus departs from most Palæocrinoidea in two important particulars, and upon these, mainly, the present family is founded. First: The plates of the calyx, which in all other species with large numbers of plates decrease in size from the basals to the arm bases, in *Acrocrinus* exhibit a decided increase in the same direction. Second: The radials are not connected with the basals, but separated from them by several rings of plates, which in position are partly radial, partly interradial, and which apparently are not represented in other genera of the Palæocrinoidea. This peculiar structure renders it exceedingly difficult in this form to identify even those elements which are so readily recognized in other genera.

In *Acrocrinus Wortheni* Wachsmuth, the comparatively large basals are succeeded by a ring of twelve triangular plates, so minute, however, that it requires a magnifier to discover them. Another series of twelve larger plates constitutes the second ring. These plates are joined by their lateral edges, their lower angles resting between the preceding plates. Five of them have a radial direction, seven are placed interradially, one opposite each of the four regular interradial sides, three facing the anal side. Ten of the plates are hexagonal; only the middle one on the azygous side, and the plate which is directed to the anterior ray, are heptagonal. The two latter plates have truncate upper sides, which support, respectively, a vertical row of four very similar hexagonal pieces; one of them is interradial, and succeeded by anal plates, the other strictly radial.

The third ring consists of fourteen plates, larger than those of the preceding one. They are not so regularly arranged, and more variable in their size and form. Twelve of them alternate with the plates of the second ring, while the other two rest upon the truncate upper side of the heptagonal pieces just described. By this arrangement (see diagram, Pl. 9, fig. 1), the plate toward the anterior ray is the only plate in this ring which has a radial position, all others being located interradially, two to each of the four regular interradial sides, four to the azygous side.

The plates of the fourth ring differ considerably in form and size, and their whole arrangement is irregular throughout. They are sixteen in number, five radial in position, five directed to the anal side, one to each side adjoining the anterior ray, and two to each of the other two interradial sides.

Above the fourth ring, the plates are readily recognized as radials and interradials. In the specimen there are 2 × 5 radials, and the interradials consist of three to each of the four regular sides, and eight on the azygous side. The two radials connect with the radial plates of the fourth ring only in the anterior ray, in the four other rays they are separated from that ring by two interradial pieces, which join underneath.

In the original description of *Acrocrinus Wortheni*, the plates of the fourth ring were included with the radials and interradials, and the number of the former was given at three in the four lateral rays, and four in the anterior ray, the number of interradials at six to seven, with eighteen anal pieces.

In this formula, the so-called first radials in four of the rays are laterally separated from the rest by intervening interradial pieces, a very uncommon but not altogether unprecedented occurrence among Palæocrinoids. In *Periechocrinus* the radials are not unfrequently found connected by their angles only, and sometimes, but exceptionally, one of them is altogether separated from the rest by intervening interradial plates. Such a feature, thus widely departing from the usual mode of occurrence, may in certain cases become a fixed and constant character, but it must not be overlooked, that by admitting the plates of this upper ring as radials, it becomes imperative to extend the term radials to every radial plate below, as each one of them is separated from the preceding plate in a like manner. This would increase the number of radials in *Acrocrinus Wortheni* to five (there was evidently a small bifurcating piece filling the concavity of the upper plate) in the lateral rays, and six in the anterior ray, a comparatively small number to what we must expect to find in *Acrocrinus Shumardi*, if we adopt the above interpretation for these plates.

Through the kindness of Prof. Whitfield, we recently had an opportunity to examine three specimens of the latter species from the Museum of Natural History of New York, which have afforded us additional information upon this interesting genus.

Acrocrinus Shumardi is much larger than *Acrocr. Wortheni*, and the calyx is composed of six to seven hundred pieces, while in the latter it has less than one hundred. There are two large basals; two contiguous radials, the lower one small, pentagonal, the other hexagonal with excavated upper side; three interradial pieces arranged as in the preceding species, the larger one resting between both radials of adjoining rays, the two lower ones abutting against the lower sloping sides of the second radials. The above radials and interradials are distinctly separated from the basals by a belt of small hexagonal pieces, which in position are partly radial, partly interradial. They are arranged alternately in rows, those of each successive series comparatively larger; but, while in *A. Wortheni* there are only four rings of from 12 to 14 pieces, Yandell's species has 14 to 20 rings, more or less, and 25 to 30 or more plates in each ring. Counting as before all plates which are radial in position as radials, and all intermediate plates as interradials, the species possesses 12 and more radials to the ray, and 100 and more plates in each interradial space—an enormous increase over the plates in *Acrocr. Wortheni.* Such a wide difference in the number of interradial plates among species of the same genus is certainly very remarkable, but might be accounted for, as this class of plates is subject to great variation; but a numerical difference in the primary radials, if such was the case, would be exceptional. The primary radials are elements which, once developed, do not multiply, but their number is constant throughout the genus, and we doubt if *Acrocrinus* forms such a remarkable exception to the rule. It seems to us more probable that only the two large, contiguous upper plates, and the small triangular bifurcating piece succeeding them, are radials, that only the three intervening pieces in a lateral direction are true interradials, and that all lower plates, from the basals up, are merely accessory pieces, which obtained their position, whether radial or interradial, accidentally through their alternate arrangement, and the regularity with which they are distributed. By this interpretation the two species, which appeared to be so widely distinct, are brought within the limits of the same rule—both having the same number of radials, interradials and anal plates. It is true that accessory pieces like these are not found dorsally in any other genus of the Palæocrinoidea, but they are not uncommon among Cystideans, and similar plates occur ventrally in some of the larger Actinocrinidæ and Rhodocrinidæ, which, like those of the calyx, increase numerically by age, being represented sometimes by a single ring, and again, in the same species, by a wide belt of pieces. The accessory pieces in *Acrocrinus* increased in number by adding constantly new rings above the basals. This is well shown by the small specimen of *Acrocrinus Wortheni*, in which the plates of the latest ring are yet triangular, only the upper portion being developed; and it is further indicated by the increase in the size of the plates, which is in an upward direction.

In two of the New York specimens, the arms are partly preserved, and in the third one also portions of the vault. *Acrocrinus* had a third primary radial, which had not been observed in *Acrocrinus Wortheni.* It is triangular and resembles the small second radials of *Platycrinus*, resting like those within the concavity of the larger plate. There are also secondary radials, but these extend into free rays.

ACROCRINUS Yandell.

1855. Yandell, Amer. Journ. Sci. and Arts, vol. xx (new ser.), p, 135.
1858. Hall, Geol. Rep. Iowa i, Pl. ii, p. 689.
1882. Wachsmuth, Bull. i, Illinois St. Mus. Nat. Hist., p. 41.

Revised Generic Diagnosis.—Calyx goblet-cup or urn-shaped; composed of a large number of plates, which increase in size gradually from the basals up; plates thin and without ornamentation.

Basals two, comparatively large, either formed into a cup, or thickened at the lower side and extended into a rim: sometimes depressed and in form of a disk. The two plates are about equal, their suture running from the anterior to the posterior side; the upper side not excavated.

Primary radials 3 × 5, separated from the basals by a belt of numerous, small hexagonal pieces, arranged alternately in rows, those of each succeeding series comparatively larger. The first plate pentagonal, resting with the lower angles between the interradial plates of adjoining fields, the upper side supporting a second radial. Second radials hexagonal, more than twice as large as the first, especially much wider. They abut by their lower sloping sides against the upper interradials, and their lateral faces rest against corresponding plates of adjoining rays, except toward the posterior side, where an anal plate intervenes. Their upper sides are truncate and somewhat excavated. The third radials are axillary, very small, triangular, sometimes but partly occupying the concavity of the preceding plate. The higher orders of radials, so far as known, are extended into free rays as in *Platycrinus*. There are 2 × 2 × 5 secondary radials, which rest obliquely against the sloping sides of the triangular piece. They are short but wide; their inner sides connected by a suture, the outer side partly placed against a second primary radial, filling part of its concavity, and partly extended beyond it. In *Acrocr. Shumardi*, the outer pair of secondary radials gives off an arm; the inner division bifurcates again at the second plate, and supports 2 × 2 tertiary radials with an arm each, thus giving three arms to each main division, and six to the entire ray. The arm formula, however, may vary in other species.

Arms long, of nearly equal thickness throughout their length. They are composed of two series of very short pieces, alternately arranged. Ventral furrow wide and deep. Pinnules long, closely packed together, composed of six to seven joints, three times longer than wide.

Interradials three, in two series; the first series composed of two plates, which rest upon the belt of the supplementary intervening pieces already described, and between the sloping sides of the second radials. The second series consists of a single piece, placed between the upper sloping sides of the first radials, and the lower sloping sides of the second radials. The azygous side is known only in *A. Wortheni.* In that species it is composed of two hexagonal anal plates, resting upon a row of similar pieces, which, like those, are longitudinally arranged. The upper anal plate is placed in line with the second primary radials, and is higher, but not quite so wide; the second plate is somewhat smaller. At each side of the anal plates there are three interradials, which are formed and arranged like those of the four other sides.

The ventral covering is but imperfectly known; we only observed numerous thin, very minute, irregular pieces, with an elevation toward each ray. Position and form of the anus unknown.

Column round. somewhat tapering downward. composed of thin joints; central canal small.

Geological Position, etc.—Acrocrinus is the last and only surviving genus of the Camarata at the close of the subcarboniferous. It has been found only in the Mississippi valley, where it is exceedingly rare.

1855. **A. Shumardi** Yandell. Type of the genus, Amer. Journ. Sci. and Arts, vol. xx (new ser.), p. 135 with figure. (It was previously figured without description or name by Yandell and Shumard, 1847, in their Contrib. Geol. Kentucky, Pl. 1, fig. 3).—Chester or Kaskaskia limest. Grayson Co., Ky.

1858. **A. urnæformis** Hall. Geol. Rep. Iowa. i, Pl. ii. p. 690, Pl. 25, fig. 11 a, b.—Chester or Kaskaskia limest. Pope Co., Ill.

1882. **A. Wortheni** Wachsmuth. Bull. i. Ill. St. Mus. Nat. Hist., p. 41; also Geol. Rep. Ill., vii, p. 343, Pl. 30, fig. 13.—Coal measures. Peoria Co., Ill.

FAMILY IX.—BARRANDEOCRINIDÆ Angl.

BARRANDEOCRINUS Angl.

This is one of the most remarkable forms of the Palæocrinoidea. Looking at a perfect specimen with all its arms intact, it superficially resembles a Blastoid. However, with the arms removed, it is found to possess all the essential characters of the Actinocrinidæ, and doubts might be entertained whether it should not be grouped with that family. Angelin and Zittel have made it the type of a distinct family, and we think the peculiar construction of the arms and ventral side fully justifies this separation. The arms of *Barrandeocrinus*, if we correctly understand the figures, were permanently in a recumbent state or moved with great difficulty; they were laterally connected at the tips of their pinnules, at least those of the same ray, and could not be closed in the usual way.

Generic Diagnosis.—In its general outline, with the arms attached, resembling a Blastoid; form globose; calyx, without arms, cup-shaped. Arms arranged in pairs; recumbent; their dorsal side directed toward the calyx, the ventral side exposed to view. They are united laterally by the tips of their pinnules so as to completely cover the calyx, and extend beyond it to the upper part of the column, which is somewhat indented for their reception.

Basals three, equal. Primary radials (?) 3 × 5,[1] the first considerably larger. The axillary radials support at each upper side a single rather large secondary radial, and these support an arm each. Interradials arranged as in the Actinocrinidæ; the four regular sides, up to the arms, consisting of only one plate, which rests upon the first radials. The axygous side has two large anal plates; the lower one meeting the basals, the other placed between the interradial which is bisected for its reception. These are succeeded by three much smaller and elongate interradial plates, and a similar number of interaxillary pieces of exactly the same form and arrangement as the three interradial ones. Ventral surface deeply depressed along interradial and interaxillary spaces, the depressions which grow deeper toward the equatorial zone alternating with ten flattened ridges which led to the ten arms.

Arms heavy; composed of a single row of closely set, quad-

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[1] Angelin states that the number of radials is 2 × 5, while Zittel gives it as 3 × 5. In Angelin's figure, Icon. Suec., Pl. v, figs. 6, 6 a, there appear to be but two primary radials, the second plate being axillary. But in the specimens represented on Pl. iv., fig. 5 a, and Pl. xxii, fig. 3, three of them are visible, arranged as those of *Actinocrinus*. It is probable that the true number is three, and that in the first mentioned specimen the sutures between the second and third radials became obliterated by anchylosis.

rangular plates, with strong, apparently immovable pinnules, laterally connected. The arms are so closely folded together that they appear as if they were suturally connected, and formed around the calyx a solid body with ten ambulacra upon the surface.

Column stout, circular, with pentangular axial canal.

The only known species is:

1878. **Barrandeocrinus sceptrum** Angl. Icono. Crin. Suec., p. 8, Pl. 4, figs. 5, 5 a, and Pl. 5, figs. 6, 6 a, and Pl. 22, figs. 2-4.—Upper Silur. Gothland, Sweden.

FAMILY X.—CALYPTOCRINIDÆ Roemer.

Roemer, in proposing this family, used the name Eucalyptocrinidæ (Leth. Geogn., Aug. 3, 1855, p. 229), which was afterwards changed by Angelin to Calyptocrinidæ (Icon. Crin. Suec., 1879, p. 14). The latter name was accepted by Zittel, who referred to it also Lyriocrinus Hall, which we have placed under the Rhodocrinidæ.

EUCALYPTOCRINUS Goldfuss.

(HYPANTHOCRINUS Phillips.)

1826. Goldfuss. Petref. Germ., i, p. 212.
1835. Agassiz. Mem. Soc. des Sci. natur. de Neuchatel. i, p. 197.
1838. Goldfuss. Nova Acta. Leopold., xix, i, p. 335.
1841. Müller. Berl. Acad. d. Wissensch., p. 210.
1841. Hall. Paleont. N. York, ii, p. 207.
1843. Roemer. Rhein. Nebergangsgeb., p. 64.
1850. D'Orbigny. Prodr. de Paléont., i, p. 45.
1852. Quenstedt. Handb. der. Petrefactenk., p. 624.
1854. McCoy (in part). Synops. Brit. Palæoz. Fossils, p. 57.
1855. F. Roemer. Lethæa Geogn. (Ausg. 3), p. 257.
1857. Pictét. Traité de Paléont., iv, p. 367.
1860. Bronn. Klassen des Thierreichs (Actinozoa), Pl. 27.
1862. Hall. Notice of New Foss. from Waldron, p. 3.
1862. Dujardin and Dupé. Hist. natur. des Zooph. Echin., p. 115.
1865. Hall. 15th Rep. N. Y. State Cab. Nat. Hist. p. 32.
1866. Schultze. Monogr. Echin. Eifl. Kalk., p. 90.
1878. Angelin. Iconogr. Crinoid. Suec., p. 16.
1879. Hall. 28th Rep. N. Y. State Cab. Nat. Hist. (edit. ii). Pls. 16-19.
1879. Wetherby. Journ. Cincin. Soc. Nat. Hist. (April), No. 5.
1879. Zittel. Handb. der Paleont., i, p. 379.
1882. S. A. Miller. Journ. Cincin. Soc. Nat. Hist. (July).

(?) Syn. *Hypanthocrinus* Phill., 1839; Murchison's Silur. System, p. 672, Pl. 17, fig. 3; Zittel, 1879; Angelin, 1878; S. A. Miller, 1880.

There is some doubt whether *Hypanthocrinus* Phillips is a synonym of *Eucalyptocrinus* or a good genus. *Hypanthocrinus* was separated by Phillips simply upon the presence of a column, which Goldfuss thought to be absent in *Eucalyptocrinus*, but as *E. rosaceus*, his type is known to be pedunculated, this distinction fails. Angelin and Zittel, who both uphold *Hypanthocrinus*, describe the base as being less deeply funnel-shaped, the anal tube as extending beyond the arms, and the partition walls surrounding the arms as being constructed principally of a single piece. A critical comparison has convinced us that these characters are not constant throughout the species. The only character upon which a separation might possibly be effected, is the proboscis-like anal tube, but this part, unfortunately, is rarely preserved. Some of the American species with a long tube have a deep, funnel-shaped base, while in others with a simple opening, the base is comparatively shallow. In all of them the partition walls between the arms consist of two pieces, but in some species the lower one is comparatively longer than in others. We shall ignore *Hypanthocrinus* until better distinctions are given.

Eucalyptocrinus is closely allied to *Callicrinus*, from which it differs in having rudimentary partitions between the arms, extending out only a short distance, leaving the greater part of the arms free and unprotected.

Among the species that have been referred to *Eucalyptocrinus*, are several which were described from natural casts. We do not deny that their generic relations were correctly identified, nor that differences of specific value probably exist among them, but we doubt if it is possible for any one to decide from internal casts whether such specimens are specifically distinct from others in which the test is preserved, and hence consider them for the present as doubtful species.

Troost's *Eucalyptocrinus conicus*, *E. extensus*, *E. gibbosus*, *E. Goldfussi*, *E. lævis*, *E. Nashvillæ*, *E. Phillipsii* and *E. Tennesseæ*, all from the Niagara of Western Tennessee, are mere catalogue names, no descriptions having been published.

Generic Diagnosis.—When the arms are attached more or less ovoid; without arms resembling a wine bottle with concave bottom and long slender neck. The neck is surrounded by ten partitions, arranged vertically so as to form ten niches or compartments for the reception of the arms. The calyx is composed of heavy plates, is either cup- or saucer-shaped, with basal regions deeply concave, somewhat funnel-shaped. In the dorsal cup the pentamerous symmetry is interrupted by the basals only; at the ventral side, however, it is greatly disturbed. Anus central, located at the top of the neck-like prolongation, or at the end of a tube.

Basals four, small, unequal in size, one of them larger than the rest; axial canal five-rayed; its radii directed interradially, there being two of them in the larger plate. As a rule the basals are not seen externally, being placed at the upper end of the concavity, which also involves the greater part of the first radials, and frequently other plates.

Radials in three orders, the tertiary radials, however, imperfectly developed, and taking rather the form of brachials. Primary radials 3 × 5; the first one large, wider than the other two; the second quadrangular, wider than high; the third hexagonal, its upper side truncate for the reception of an interaxillary plate. Secondary radials 2 × 2 × 5, all pentangular, the lower series larger than the upper, those of the same division connected by horizontal suture. The upper secondary radial is axillary, and supports the tertiary radials, which are composed of two short transverse pieces supporting the arms.

Dorsal interradials three to each interradius, throughout the genus, in young as well as in adult specimens. The lower one is the largest plate in the calyx, and always decagonal. The two upper plates are connected by a vertical suture to their full length, and both combined are smaller than the lower one. Their upper ends form a narrow quadrangular projection, which extends to the top of the tertiary radials, and supports upon its truncate upper side the interradial partition walls. The interaxillary plates of the dorsal side consist of a single piece in each ray, placed between the secondary radials. In form and dimensions it resembles most remarkably the two upper interradial plates, its upper end projecting in a similar manner to the top of the tertiary radials, and also supporting a partition. The peculiar projections between the arm sockets give to the specimen a very marked appearance, and when the ventral side is not preserved, form a reliable guide for generic identification.

The ventral side consists of four rings of plates. The lower ring is composed of five elongate interradials, which rest upon the projecting faces of the interradials at the dorsal side. There are five interaxillary plates of a similar form, supported by the dorsal interaxillaries, and ten small triangular interbrachial pieces, interposed in such a manner between the foregoing plates that always an interradial and an interaxillary meet laterally above an interbrachial. The second and third rings consist of four plates each; the fourth of ten. The two former ones together form the neck-like prolongation of the body, and the plates of the fourth ring, combined with those of the first ring, the partition walls encasing the arms.

The interradials and interaxillaries of the first ring are uniform in size and shape; they are knife-like, their blunt sides exposed to view, their sharp edges turned inward. Toward the lower end where the plates decrease in depth, lateral flanges project out from their inner edges, which unite suturally, and enclose the visceral cavity, while the knife-like outer portions, as we understand it, are merely extraordinary protuberances, like the nodes or spines in some Actinocrinidæ, but forming by means of their connected wing-like extensions a cover or protection for the arms.

The plates of the second ring fit into the ten angles formed by the preceding plates, but do not alternate with them. Two of them are a little wider, and these are alternately arranged with the smaller ones. The two narrower plates are generally longer, angular above, while the two others are truncate, and their lateral faces slightly sloping upward. When united, they form a funnel with the narrow opening upward. Transversely they form a ring with ten protuberances, which on their outer surface represent longitudinal ridges. The ridges correspond in position with the interradial and interaxillary partition walls which overlap them, while the alternate grooves form the inner angle of the niches.

The third ring, like the second, consists of four plates, but these, as a rule, are not so large, and have a more irregular arrangement; two of them are generally shorter, and do not touch those of the preceding ring. They are provided at their outer faces with ten longitudinal ridges, which, to their full length, are overlapped by the partition walls, which extend downward from the fourth ring of plates.

The plates of the fourth ring are constructed upon a similar plan as those of the first ring. Like those, they consist of ten pieces, but they undergo more variations among species, and show more irregularities than any of the other plates. In some species they are confined almost exclusively to the upper face, being mere top pieces; in others they represent an important part in the partition walls, while in still others they extend deeply down into the tubular neck, forming the upper part of its walls. In all cases, however, their obtuse edges are turned outward, and form the upper part of the partition, being suturally connected with the lower part of them.

The plates covering the tubular neck, *i. e.*, anal plates, consist of small pieces, with a somewhat subcentral opening, or, as in *Eucalyptocrinus rigens* Angelin, of valvular plates. Sometimes they are extended into a free tube, composed of hexagonal pieces. The arrangement of the plates surrounding the anal opening is more regular than it appears from some specimens. The apparent irregularities are caused largely by the plates of the third ring, which, in some species, have their upper ends partly exposed.

The arms are arranged in pairs, each pair filling one of the ten compartments, with an interradial partition wall on one side, and an interaxillary one on the other. The arms evidently moved with difficulty, being heavy, and in the adult composed of two rows of short transverse pieces, with horizontal sutures, but there was a single row of wedge-shaped pieces in young specimens. They have a deep ventral furrow, and long pinnules composed of numerous joints, which gradually decrease in width. The arms and pinnules are so closely fitted into the partition walls, that when the arms are perfectly closed, it appears as if they were suturally connected and constituted a part of the body.

The visceral cavity actually is formed only by the plates of the dorsal cup and by the two lower rings of plates in the vault, the plates of the two upper ones forming the neck-like prolongation. The food grooves enter the calyx at the base of the arms, and proceed within shallow grooves at the inner floor to near the top of the second ring. The hydrospires evidently extended to the lower portion of the neck, and perhaps (?) communicated with the exterior through the anal aperture, as apparently no other opening except the ambulacral passages enter the body.

The column is moderately large, cylindrical, composed of rather long joints, with pentapetalous central canal. It evidently had no lateral cirrhi, except at the root, where it gives off hundreds of little rootlets, which gradually taper, spreading out horizontally.

Eucalyptocrinus is one of the most perplexing genera, especially by reason of its peculiar ventral structure. The only ventral plates about which there seems to be no doubt are those of the first ring, which have been designated by all writers as large interradials and interaxillaries, *i. e.*, interdistichalia. More dubious are those of the second ring, which partly cover the peristome. They fit with their projecting angles into the ten re-entering angles formed by the sloping sides of the preceding plates. The plates of the one ring practically alternate with those of the other, for by bisecting the two smaller plates, and dividing the larger ones into three pieces, we obtain ten nearly equal plates, alternately arranged, thus proving that the plates are not in part interaxillaries; but what are they? We doubt if they are calyx interradials; the fact that there are four plates is certainly a very serious objection. By dividing the plates among the five interradii, some of the pieces would be distributed among different areas. Another interpretation seems to us more probable, and offers at the same time an explanation of the plates in the third ring.

The proximals and the oral plate, in all Palæocrinoids with nearly central anal tube, are pushed to the anterior side, and the oral plate and the two smaller proximals constitute actually a part of the tube of which the four larger proximals form the base. We think the case is very similar in *Eucalyptocrinus*, but here, owing to the strictly central position of the anal tube, not only one of the proximals, but also the oral plate is penetrated by the anal passage, and divided into two parts. This, if correct, suggests that in *Eucalyptocrinus* the four plates of the second ring represent the four large proximals, a view which seems to be confirmed by the peculiar arrangement of the plates in the third ring, in which we consider that the two smaller ones represent the two smaller proximals, while the two larger pieces, which rest upon all plates of the second ring, are equivalent to the oral plate. This would further suggest, that the ten plates in the fourth ring are extravagantly developed anal plates.

Geological position, etc.—*Eucalyptocrinus* is one of the leading genera of the Upper Silurian, and it occurs in America and Europe. A single species is known from the Devonian.

The following species have been described :—

(?) 1865. **Eucalyptocr. chicagoensis** Winch. & Marcy. Mem. Bost. Soc. Nat. Hist., vol. i, No. 1, p. 90.—Niagara gr., Chicago, Ill. (Described from casts.)

1843. **E. cœlatus** Hall (**Hypanthocrinus cœlatus**). Geol. 4th Distr. N. Y., p. 113, fig. 1.—F. Roemer, 1855, Leth. Geogn. (Aug. 3), p. 260. **E. cœlatus** 1852, Hall, Palæont., N. Y., p. 210, Pl. 47, figs. 4 *a–c;* F. Roemer, 1868, Silur. Fauna West. Tenn., p. 48, Pl. 4, fig. 3; Hall, 1865, Trans. Alb. Inst. (Abstr., p. 32); also 20th Rep. N. Y. State Cab. Nat. Hist., pp. 321–329 (Revised Edit., pp. 363–366); 28th Rep. N. Y. State Cab. Nat. Hist., p. 142, Pl. 16, figs. 1–10, and Pl. 19, figs. 1–3; also 11th Ann. Geol. Rep. Indiana, p. 274, with plates.—Niagara gr. Lockport, N. Y.

(?) 1864. **E. cornutus** Hall. New or little known Foss. Niagara gr., p. 18; also 1865, 18th Rep. N. Y. State Cab. Nat. Hist., p. 322, Pl. 11, figs. 8–10.—Niagara gr. Waukesha and Racine, Wisc. (Described from casts.)

Var. excavatus Hall, 1864. New or little known Foss. Niagr. gr., p. 18; also 18th Rep. N. Y. State Cab. Nat. Hist., p. 322, Pl. 11, figs. 8–10.—Niagara gr. Racine, Wisc.

1879. **E. constrictus** Hall. Trans. Alb. Inst., vol. x (Abstr., p. 10); also 11th Ann. Geol. Rep. Indiana, p. 273, Pl. 15, fig. 1.—Niagara gr. Waldron, Ind.

1863. **E. crassus** Hall. Trans. Alb. Inst., vol. iv, p. 197; 18th Rep. N. Y. State Cab. Nat. Hist., p. 323, Pl. 11, figs. 2, 3 (Revised Edit., p. 365); also 28th Rep. N. Y. State Cab. Nat. Hist., p. 141, and Pl. 17, figs. 1–11, and Pl. 18, figs. 1–9; also Pl. 19, figs. 2, 4, 5; Eleventh Ann. Rep. Indiana, 1851, p. 27, Pl. 17, figs. 1–11, and Pl. 18, figs. 1–9; Geol. Surv. Ohio, Paleont., ii, p. 129, Pl. 6, fig. 11 (Green Co., O.).—Niagara gr. Waldron, Ind.

1839. **E. decorus** Phill. (**Hypanthocr. decorus**) Murch. Silur. Syst. p. 672, Pl. 17, fig. 3; also Hall, 1843, Geol. 4th Dist. N. Y., p. 113, figs. 2–3. **Eucalyptocr. decorus** Hall, 1852, Paleont. N. Y., vol. ii, p. 207, Pl. 47, figs. 1–3; and Pl. 85, fig. 7; also McCoy, Synops. Brit. Palæoz. Foss, p. 58; also F. Roemer Leth. Geogn., 1855 (Aug. 3, p. 259); Dujardin and Hupé, 1862, Hist. natur. des Zooph. Echinod., p. 116.—Rochester and Lockport, N. Y., and Dudley, Engl. (?)

1878. **E. decoratus** Angelin. Iconogr. Crin. Suec., p. 17, Pl. 5, figs. 4, 4 a.—Upper Silurian. Gothland, Sweden.

(?) 1880. **E. depressus** S. A. Miller. Journ. Cincin. Soc. Nat. Hist. (October), Pl. 7, figs. 1, 1 a.—Niagara gr. Chicago, Ill. (Described from a cast.)

(?) 1880. **E. Egani** S. A. Miller. Journ. Cincin. Soc. Nat. Hist., vol. iii, Pl. 4, fig. 1. —Niagara gr. Chicago, Ill. (Described from casts.)

1878. **E. excellentissimus** Angelin. Iconogr. Crin. Suec., p. 16, Pl. 24, fig. 15.—Upper Silurian. Gothland, Sweden.

1847. **E. granulatus** (Lewis) Morris (**Hypanthocr. granulatus**). London Geol. Journ., Part 3, p. 99, Pl. 21, figs. 1–5; also Angelin, Iconogr. Crin. Suec., 1878, p. 18, Pl. 6, figs. 3, 4; also Pl. 24, figs. 10–12; and Pl. 29, figs. 69, 70–74.—Upper Silurian. Walsall, Engl., and Gothland, Sweden.

1875. **E. magnus** Worthen. Geol. Rep. Illinois, vol. vi, p. 501, Pl. 25, fig. 3.—Niagara gr. Wayne Co., Tenn.

*1878. **E. minor** Angelin (**Hypanthocr. minor**). Iconogr. Crin. Suec., p. 17, Pl. 6, fig. 1; also pl. 24, figs. 9–13.—Upper Silurian. Gothland, Sweden.

(?) 1864. **E. obconicus** Hall. New or little known Foss. Niagr. gr., p. 19; also 1865, 18th Rep. N. Y. State Cab. Nat. Hist., p. 323, Pl. 11, fig. 1.—Niagara gr. Racine, Wisc. (Described from internal casts.)

(?) 1861. **E. ornatus** Hall. Rep. of Progress of Geol. Surv. Wisc., p. 20.—Niagara gr. Racine, Wisc. (Described from internal casts.)

1850. **E. ovalis** Troost. Proc. A. A. A. Sci., p. 60: Hall, 1876.

(**E. ovatus** Hall. Not Angelin, was printed in place of **E. ovalis.**) Doc. Edit., 1878, p. 143, Pl. 17, figs. 12, 13; also 11th Ann. Geol. Rep. Indiana, with plates.—Niagara gr. Waldron, Ind.

1878. **E. ovatus** Angelin. Iconogr. Crin. Suec., p. 17, Pl. 5, figs. 1, 2.—Upper Silurian. Gothland, Sweden.

1852. **E. papulosus** Hall. Paleont. Rep. N. York, vol. ii, p. 211, Pl. 47, figs. 5 a, b; also F. Roemer, Leth. Geogn., 1855 (Aug. 3, p. 260).—Niagara gr. Monroe Co., N. Y.

1878. **E. plebejus** Angelin. Iconogr. Crin. Suec., p. 17, Pl. 5, fig. 7.—Upper Silurian. Gothland, Sweden.

(?) 1882. **E. proboscidalis** S. A. Miller. Cincin. Jour. Nat. Hist. (December), p. 224. —Niagara gr. Pontiac, O. (Described from internal casts.)

1860. **E. ramifer** Roemer. Silur. Fauna West. Tenn., p. 51., Pl. 4, fig. 1.—Niagara gr. Decatur Co., Tenn.

*1837. **E. regularis** (Hisinger), **Actinocr. regularis.** Lethaea Suec. (Suppl. 2), p. 6, Pl. 39, fig. 6.—**Hypanthocr. regularis** Angelin, 1878, Iconogr. Crin. Suec., p. 17, Pl. 6, fig. 2; and Pl. 24, figs. 11–20; and Pl. 29, figs. 35–64. Upper Silurian. Gothland, Sweden.

1878. **E. rigens** Angelin. Iconogr. Crin. Suec., p. 17, Pl. 9, fig. 13; and Pl. 24, figs. 16–19–21; and Pl. 29, figs. 30, 31.—Upper Silurian. Gothland, Sweden.

1826. **E. rosaceus** Goldf. (Type of the genus). Petref. German. i, p. 214, Pl. 64, fig. 7; also Nov. Acta Leop. xix, p. 335, Pl. 30, fig. 6. Agassiz, 1835, Mem. des Sci. natur. de Neuchat. i, p. 197; also F. Roemer, Rhein. Nebergangsgeb., p. 64. De Koninck and Lehon, Crinoid. Carb. Belg., p. 73; also Roemer, Leth. Geogn., 1855 (Aug. 3), p. 259, Pl. 4, figs. 20 a–e, and Pl. 4, figs. 11 a–e. Dujardin and Dupé, 1862, Hist. natur. des. Zooph. Echinod., p. 116; Bronn, Klassen d. Thierreichs (Actinozoa), Pl. 27, fig. 2; Pictét, 1857, Traité de Paléont. iv, Pl. e, fig. 1; Schultze, 1866, Monogr. Echin. Eifler Kalk., p. 90, Pl. 11, figs. 1–14.—Lower Devonian. Eifel, Germany.

(?) 1882. **E. rotundus** S. A. Miller. Cincin. Journ. Nat. Hist., vol. v (July), Pl. 3, fig. 4.—Niagara gr. Chicago, Ill. (Described from casts.)

1878. **E. speciosus** Angelin, Iconogr. Crin. Suec., p. 16, Pl. 5, fig. 3, and Pl. 29, figs. 27–29 and 32–34.—Upper Silur. Gothland, Sweden.

1877. **E. splendidus** (Troost) Hall, Geol. Surv. Ohio, Paleont. ii, p. 128, Pl. 6, fig. 12. Niagara gr. Springfield, O.

(?) 1878. **E. tuberculatus** Miller and Dyer, Journ. Cincin. Soc. Nat. Hist. (April), Pl. 2, figs. 9, 9 a.—Niagara gr. Waldron, Ind.—Evidently a mere variety of **E. cœlatus** Hall.

(?) 1882. **E. turbinatus** S. A. Miller, Cincin. Journ. Nat. Hist., vol. v (July), Pl. 3, fig. 5.—Niagara gr. Chicago, Ill.—Described from internal casts.

Note.—*Eucalyptocrinus polydactylus* McCoy. is a *Corymbocrinus*, and *E. armosus* McChesney is too imperfectly known for identification.

CALLICRINUS D'Orbigny.

1850. D'Orbigny (*Calliocrinus*), Prodr. i, p. 45.
1878. Angelin (*Callicrinus*), Iconogr. Crin. Suec., p. 14.
1879. Zittel (*Callicrinus*), Handb. d. Paleont. i, p. 378.
Syn. *Eugeniacrinites* Hisinger (not Miller), 1857, Leth. Suec., p. 86.

Callicrinus (*Calliocrinus* d'Orbigny) may be considered as a transition form between *Corymbocrinus* of the Actinocrinidæ and *Eucalyptocrinus*. It possesses the structural peculiarities of the latter, but these are not so distinctly expressed, and it appears as if the genus represented an earlier phase in the development of this family. In both genera, the dorsal and ventral side is composed of plates of a similar kind and like number, and both have partitions ventrally; but, while those of *Eucalyptocrinus* surround the arms on all sides, the partitions of *Callicrinus* are rudimentary, the greater part of the arms being uninclosed.

Generic Diagnosis.—Calyx as in *Eucalyptocrinus*, extending to the tips of arms, resembling a wine bottle with long, slender neck, and deep concavity at the bottom, but the partition walls, in place of forming deep niches, consist only of braces between the arm bases, projecting out between the lower portions of the arms; not extending in height beyond the limits of the first ring of plates. Anus central. The plates are frequently ornamented, sometimes nodose, and certain plates spiniferous.

Form of calyx, number and arrangement of plates as in *Eucalyptocrinus*. Dorsal cup composed of four basals; 3 × 5 primary, 2 × 2 × 5 secondary, and 1 × 2 × 10 tertiary radials; always 3 × 5 interradials and one interaxillary. Ventral side composed of four rings of plates; the first ring containing five interradials, five interaxillaries, and ten interbrachial pieces. The interbrachials, as a rule, are somewhat larger than those of *Eucalyptocrinus*, and they are provided, like the interradials and interaxillaries, with a projecting brace, but less prominent than those of the other plates. The latter are always stronger, and sometimes extended into a long spine. The twenty braces or partition walls are arranged parallel to each other, and vertically along the median part of the plates. The second ring, if our interpretation is correct, consists of the four large proximals (compare our remarks in *Eucalyptocrinus*); the third ring of the divided oral or central plate and the two smaller proximals, which agree in their form and arrangement with those in *Eucalyptocrinus*. The plates of the fourth ring, which form the upper part of the neck, are generally composed of four plates, forming a tubular cavity, which is covered by small pieces surrounding the anal opening. There are no lateral extensions along these plates, but the upper end is frequently provided with a thickened rim, sometimes, however, extended into long spines, which are spread out horizontally.

Arms twenty, not extending beyond the top of the tubular neck; they are composed of two series of interlocking pieces, and are provided with long pinnules, composed of six or more elongate joints. The arms rest within the niches formed by the braces, the greater portion of them remaining free.

Column round, composed of rather long joints with a medium-sized, apparently circular canal.

Geological Position, etc.—*Callicrinus* has been recognized only from the Upper Silurian of Sweden; it is possible, however, that some of the casts described from the Niagara group of Wisconsin represent this genus.

1878. **Callicrinus beyrichianus** Angelin, Iconogr. Crin. Suec., p. 15, Pl. 2, fig. 6.—Upper Silurian. Gothland, Sweden.

1837. **C. costatus** (Hisinger), Eugeniacrinites (?) rostatus, Lethæa Suec., p. 90, Pl. 30, fig. 11 a b: D'Orbigny, 1850, **Calliocrinus costatus** (Type of the genus), Prodrome i, p. 15; Angelin, 1878, **Callicrinus costatus**, Iconogr. Crin. Suec., p. 15, Pl. 1, fig. 6, and Pl. 2, figs. 1–4; Pl. 21, figs. 4, 5; also Pl. 24, figs. 23–26; Pl. 28, figs. 19–22 and 24, 25; also Pl. 29, figs. 1–26 and 65–68.—Upper Silurian. Gothland, Sweden.

1878. **C. diadema** Angelin, Iconogr. Crin. Suec., p. 16, Pl. 28, figs. 27, 27 a.—Upper Silurian. Gothland, Sweden.

1878. **C. koninckianus** Angelin, Iconogr. Crin. Suec., p. 15, Pl. 1, figs. 4, 4 a, and Pl. 28, figs. 18–26.—Upper Silurian. Gothland, Sweden.

1878. **C. minor** Angelin, Iconogr. Crin. Suec., p. 16, Pl. 25, fig. 15.—Upper Silurian. Gothland, Sweden.

1878. **C. murchisonianus** Angelin, Iconogr. Crin. Suec., p. 15, Pl. 1, fig. 3, and Pl, 28, figs. 11–17.—Upper Silurian. Gothland, Sweden.

1878. **C. rœmerianus** Angelin, Iconogr. Crin. Suec., p. 15, Pl. 1, figs. 1, 2, and Pl. 28, fig. 23.—Upper Silurian. Gothland, Sweden.

1878. **C. sedgwickianus** Angelin, Iconogr. Crin. Suec., p. 15, Pl. 1, fig. 5.—Upper Silurian. Gothland, Sweden.

CORRECTIONS.

On p. 252 (Ex. Ed., p. 30), 2d line from bottom, read: "*wholly or partly*" before the word "ventrally."

On p. 268 (Ex. Ed., p. 46), 10th line from top, we stated that Prof. Zittel had been the next writer after Prof. Allman, who acknowledged the presence of orals in *Haplocrinus*, *Coccocrinus*, and the Cyathocrinidæ; we discovered however since that Dr. Carpenter already alludes to them in his paper of April, 1879, while Prof. Zittel's Handbuch der Palæontologie appeared in January, 1880.

On p. 275 (Ex. Ed., p. 53), 9th line from top, read: "*peristomeal area*" in place of "tentacular vestibule."

On p. 280 (Ex. Ed., p. 58), 2d line from bottom, after the word *Allagecrinus* insert the following: "*in which the whole ventral side were constructed of actinal plates.*"

On p. 281 (Ex. Ed., p. 59), 13th line from bottom, read: "the latter are *rarely* perforated" in place of "*not* perforated."

On p. 284 (Ex. Ed., p. 62), 16th line from bottom, in place of "and that these Crinoids possessed an orocentral nervous system like all other Echinoderms, except the Neocrinoidea, in which the nervous system, as now generally admitted, is connected with the chambered organ within the basal cavity," insert the following: "*and that perhaps in these Crinoids, contrary to others, and to the Neocrinoidea generally, the entire nervous system was located at the oral side, in conformity with other Echinoderms.*"

On p. 293 (Ex. Ed., p. 71), 4th line from bottom, in place of "were *covered*" read: "were *succeeded*."

On p. 294 (Ex. Ed., p. 72), at the top of page, we expressed our surprise that Dr. P. H. Carpenter admitted calyx interradials in *Apiocrinus roissyanus* and not in *A. Meriani*, *A. Rathieri* and *A. murchisonianus*. On pp. 149–151, and also on p. 183 in the Challenger Report, and wherever Dr. Carpenter speaks of calyx interradials in Neocrinoidea, he refers to the genera *Guettardicrinus*, *Uintacrinus* and to *Apiocrinus roissyanus*, without mentioning the three other well-known species, in which plates are distributed interradially likewise, and in a similar manner. All this led us to the conclusion that he regarded the plates of the latter species as wholly perisomic. Dr. Carpenter informed us since that he never held such view, and that he regards the plates in question in all four species as representing substantially the same thing. It must be further stated that Dr. Carpenter admits in *A. roissyanus* as calyx interradials the whole series of plates up to the top of the second radials, and not only the first plate, as we thought to infer from his figure on p. 150, and from his descriptions. We are pleased to make this correction, at the same time we are at a loss to know where the small plates commence to which the letter i alludes, and which, as stated by Carpenter himself (Challenger Rep., p. 150), "pass gradually upwards into those of the ventral side."

EXPLANATION OF THE PLATES.

The following letters are employed throughout all the plates.

a	azygous plates.
b	basals.
br	brachials.
c	column, and sections of the column.
cd	centrodorsal.
cr	compound radial.
d	interaxillaries.
e	covering plates (Saumplättchen).
h =	non-arm-bearing radials.
i	interradials (dorsally and ventrally).
o	oral plate or plates.
p -	proximals.
r -	radials in the calyx and summit.
*r*¹ -	first radial.
*r*²	second radial.
t	plate of the ventral tube.
u =	underbasals.
wp	water-pore.
x	anal plates.
xo -	anal opening.
xr -	posterior radials enclosed in the ring of proximals.
/ -	interradially.
IX	azygous interradius.

The diagrams on Plate 6 are designed to show the position of basals and underbasals to the different parts of the column; those of Plates 7 and 8, to show the relation of the summit-plates with each other and with adjoining plates.

EXPLANATION OF PLATE IV.

FIG. 1. *Cupressocrinus abbreviatus* Goldfuss, showing the consolidated muscle-plates, the axial canals, arm openings, and the position of the anal aperture.

FIG. 2. Ventral aspect of *Cyathocrinus Gilesi.* The interradials crowned by tubercles, and resting against the incurved ends of the radials.

FIG. 3. Similar view of another specimen, showing the interradials in the same position, but partly covered by perisomic plates, which connect with the outer edges of the incurved ends of the radials.

FIG. 4. Impression of the ventral side of a specimen of *Teleiocrinus.* The radiating ridges represent paired canals along the inner floor of the test. The original is in the collection of Mr. R. R. Rowley.

FIG. 5. Ventral side of *Dorycrinus Missouriensis.* The ambulacral tubes are exposed only close to the arm-bases, disappearing toward the centre beneath the infiltrating material.

FIG. 6. *Cyathocrinus multibrachiatus.* Ventral surface showing the perisomic plates, portions of the interradials, and the summit plates, the latter in process of resorption.

FIG. 7 *a.* A portion of an arm of the same species. Side plates and covering pieces in position (enlarged).

FIG. 7 *b.* A portion of the same specimen still more enlarged.

FIG. 8. Portion of an arm of *Symbathocrinus dentatus,* showing the ventral furrow and its covering.

FIG. 9. Ventral aspect of *Symbathocrinus Wortheni* after removing the upper half of the first brachials.

FIG. 10. Showing the inner floor of the summit plates in *Symbathocrinus Wortheni.* Seen from below, in a transverse section through the first brachials.

FIG. 11. Cross section of arms and ventral tube at a point midway between the base and tips of the arms, from the same specimen.

EXPLANATION OF PLATE V.

FIG. 1. *Haplocrinus mespiliformis* Goldfuss. Ventral aspect, showing the interradials and anal opening.

FIG. 2. Posterior view of the same specimen.

FIG. 3. Distal face of the bifurcating primary radial of *Forbesiocrinus nobilis,* showing its two axial canals.

FIG. 4. Proximal face of the same.

FIG. 5. Lateral face of an interradial of the same species.

FIG. 6. Ventral aspect of an internal cast of *Batocrinus Christyi.* The dark places represent the pillars suspending the perisome, and the radial ridges the subtegminal ambulacral tubes.

FIG. 7. Ventral aspect of *Cyathocrinus iowensis.* All summit plates bisected or partly resorbed.

FIG. 8. Internal view of the central part of the vault, showing a portion of the perisome, and the peristomeal area beneath the centre of the oral plate, whose sutures are visible in the deeply shaded portion. The figure does not show the specimen as far as the arm bases.

FIG. 9. Ventral aspect of an internal cast of *Platycrinus.* The interradials forming a continuous ring around the proximals, surmounting the covering plates, which emerge from beneath the vault close to the arm bases.

FIG. 10. *Belemnocrinus typus* White. Side view of a perfect specimen, showing the porous ventral tube and the arrangement of arms and pinnules.

FIG. 11. *Belemnocrinus florifer* W. & Sp. Side view of type specimen, showing the arrangement of arms and pinnules; the ventral tube, and the position of the cirrhi.

FIG. 12. *Symbathocrinus Wachsmuthi* M. & W. Ventral aspect, showing the arrangement of the summit pieces and the anal plate.

FIG. 13. Side view of the same specimen, showing the proximals and the radial-dome-plates which alternate with small interradials and together with the former plates rest against the muscle-plates.

FIG. 14. Side view of another specimen, showing the summit plates, interradials, portions of the arms and of the anal tube.

FIG. 15. *Catillocrinus Wachsmuthi* M. & W. A nearly perfect specimen with arms, showing the small anterior and one of the large antero-lateral radials.

FIG. 15 *a*. View of the broken upper end of the same specimen, giving a transverse section of arms and ventral tube.

FIG. 16. Side view of another specimen, showing the dorsal side of the large plates composing the anal tube.

FIG. 17. Underbasal disk of *Agassizocrinus*. Ventral view, showing the ramifying furrows toward the basals, and the six pits within the inner cavity.

EXPLANATION OF PLATE VI.

A series of diagrams, showing the position of the lateral cirrhi, that of the axial canals and outer angles of the stem, in monocyclic and dicyclic Crinoids. For better comparison, the upper side is in all these figures interradial, and represents in most cases the azygous side.

FIG. 1. Abactinal aspect of *Xenocrinus*.
FIG. 2. Base of *Reteocrinus*.
FIG. 3. Calyx plates of *Talarocrinus*.
FIG. 4. Calyx plates of *Atelestocrinus robustus*.
FIG. 5. Calyx plates of *Tribrachiocrinus*.
FIG. 6. Base of *Rhodocrinus*.
FIG. 7. Calyx plates of *Carabocrinus*.
FIG. 8. Abactinal aspect of *Millerocrinus Milleri*. After De Loriol.
FIG. 9. Abactinal aspect of *Zeacrinus nodosus*.
FIG. 10. Inner view of the calyx of *Millerocrinus Milleri*, showing the position of the axial canals. After De Loriol.
FIG. 11. Abactinal aspect of the larva of *Antedon rosacea*, shortly before the detachment from the stem. After Dr. W. B. Carpenter.
FIG. 12. Base of *Heterocrinus* and *Stenocrinus*, the column removed.
FIG. 13. Basals of *Stenocrinus*, with a joint of the quinque-partite column.
FIG. 14. Basals of *Heterocrinus*, with a joint of the tri-partite column.
FIG. 15. Basals of *Barycrinus*, with the joint of the quinque-partite column.
FIG. 16. Underbasals and first stem-joint of *Poteriocrinus*.
FIG. 17. Basals and first stem-joint of *Glyptocrinus*.
FIG. 18. Basals and the tri-partite upper part of the stem in *Forbesiocrinus*, *Onychocrinus* and *Taxocrinus*. (The underbasals are covered.)
FIG. 19. Basals and column of *Actinocrinus*, *Batocrinus*, etc.
FIG. 20. Basals and colums of *Megistocrinus Evansii*.
FIG. 21. Basals and column of *Dolatocrinus*.
FIG. 22. Basals of *Eucalyptocrinus and Melocrinus*.

FIG. 23. Inner aspect of the calyx of *Ichthyocrinus burlingtonensis*, showing the position of the small underbasal.

FIG. 24. Basals of *Pentremites*, showing the position of the smaller plate.

FIG. 25. Basals of *Platycrinus*, showing the same thing.

FIG. 26. Basals of *Symbathocrinus*, showing the same.

FIG. 27. Column of *Poteriocrinus and Cyathocrinus Harrisi*, with radial cirrhi.

FIG. 28. Column of *Belemnocrinus florifer* with interradial cirrhi.

FIG. 29. Column of *Cupressocrinus*, showing the position of the peripheral canals

FIG. 30. Column of *Pentacrinus* with radial cirrhi.

EXPLANATION OF PLATE VII.

These diagrams are designed to show the relation of the summit plates with each other, and with adjoining plates :—

FIG. 1. Diagram of the plates in the early larva of *Antedon rosacea*. After Dr. P. H. Carpenter.

FIG. 2. Summit plates of *Dorycrinus mississippiensis*.

FIG. 3. Ventral aspect of *Eretmocrinus coronatus*.

FIG. 4. Summit plates of *Amphoracrinus spinobrachiatus*.

FIG. 5. Ventral aspect of *Platycrinus glyptus*.

FIG. 6. The same of *Platycrinus subspinosus*.

FIG. 7. The same of *Platycrinus Halli*.

FIG. 8. The same of *Platycrinus tuberosus*.

FIG. 9. The same of *Agaricocrinus Wortheni*.

FIG. 10. The same of a large specimen of *Agaricocrinus americanus*. The dorsal interradials are attached on three sides.

EXPLANATION OF PLATE VIII.

FIG. 1. Internal cast of *Strotocrinus regalis*, showing the impression of the radiating canals along the inner floor of the vault, and the presence of three summit radials between each proximal.

FIG. 2. Internal cast of *Actinocrinus multiradiatus*, showing the same as fig. 1, however, with two summit radials anteriorly and three posteriorly. (The pentapartite protuberance along the oral plate is too prominent in the figure).

FIG. 3. Internal cast of a specimen of *Teleiocrinus*, showing the same as fig. 1.

FIG. 4. Ventral aspect of *Steganocrinus concinnus*.

FIG. 5. Ventral aspect of *Megistocrinus Evansii*.

FIG. 6. Ventral aspect of *Platycrinus burlingtonensis*.

FIG. 7. Ventral aspect of *Marsupiocrinus Tennesseæ*.

FIG. 8. Ventral aspect of *Batocrinus subæqualis*.

EXPLANATION OF PLATE IX.

Fig. 1. Diagram of the calyx plates of *Acrocrinus Wortheni.*

Fig. 2. Interior view of *Glyptocrinus ramulosus.* The specimen is broken in halves, exposing the inner surface of the test, and it shows the continuity of the interradials from the dorsal to the ventral side, the presence of galleries lodging the ambulacra, and the absence of covering pieces in the test; also the apparent existence of a calcareous perisome, supported by pillars as in the Actinocrinidæ.—From a specimen in the Canada Survey Museum.

Fig. 3. Side view of *Zeacrinus nodosus.*

Fig. 4. Side view of *Atelestocrinus robustus.*

Fig. 5. Dorsal aspect of *Cleiocrinus regius.* After a drawing by Mr. Walter R. Billings from type specimen. Basals and underbasals indicated by dotted lines.

Fig. 6. Side view of *Platycrinus burlingtonensis.*

Fig. 7. Side view of *Stemmatocrinus Trautscholdi.*

Fig. 8. Internal view of the same. S. Face for the attachment of the interradials.

AUGUST 4.

Mr. CHARLES MORRIS in the chair.

Nineteen persons present.

Note on Quercus prinoides Willd.—Mr. MEEHAN exhibited a series of fruiting specimens of branches of *Quercus prinoides*. In some, the leaves were almost orbicular and obtuse; in others narrowly lanceolate or saliciform and acute; others had lobed and wavy edges, while others were quite entire. The plants were all growing within a few feet of each other, and the parent plants were also all under the same conditions of environment, and were at no distant date from one parentage.

They were exhibited for two purposes—first, to show that environment, as commonly understood, was not a main factor in the origination of variation; and secondly, to show that variation was independent of mere conditions of growth or sexual peculiarities to which variation was sometimes referred. It was, indeed, true, that young plants often had leaves varying from those on the older plants, and plants or branches bearing flowers of one sex would have characters varying from those of another sex; but these specimens were all fertile, and with young acorns. There was no possible ground for any suggestion as to different conditions in any sense, and the variations could be only attributed to an innate and wholly unknown power to vary, which science had so far been unable to reach.

AUGUST 11.

Mr. THOS. MEEHAN, Vice-President, in the chair.

Eighteen persons present.

On the Fruit of Opuntia.—Mr. THOMAS MEEHAN exhibited a series of specimens of an unknown species of *Opuntia* closely allied to *O. Brasiliensis*, showing a gradual change from the joint or frond to the fruit. In one case there was the thin orbicular frond; then a frond with a slight rounding and tapering at the base; then one somewhat resembling a fruit, but very much compressed, and with an abortive flower-bud leaving a scar at the apex; then another, but very much elongated and fluted, and with a perfect flower, though small; and, lastly, the frond reduced to an inch in length, pyriform, and with the perfect, large yellow flower. He remarked that it could not be called a novel point to make that the fruit of a cactus was simply a metamorphosed frond, or joint as the section is commonly called, and that the petals were the usually (in the frond) very much suppressed leaves; but it might serve a good purpose to place on record this excellent illustration of the fact.

August 18.

Mr. Charles Roberts in the chair.

Fifteen persons present.

A paper entitled "A Review of the Species of the Genus Esox," by Seth E. Meek and Robert Newland, was presented for publication.

The following deaths were announced:—

Moro Phillips, a member, August 9, 1885.

Rud. Wm. Dunker, a correspondent, March 13, 1885.

September 1.

Mr. Thos. A. Robinson in the chair.

Twenty persons present.

The following was ordered to be printed:—

A REVIEW OF THE SPECIES OF THE GENUS ESOX.

BY SETH E. MEEK AND ROBERT NEWLAND.

In the present paper is given the synonymy of the species of the genus *Esox*, with an analytical key by which the species can be determined. The specimens which we have studied belong to the Indiana University.

We acknowledge our indebtedness to Professor Jordan, for the use of his library and for other aids.

Genus ESOX.

Esox Artedi, Genera 14, 1738 (includes the modern genera *Esox, Belone* and *Lepidosteus*).

Esox, Linnæus, Systema Naturæ, 1758, 314 (*lucius*, etc.).

Lucius,[1] Rafinesque Idiee d'Ittiol. Sicil, 1810 (*lucius*).

Picorellus, Rafinesque, Ichthiol. Ohioensis, 1820, 70 (*vittatus*) *salmoneus* (subgenus).

Mascalongus, Jordan, Klippart's Second Rept. Ohio Fish Comm., 1878, 92 (*nobilior-masquinongy*) (subgenus).

Analysis of Species of Esox.

a. Cheeks and opercles entirely scaly.
  b. Branchiostegals normally 12 (11 to 13); scales in the lateral line 105 to 108; D. 11 or 12; A. 11 or 12; middle of eye nearer tip of lower jaw than posterior margin of opercle.
    c. Head short, $3\frac{4}{7}$ in length of body; snout $2\frac{1}{2}$ in length of head; eye $2\frac{2}{3}$ in length of snout. Color dark green; sides with about twenty distinct blackish curved bars; fins plain. *Americanus.* 1.
    cc. Head longer, $3\frac{1}{4}$ in length of body; snout $2\frac{1}{5}$ in length of head; eye $2\frac{1}{2}$ in length of snout. Color greenish, sides with many narrow curved darker streaks, usually distinct and more or less reticulated; fins mostly plain. *Vermiculatus.* 2.

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[1] The name *Esox* is in this paper restricted to *Esox belone* L., the type of the genus *Belone* Cuvier, while the name *Lucius* is reserved for the pikes. The name *Esox* has been universally associated with the Pikes rather than with the Gar-fishes, but perhaps in strict technicality, the name *Lucius* should be used for the former and that of *Esox* for the latter. It is perhaps not unfair, however, to assume that Linnæus would have considered the Pike, rather than the Gar-fish, as typical of his genus *Esox*.

bb. Branchiostegals 14 to 16; D. 14; A. 13; scales in lateral line about 125; middle of eye midway between tip of lower jaw and posterior margin of opercle; head about $3\frac{1}{3}$ in length of body; snout $2\frac{1}{3}$ in head; eye $3\frac{1}{2}$ in snout. Color greenish, marked with numerous narrow dark lines and streaks which are mostly horizontal, and are more or less reticulated; fins plain. *Reticulatus.* 3.

aa. Cheeks scaly; lower half of opercle bare; branchiostegals 14 to 16; D. 16 or 17; A. 13 or 14; scales in lateral line 123; head $3\frac{1}{3}$ in length of body; snout $2\frac{2}{5}$ in length of head; eye 3 in length of snout; middle of eye midway between tip of lower jaw and posterior margin of opercle. Color grayish with many whitish spots, the young barred; dorsal, anal, and caudal fins spotted with black; a white horizontal bar bounding the naked portion of opercle. *Lucius.* 4.

aaa. Cheeks as well as opercles bare on lower half; branchiostegals 17 to 19; D. 17; A. 15; scales in the lateral line about 150; middle of eye midway between tip of lower jaw and posterior margin of opercle; head $3\frac{2}{3}$ in length of body; snout $2\frac{1}{3}$ in head; eye more than four times in length of snout. Color dark gray, sides with round blackish spots; fins spotted with black. *Masquinongy.* 5.

1. **Esox americanus.**

Esox americanus Schoepf, "Naturforscher, tom. xx, 1784, 26" (Long Island).

Esox lucius β americanus Gmelin, Systema Naturæ, 1788. 1390 (based on Schoepf).

Esox americanus Lacépède, Hist. Nat. Poiss., v, 1803, 299; Cuvier and Valenciennes, Hist. Nat. Poiss., xviii, 1846, 329 (Saratoga Lake), Jordan, Annals N. Y. Acad. Nat. Hist., vol. i, No. 4, 1877, 104 (Delaware River; Long Island); Jordan, Bull. U. S. Geol. Sur. Ter., iv, 1878, 132; Bean, Proc. U. S. Nat. Mus., 1879, 285 (McBean creek, Georgia); Goode and Bean, Bull. Essex Inst., vol. ix, 1879, 22 (Newham Lake, Mass.); Bean, Bull. U. S. Fish Comm., 1880, 104 (Piermont, N. Y.; Trenton, N. J.; Long Island); Jordan, Man. Vert. Ed. iii, 1880, 267; Goode, Bull. U. S. Nat. Mus., 21, 1880, 32; Jordan and Gilbert, Syn. Fish, N. A., 1882, 352; Jordan, Cat. Fish. N. A. 50, 1885.

Picorellus americanus Jordan and Copeland, Bull. Buffalo Soc. Nat. Sci., 1876, 143 (Check List).

Esox niger Le Sueur, Jour. Acad. Nat. Sci. Phila., 1817, 415 (South Carolina).

Esox scomberius Mitchill. Amer. Monthly Mag., 1818, 322 (Murderer's Creek, N. Y.); De Kay, N. Y. Fauna, Fish, 1842, 225 (copied).

Esox fasciatus De Kay, N. Y. Fauna, Fish, 1842, 224, pl. 34, fig. 110 (Long Island).

Esox ornatus Girard, "Proc. Bost. Soc. Nat. Hist., 1854, 41" (Massachusetts); Storer, Hist. Fish, Mass., 1867, 313 (Boston market).

Esox ravenelii Holbrook, Ichthyol. S. C., 1855, 201 (South Carolina); Cope, Proc. Acad, Nat. Sci. Phila., 1865, 79 (Catawba River); Cope, Proc. Amer. Phil. Soc., 1870, 457 (Catawba River); Günther, Cat. Fish, Brit. Mus., vi, 1866, 230 (copied); Jordan, Annals N. Y. Lyceum Nat. Hist., vol. xi, 1877, 368 (Coosa R., Georgia); Jordan & Brayton, Bull. U. S. Nat. Mus., xii, 1878, 16 (Catawba River); Goode, Proc. U. S. Nat. Mus., 1879, 117.

Picorellus ravenelii Jordan & Copeland, Bull. Buffalo Soc. Nat. Sci., 1875, 143 (Check list).

Habitat.—Coastwise streams from the Charles River, Mass., to the Savannah River, Georgia.

The specimen examined by us is from the market.

The synonymy of the species offers little room for question, although some of the earlier descriptions are very scanty.

2. **Esox vermiculatus.**

Esox vermiculatus (Le Sueur MSS.) Cuvier & Valenciennes, Hist. Nat. Poiss., xviii, 1846, 333 (Wabash Valley); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1884, 110; Forbes, Ill. State Fish Comm., 1884, 71 (Illinois); Gilbert, Proc. U. S. Nat. Mus., 1884, 209 (East Fork of White River, Indiana); Gilbert, Proc. U. S. Nat. Mus., 1884, 208 (Switz City Swamp, Greene Co., Indiana); Jordan, Cat. Fish. N. A., 50, 1885.

Esox lineatus (Le Sueur MSS.) Cuvier & Valenciennes, Hist. Nat. Poiss., 1846, 335 (Wabash Valley, young).

Esox umbrosus Kirtland, "Cleveland Annals of Sciences, 1854, 79" (near Cleveland, Ohio); Cope, Proc. Acad. Nat. Sci. Phila., 1855, 79; Cope, Trans. Amer. Phil. Soc., 1866, 409 (Grosse Isle, Michigan); Hay, Bull. U. S. Nat. Mus., 1882, 67, 74 (Memphis; Jackson; Vaughans; Granada).

? *Esox crassus* Agassiz. Amer. Jour. Sci. & Arts, 1854, 308 (Tennessee River, at Huntsville, Alabama); Cope, Proc. Acad. Nat. Sci. Phila., 1865, 79 (copied); Jordan & Copeland, Bull. Buffalo Soc. Nat. Sci., 1876, 143 (Check list).

Esox cypho Cope, Proc. Acad. Nat. Sci. Phila., 1865, 78 (Waterford, Oakland Co., Michigan); Günther, Cat. Fish. Brit. Mus., vi, 1866, 230 (copied); Jordan Annals N. Y. Acad. Sci., vol. i, No. 4, 1877, 368 (Fox River, Illinois); Nelson, Bull. Ill. Mus. Nat. Hist., i, 1877, 43 (Fox River at Geneva); Jordan, Bull. U. S. Geol. Sur. Terr., iv, 1878, 432; Jordan, Man. Vert. Ed., iii, 1880, 267.

Picorellus cypho Jordan & Copeland, Bull. Buffalo Soc. Nat. Sci., 1875, 143 (Check List).

? *Esox niger* Günther, Cat. Fish. Brit. Mus., vi, 1866, 229 (New Orleans), not of Le Sueur.

Esox porosus Cope, Trans. Amer. Phil. Soc., 1866, 408 (Lake Michigan).

Esox salmoneus Jordan, Bull. Buffalo, Soc. Nat. Hist., 1876, 96.

Esox salmoneus Jordan, Annals N. Y. Acad. Sci., vol. i, No. 4, 1877, 104 (White River; Ohio River: Illinois River; Wabash River; Maumee River; Lake Erie); Jordan, Bull. U. S. Nat. Mus., 1877, 42; Jordan Annals N. Y. Lyceum, vol. xi, 1877, 376 (White River, Indiana); Jordan, Proc. Acad. Nat. Sci. Phila., 1877, 44 (Lakes of Laporte County, Indiana; St. Joseph's River, Indiana; Maumee River, Indiana; Tippecanoe River, Indiana): Nelson, Bull. Ill. Mus. Nat. Hist., i, 1877, 43 (Illinois); Jordan, Bull Ill. Mus. Nat. Hist., ii, 1878, 53; (Illinois River at Pekin; Fox River, Union County, Ill.); Jordan Syn. Fish. N. A., 1882, 352; Jordan Zoölogy of Ohio, vol. iv, 1882, 914 (not of Mitchill; probably not of Rafinesque).

Picorellus salmoneus Jordan, Man. Vert. Ed., i, 1876; Jordan & Copeland, Bull. Buffalo Soc. Nat. Sci., 1876, 143 (Check List).

Esox ravenelii Jordan, Bull. Ill. Mus. Nat. Hist., 1876, 53 (Union County, Illinois) not of Holbrook).

Habitat.—Mississippi Valley and Great Lake region, most abundant in the central States. Not found east of the Allegheny Mountains, nor in the Texan region. Frequenting sluggish waters and bayous.

The specimens examined by us are from Falls of Ohio; Ohio River, Southern Indiana; Bean Blossom Creek, Monroe Co., Indiana; Pipe Creek, Madison County, Indiana; Mecca, Parke County, Indiana; Kankakee River at Riverside, Indiana, and Hicksville, Defiance County, Ohio.

This species has the general coloration of *E. reticulatus*, with its other characters, very close to those of *E. americanus*. From the latter species it differs but slightly, but the greater length of the snout, small as it is, seems to be very constant.

The name *Esox salmoneus*, frequently applied to this species, cannot be retained, as it was earlier given by Mitchill to *Synodus foetens*. It is also probable that Rafinesque's original *salmoneus* is a mythical species, not identifiable with anything. In his copy of the original drawing (in his MSS. note books) the insertion of the dorsal is said to be represented as midway between the tip of the snout and the base of the caudal.

3. **Esox reticulatus.**

Esox lucius Mitchill, Trans. Hist. & Phil. Soc. N. Y., 1815, 440 (Long Island).

Esox reticulatus Le Sueur, Jour. Acad. Nat. Sci. Phila., 1818, 414, No. 2 (Philadelphia); Storer, Rept. Fish. Mass., 1839, 97 (Maine; Massachusetts); De Kay, N. Y. Fauna Fish., 1842, 223 (New York); Ayres, Bost. Jour. Nat. Hist., iv, 1842, 269 (Brookhaven, Long Island; Hockanum River, Conn.).

Esox reticulatus Cuvier & Valenciennes, Hist. Nat. Poiss., xviii, 1846, 327 (Philadelphia; Charleston, S. C.); Storer, Syn. Fish. N. A., 1846, 437; Thompson, "Hist. of Vermont, 1846, 138" (Vermont); Griffiths Cuvier. Regne Animal, 1854, 390; Cope, Proc. Acad. Nat. Sci. Phila., 1865, 79; Cope, Trans. Amer. Phil. Soc. Phila., 1866, 410; Günther, Cat. Fishes Brit. Mus., vi, 1866, 229 (Boston; New York); Storer, Hist. Fish. Mass., 1867 (Maine: Massachusetts); Jordan, Ohio State Fish Comm., 1876, 186.

Esox reticulatus Jordan, Annals N. Y. Acad. Sci., vol. i, No. 4, 1877, 104 (Westfield River; Delaware River; Ocmulgee River; Etowah River; Potomac River); Jordan, Bull. U. S. Geol. Sur. Terr., iv, 1878, 432; Jordan & Brayton, Bull. U. S. Nat. Mus., xii, 1878, 40 (Etowah River); Jordan & Brayton, Bull. U. S. Nat. Mus., xii, 1878, 16; Goode, Proc. U. S. Nat. Mus., 1879, 117; Goode & Bean, Bull. Essex Institute, vol. ix, 1879, 22 (Massachusetts); Goode, Bull. U. S. Nat. Mus., xxi, 1880, 32 (East Wareham, Massachusetts): Bean, Proc. U. S. Nat. Mus., 1880, 104 (Norfolk, Va.; South Hadley Falls, Mass.); Jordan, Man. Vert., Ed. 3, 1880, 267; Hay, Bull. U. S. Nat. Mus., 1882, 67, 74 (Big Black River, Mississippi; Pearl River, Mississippi); Jordan & Gilbert, Syn. Fish. N. A., 1882, 353; Jordan, Cat. Fish. N. A., 50, 1885.

Picorellus reticulatus Jordan & Copeland, Bull. Buffalo Soc. Nat. Hist., 1876, 143 (Check list).

? *Esox phaleratus* (Say) Le Sueur, Jour. Sci. Phila., 1818, 416 (near St. Augustine, Fla.); De Kay, N. Y. Fauna Fish, 1842, 226 (copied): Cuvier & Valenciennes, Hist. Nat. Poiss., xviii, 1846, 333 (copied).

? *Esox phaleratus* Goode, Proc. U. S. Nat. Mus., 1879, 117.

Esox tridecem-lineatus Mitchill, ? "Mirror, 1825, 361" (Oneida Lake).

Esox tridecem-radiatus DeKay, N. Y. Fauna. Fish., 1842, 225 (copied).

Esox affinis Holbrook, "Ichth. South Car., 1855, 198" (South Carolina); Cope, Proc. Acad. Nat. Sci. Phila., 1865, 79 (Neuse River); Cope, Proc. Amer. Phil. Soc., Phila., 1870, 457.

Picorellus affinis Jordan & Copeland, Bull. Buffalo. Soc. Nat. Sci., 1876, 143 (Check List); Jordan, Man. Vert., 1876, Ed. i, 255.

Esox reticulatus var. *affinis* Jordon Annals. N. Y. Lyceum Nat. Hist., vol. xi, 1877, 369 (Etowah River, Georgia).

Habitat.—Maine to Mississippi, chiefly or only in streams and lakes east of the mountains.

The specimens examined by us are from the Potomac and Delaware Rivers.

1. **Esox lucius.**

*Esox lucius** Linnæus, Systema Naturæ, Ed. x, 1758, 314 (European specimens).

American References.

? *Esox lucius* Richardson, "Fauna Bor. Amer. Fishes, iii, 1836, 124" (Northern regions); De Kay, N. Y. Fauna, Fish., 1842, 226 (copied).

Esox lucius Cope, Proc. Acad. Nat. Sci. Phila., 1865, 79; Cope, Trans. Amer. Phil. Soc. Phila., 1866, 408 (Great Lakes; Lake Whittlesey, Minnesota); Günther, Cat. Fish. Brit. Mus., vi, 1866, 227 (Albany River; Lake Whittlessey, Minnesota: Arctic, N. A.); Jordan & Copeland, Bull. Buffalo Soc. Nat. Sci., 1876, 143 (Check List); Jordan, Ohio State Fish. Comm., 1876, 186, fig. 16, pl. 11: Jordan, Bull. U. S., Geol. Sur. Terr., iv, 1876, 797 (Turtle Mountain; St. Mary's River, Rocky Mountains); Jordan, Proc. Acad. Nat. Sci. Phila., 1877, 44 (St. Joseph's River, Indiana); Jordan Annals, N. Y. Acad. Sci., vol. i, No. 4, 1877, 101, (Lake Ontario; Lake Erie; Lake Michigan; Fox River, Illinois; Mississippi River); Jordan, Bull. U. S. Nat. Mus., x, 1877, 55; Jordan, Bull. U. S. Geol. Sur. Terr., 1878, 432.

Esox lucius Jordan, Bull. Ill. Mus. Nat. Hist., ii, 1878, 53 (Rock River, Ill.); Jordan, Man. Vert. Ed. 3, 1880, 266; Bean, Proc. U. S. Nat. Mus., 1880, 104 (Sandusky, Ohio; South Hadley Falls, Massachusetts); Goode, Bull. U. S. Nat. Mus., 21, 1880, 32 (Sandusky, Ohio); Bean, Proc. U. S. Nat. Mus., 1881, 255, 268, 271 (Alaska; Youkon River); Jordan, Zöology of Ohio, iv, 1882, 915; Jordan & Gilbert, Syn. Fish. N. A., 1882, 353; Forbes, Ill. State Fish Comm., 1884, 71 (Illinois); Jordan, Cat. Fish. N. A., 51, 1885.

?? *Esox vittatus* Rafinesque, American Monthly Mag., vol. iii, 1818, 447: Rafinesque, Ichth. Oh., 1820, 70 (Mythical).

Esox Estor Le Sueur, Jour. Acad. Nat. Sci. Phila., 1818, 413 (Lake Erie); DeKay, N. Y. Fauna Fish. 1842, 222; Cuvier & Valenciennes, Hist. Nat. Poiss., xviii, 1846, 324, pl. 542 (Lake Erie); Günther, Cat. Fish. Brit. Mus., 1866, 228 (copied).

Esox lucius var. *estor* Jordan, Man. Vert., 1876, 255; (Nelson, Bull. Ill. Mus. Nat. Hist., i, 1876, 43 (Northern Illinois); Jordan & Copeland, Bull. Buffalo Soc. Nat. Sci., 1876, 43 (Check List).

Esox reticulatus Kirtland, "Zöology of Ohio, 1820, 194;" Kirtland, "Bost. Jour. Nat. Hist., 1843, 33, pl. 10, fig. 2" (Lake Erie); (not of Le Sueur).

?? *Esox salmoneus* Rafinesque, Ichthiol. Ohiensis, 1820, 70 (Mythical).

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* The European synonymy of this species is very extensive, and we have not attempted to collect it.

Esox deprandus (Le Sueur MSS.) Cuvier & Valenciennes, Hist. Nat. Poiss., xviii, 1846, 336 (Wabash River at New Harmony, Indiana); Cope, Proc. Acad. Nat. Sci. Phila., 1865, 79; Cope, Trans. Amer. Phil. Soc. Phila., 1866, 408 (copied); Günther, Cat. Fish. Brit. Mus., 1866, 229 (copied); Jordan, Proc. U. S. Nat. Mus., 1879, 225 (Identification of Le Sueur's type).

? *Esox lugubrosus* (Le Sueur MSS.) Cuvier & Valenciennes, Hist. Nat. Poiss., xviii, 1846, 338 (Crab Orchard, Ky.; no description).

Esox lucioides "Agassiz & Girard," Herbert Frank Forester's Fish and Fishing, 1849 (Lake Superior).

Esox boreus Agassiz, "Lake Superior, 1850, 317" (Lake Superior; same as *E. lucioides*); Cope, Proc. Acad. Nat. Sci. Phila., 1865, 79; Nelson, Bull. Ill. Mus. Nat. Hist., i, 1877, 43 (Northern Illinois).

Habitat.—Streams and lakes of Europe; Northern Asia, Alaska, and Northeastern parts of North America; South to New York and Ohio River, and west to the Rocky Mountains.

The specimens examined by us are from Venice, Lake Erie, and Lake Michigan.

We can see no difference whatever between American and European examples of this species, when specimens of similar size and condition are compared. The names *Esox estor*, *deprandus*, *lucioides* and *boreus* are therefore strictly synonymous with *E. lucius*.

5. **Esox masquinongy.**

Esox masquinongy Mitchill, "Mirror, 1824, 297" (but the description is said not to be there); Kirtland, Zoölogy of Ohio, 1838, 194 (Lake Erie).

Esox estor Richardson, "Fauna Bor. Amer., iii, 1836, 127" (Lake Huron); Kirtland, Bost. Jour. Nat. Sci., 1842, 329; Agassiz, "Amer. Jour. Sci. & Arts, xvi, 1853, 308" (not *Esox estor*, Le Sueur).

Esox nobilior Thompson, "Proc Bost. Soc. Nat. Hist., iii, 1850, 163, 173, 305" (Lake Champlain: Cope, Proc. Acad. Nat. Sci. Phila., 1865, 79; Cope, Trans. Amer. Phil. Soc. Phila., 1866, 410 (Coneaught Lake, Pa.; Alleghany River); Jordan & Copeland, Bull. Buffalo Soc. Nat. Sci., 1876, 143 (Check list); Jordan, Annals N. Y. Acad. Sci., vol. i, No. 4, 1877, 104 (Lake Michigan; Lake Huron; Lake Erie); Jordan, Bull. U. S. Nat. Mus., 1877, 54 (Ecorse, Michigan; Lake Huron); Nelson, Bull. Ill. Mus. Nat. Hist., i, 1877, 43 (Lake Michigan); Jordan, Man. Vert., Ed. ii, 1878, 266; Jordan, Bull. Ill. Mus. Nat. Hist., 1878, 53 (Lake Michigan); Goode, Bull. U. S. Nat. Mus., xiv, 1879, 55; Goode, Bull. U. S. Nat. Mus., xxi, 1880, 32 (Sandusky, Ohio; Jordan, Man. Vert., Ed. iii, 1883, 266; Bean, Bull. U. S. Fish Comm., 1880, 104 (Sandusky, Ohio); Bean, Proc. U. S. Nat. Mus. 1880, 104 (Sandusky, Ohio).

Esox nobilior Jordan, Zoölogy of Ohio, vol. iv, 1882, 917; Jordan & Gilbert, Syn. Fish. N. A., 1882, 353: Forbes, Ill. State Fish Comm., 1884, 71 (Lake Michigan); Jordan, Cat. Fish. N. A., 51, 1885.
? *Esox ohiensis* Kirtland, "Cleveland Annals of Science, 1854."

Habitat.—Great Lakes, occasionally in the Ohio and Upper Mississippi Rivers.

One specimen examined by us is from the Ohio River at New Albany, Indiana.

We here adopt the name *Esox masquinongy* of Mitchill for this species instead of the more familiar and preferable *Esox nobilior* of apparently later date.

Professor Jordan has been unable to find the description of Mitchill in the files of the Mirror, where it is said by De Kay to occur. A portion of the description of Mitchill is quoted by De Kay, and this part applies to the Muskalunge much better than to the Pikes. Moreover, reference to Mitchill's name is made by Kirtland at a date prior to the publication of the work of De Kay.

It is therefore highly probable that a description of *Esox masquinongy* has been somewhere printed by Mitchill, and if so, that this is the earliest account of the Muskalunge.

The descriptions of *Esox ohioensis* is said to refer to this species, but we have not been able to examine the original paper of Dr. Kirtland.

List of Nominal Species with Identifications.

The following is a list of nominal species referred to in the foregoing paper, arranged in chronological order with our identification of each. Tenable specific names are printed in italics.

Nominal Species.	*Date.*	*Identification.*
Esox lucius Linnæus,	1758,	Esox lucius.
Esox americanus Gmelin,	1788,	Esox americanus.
Esox reticulatus Le Sueur,	1817,	Esox reticulatus.
Esox niger Le Sueur,	1817,	Esox americanus.
Esox estor Le Sueur,	1818,	Esox lucius.
Esox vittatus Rafinesque,	1818,	(mythical).
Esox phaleratus Say,	1818,	Esox reticulatus ?
Esox scomberius Mitchill,	1818,	Esox americanus.
Esox salmoneus Rafinesque,	1820,	(mythical).
Esox masquinongy Mitchill,	1824,	Esox masquinongy.
Esox tredecem-lineatus Mitchill,	1825,	Esox reticulatus.

Nominal Species.	*Date.*	*Identification.*
Esox fasciatus De Kay,	1842,	Esox americanus.
Esox tredecem-radiatus De Kay.	1842,	Esox reticulatus.
Esox vermiculatus Le Sueur.	1846,	Esox vermiculatus.
Esox lineatus Le Sueur,	1846,	Esox vermiculatus.
Esox deprandus Le Sueur,	1846,	Esox lucius.
Esox lugubrosus Le Sueur,	1846,	Esox lucius?
Esox lucioides Agassiz & Girard,	1849,	Esox lucius.
Esox boreus Agassiz,	1850,	Esox lucius.
Esox nobilior Thompson,	1850.	Esox masquinongy.
Esox crassus, Agassiz,	1854.	Esox vermiculatus?
Esox umbrosus, Kirtland,	1854,	Esox vermiculatus.
Esox ohioensis, Kirtland,	1854,	Esox masquinongy?
Esox ornatus, Girard,	1854,	Esox americanus.
Esox affinis Holbrook,	1855,	Esox reticulatus.
Esox ravenelii Holbrook,	1855,	Esox americanus.
Esox cypho Cope,	1865.	Esox vermiculatus.
Esox porosus Cope,	1866,	Esox vermiculatus.

SEPTEMBER 8.

Dr. A. E. FOOTE in the chair.

Twelve persons present.

Inflorescence of the Compositæ.—At the meeting of the Botanical section, on the seventh inst., Mr. THOMAS MEEHAN remarked that it seemed obvious, by the rule in Asteraceous plants, or the order *Compositæ*, that the order of anthesis was inversely to the growth. But by a note of Prof. Asa Gray in his new synoptical *Flora of North America*, referring to *Liatris*, it did not appear to have received the marked attention of botanists. Among the generic characters of *Liatris*, Dr. Gray gives flowering from the top downwards, as in an inverted spike or raceme. He exhibited specimens of *Mulgedium*, *Lactuca*, *Erecthites*, *Gnaphalium*, *Aster*, *Solidago*, *Vernonia*, *Erigeron*, *Bidens*, and *Xanthium*, all gathered casually and hastily within a few yards of each other, to show that the upper or terminal flower was the first to open, then the upper flower on the next branch of the raceme or panicle, and then the lower ones in succession. If in these plants the side branches were arrested in their growth, and the terminal flowers of the branchlets brought down in proximity to the main stem, we had precisely the same kind of anthesis as in *Liatris*. If *Liatris* had a branched panicle instead of a spicate inflorescence, we should not notice any difference between it and other plants. There were some other families of plants that presented a similar order of anthesis, but it is so marked a character in *Compositæ* as to make it well worthy of consideration in connection with the peculiar construction of the flower heads.

A remarkable reflection is that this completion of growth, and their flowering down the stems backwards, ceases with the formation of the flower heads. Then the anthesis of the florets is with and not reversely to the growth. In a sunflower, for instance, any one may remember that the florets near the ray open first, and continue to open spirally until the centre is reached.

There were, however, exceptions in compositæ to the order of anthesis in the flower heads. In *Ambrosia* the lower flowers on the spike opened first, and they continued to open upwards as in the raceme of any other order of plants. In the female plants of *Ambrosia artemisiæfolia*, being abundant this season (1885) the truly racemose order of opening was the same as in the ordinary monœcious plants.

SEPTEMBER 15.

Mr. CHARLES MORRIS in the chair.

Twenty-three persons present.

On the Pectoral Filaments in the Sea Robin (*Primotus palmipes*). —Dr. HARRISON ALLEN said, in speaking of the pectoral fin of the family of teliostean fishes, the Triglidæ, that the first three rays are known as the pectoral filaments. They are disposed ventrally, separated from the body of the fin, and placed well in front of its base. The filaments are curved somewhat upon themselves, and are moved by powerful muscles. The nerves supplying them are derived from the ganglionic masses (so characteristic of the Triglidæ) at the beginning of the spinal cord. The filaments are used not only for touch but for locomotion. In directing the body toward the right, the left filaments are in constant motion (like the limbs of a salamander) while the right filaments are at rest. In directing the body toward the left, the motion thus described is reversed. The filaments are also used in stirring up the soft silt which composes the bottoms on which the fish rests. The organs are thus put to comparative rough usage, so that one learns with a sense of surprise that the tops and sides near the tips possess a high degree of differentiation of the tegument. The organ, while appearing to be tactile in nature, recalls in character the general features of a retinal surface. Both in longitudinal and in transverse section the organ is seen to be composed of four layers of cells. The first basal layer is made up of small nearly round cells. The second layer is composed of large fusiform cells, each of which contains granular contents surrounding a distinct circular nucleus. The third layer is composed of columnar cells resembling finger-like processes which are arranged like a layer of retinal rods. A connective tissue membrane which might be compared to the external limiting membrane of the retina intervenes between the third and second layer of cells. The fourth and peripheral layer is composed of diaphanous tube-like prolongations of the side of the cells which compose the third layer. It varies greatly in thickness. In some portions of each filament the fourth layer is very thin, and barely covers the tips of the processes of the third layer, or it is of a thickness nearly equal to one-half the thickness of the entire organ. The layer appears to be tightly held to the third, and is often detached in the sections. The general membrane is smooth and uniform at the tips of the filaments, but is arranged in broad capitate papillæ elsewhere.

The recorder thought the pectoral filaments to be beautiful objects for study. They can be readily obtained since the sea-robin is a common summer fish along the Atlantic coast.

SEPTEMBER 22.

The President, Dr. LEIDY, in the chair.

Twenty-five persons present.

SEPTEMBER 29.

Mr. J. H. REDFIELD in the chair.

Twenty-five persons present.

OCTOBER 5.

Mr. GEO. W. TRYON, JR., in the chair.

Twenty-four persons present.

A paper entitled "Attack and Defence as Agents in Animal Evolution," by Charles Morris, was presented for publication.

OCTOBER 13.

The President, Dr. LEIDY, in the chair.

Thirty-four persons present.

Notes on Cactaceæ.—Elastic Fruit in Mamillaria.—At the meeting of the Botanical Section of the Academy, held on the 12th inst., Mr. MEEHAN referred to his former observations on the sudden growth of the fruit of some species of cactaceæ, indicating that it was not a growth before maturity, but an elastic projection of a fruit already mature. Since that time he had been able to note in *Mamillaria gladiata*, *M. recurva*, and some other Mexican species, in which there was only the apex of the red fruit visible between the mamma over night, a full elongation to the length of an inch by 9 A. M. the next day. They were clear cases of the elongation of the fruit after maturity and not a growth.

The flowers of *Opuntia Rafinesqui* had very irritable stamens when the flowers were fully expanded under a bright sun. Some echinocacti had stamens irritable in a less degree, but in *Echinocactus erinaceus* the stamens were quite as irritable as in the *Opuntia* noted.

On the Flora of Martha's Vineyard and Nantucket.—At the same meeting of the Botanical Section Mr. REDFIELD spoke of the topographical features of Martha's Vineyard and Nantucket, in connection with the flora of those islands. The northern portion of the island of Martha's Vineyard rises into rounded hills of considerable elevation, composed of gravelly drift, strewn occasionally with large boulders. They are evidently of glacial origin. The more central portion consists of level plains of gravel, covered with oaks, mostly *Quercus obtusiloba*. The general character of the flora is much like that found on the summit of the divides in southern New Jersey, though much more limited as to species. Farther south, extensive ponds, both of fresh and salt water, introduce their characteristic vegetation. In Nantucket he had found the gravelly hills of much less height, the greater portion of the island consisting in fact of treeless plains—one extensive grove of *Pinus rigida* exists in the central portion of the island, and is known to have been planted. The plains alluded to were many years ago occupied as sheep pastures. But of late years this has been prohibited, and it is said that since then there has been a great change in the character of the vegetation. The most characteristic plant of these plains seemed to be *Arctostaphylos uva-ursi*, which grows there in greater profusion than he had ever seen it. The two species of *Hudsonia* abound, the *H. ericoides* being seen everywhere, and less frequently the more bluish-green tufts of *H. tomentosa*. *Polygala polygama*, *Myrica cerifera* and various *Vaccineæ* abound. He saw many large patches of *Corema Conradii*, the existence of which in Nantucket had first been made known by Mrs. Owen of Springfield, Mass. But the most interesting feature is the existence here of three species of heath, possibly indigenous. Mrs. Owen, who published a preliminary catalogue of the Nantucket flora a few years ago, records *Calluna vulgaris* and *Erica cinerea* as found upon the island. The first of these had long been known to occur at Tewksbury, Mass., and there had been some question as to whether its presence there was due to human agency. Its subsequent discovery in Nova Scotia and Newfoundland had seemed to strengthen the idea of its indigenous character. Mr. R. did not see the locality of *Calluna vulgaris*, but had the privilege of seeing that of the *Erica cinerea*. This plant had been known and watched for 10 or 12 years, and is evidently an old one. It grows in the open common—far away from the town—and there is nothing about its surroundings to indicate human introduction. It covers only a space of eight inches by ten.

Since Mr. Redfield's visit the third species *Erica tetralix* had been discovered in a locality very distant from that of *E. cinerea*, but under circumstances which favor the idea of its accidental introduction in connection with the importation of foreign trees. But there are said to be seven or eight of the plants all thriving, large and bushy.

October 20.

The President, Dr. Leidy, in the chair.

Twenty-eight persons present.

OCTOBER 27.

The President, Dr. LEIDY, in the chair.

Forty-two persons present.

The following papers were presented for publication:—

"A Review of the American Gasterostidæ," by Carl H. Eigenman.

"A Catalogue of the Fishes of Bean Blossom Creek, Monroe Co., Ind.," by Carl H. Eigenman and Morton W. Fordice.

"List of Fishes collected in Harvey and Cowley Counties, Kansas," by B. W. Everman and Morton W. Fordice.

"A Revision of the American species of the Genus Gerres," by B. W. Everman and Seth E. Meek.

"A Revision of the American species of the Genus Scorpæna," by Seth E. Meek and Robert Newland.

The Committee appointed to settle the estate of the late Henry N. Johnson, under whose will dated March 5, 1878, the Academy is made residuary legatee after the death of his wife, reported that Mrs. Elizabeth Johnson had died February 21, 1885, that the estimated value of the entire estate amounts to $51,761.40, and that the present income from the productive portion, less taxes and water rent, is $1434.82.

The following resolution was unanimously adopted:—

Resolved, That the thanks of the Academy are hereby tendered to Mr. Jacob Binder and to Uselma C. Smith, Esq., the Solicitor of the Academy, for their careful and laborious services in the matter of the Johnson estate.

The following was ordered to be printed:—

BIOGRAPHICAL NOTICE OF HENRY N. JOHNSON.

BY THOMAS MEEHAN.

In the central part of Germantown, on what is known as "The battle-ground," is "Upsal," the estate of John Johnson, the descendant of Dirk Jansen, an early settler in that borough. The residence is some five hundred feet west of the celebrated Chew Mansion, in which a number of British troops fortified themselves in the war of the Revolution to resist the advance of General Washington's army towards Philadelphia. In front of John Johnson's house the cannon were placed that were used by the American army in the attack on the Chew House. The estate was known as "Upsal," a name associated with the great Swedish botanist Linnæus; but in this case given from its being the birthplace of Mrs. John Johnson.

A love of botany, or at least of rare trees and plants, must have been a trait in the character of John Johnson, for when the writer first knew it, about 1856, it was, in many regards, a botanic garden, in respect to the number of rare herbaceous plants growing there, while some of the finest specimens of rare trees to be found about the city, adorned the grounds. At that time it contained a specimen of the European silver fir, which the writer measured and found over ninety feet high; a very large deciduous cypress, by examining which the late Dr. Engelmann made his first discovery of the fact that at least one coniferous plant imitated amentaceous plants in advancing considerably male flower buds in the fall; magnolias, and especially a specimen of the American yew, which remains to this day probably the finest specimen of this plant in the world. These trees, according to the statement of Henry N., the son and subject of this sketch, were planted by John Johnson about the year 1800.

Henry N. was born on the 20th of May, 1820. He completed his education in the old Germantown Academy in 1839. He was noted among his schoolmates for a studious disposition, and in the classics, literature, and mathematics, particularly, kept at the head of his class. Entering manhood he started, in connection with a friend, the business of a bookseller, on Chestnut Street, near Seventh, in Philadelphia, which was ultimately abandoned. A physical infirmity which afflicted him from birth, rendered him averse to city life, and after declining business, he took on himself the care of the estate—the garden, especially, receiving his special attention. Physically strong, he loved to apply himself to garden work, and a large number of rare trees and plants were added from time to time, and set out with his own hands. Some of the finest specimens of the Japan cedar—*Cryptomeria Japonica*—are here, and the only known plant of the mammoth *Sequoia* in existence around Philadelphia. The tree, although not seeming to like our hot summers, is growing here in fair health—all from his planting and care. He would have disclaimed the title of botanist, but his love for trees and plants, and the great amount of knowledge he possessed regarding them, was very unusual in a mere lover of gardening. He always took great interest in the progress of natural history, and, in conversation with the writer, subjects connected with the Academy of Natural Sciences, showing an interest in its welfare, were frequent topics.

He continued his interest in the oversight of the family estate till about 1865, when it was divided, and he took his separate share. About this time he married a lady of Philadelphia with whom he had been long acquainted, and went to housekeeping on Girard Avenue, near Fairmount Park, in which beautiful spot, among the trees and flowers, he would spend most of his time. He died on the 30th of August, 1879, leaving the use of all he was possessed of to his wife during her lifetime, and to revert to the Academy on her decease.

NOVEMBER 3.

Mr. THOS. MEEHAN, Vice-President, in the chair.

Twenty-five persons present.

Virulence of the Common Parsnip.—Mr. MEEHAN referred to the deaths of some children, at Danville, Pa., in the spring of 1884, reputed to be caused by eating the roots of the wild parsnip. This was usually understood to mean the roots of *Cicuta maculata*, or perhaps *Conium maculatum.* Roots had been sent to him by the attendant physician, among which was the fragment of a portion that one of the dead children had partially eaten, with teeth marks on the remains. There seemed no chance for error in this case. The root, which was evidently neither of the two reputed to be virulent, was planted. It proved to be the true garden parsnip, *Pastinaca sativa*, which has become an escape from gardens in many parts of the United States. Although the evidence that the deaths were from the wild roots of the common garden parsnip appeared so conclusive, in view of the fact that there seems to be no record of such a virulent character in connection with this plant, it was thought possible there might still be some mistake, and corroborative evidence was sought for. It was found that in the cultivated form some growers are careful about weeding or working among the leaves while the dew is on them, as severe cases of poisoning have been known to result, and on large seed farms, the workmen engaged in cutting the stalks at the seed harvest, have to protect their hands and arms against contact with the juices, or they are liable to be severely poisoned in a manner similar to that from the poison vine *Rhus toxicodendron.* With these facts it seems worth placing on record what seems to be indisputable that the deaths of the Danville children were really caused by the wild garden parsnip, *Pastinaca sativa.*

NOVEMBER 10.

The President, Dr. LEIDY, in the chair.

Twenty-four persons present.

The Shape of the Hind Limb in the Mammalia as Modified by the Weight of the Trunk.—Dr. HARRISON ALLEN directed attention to the osseous characters of the posterior extremities in mammals, as determined by the weight borne. The shape of the hind limb in the majority of the forms is that best adapted for sustaining the weight of the hinder part of the trunk.

The head of the *femur* lies upon a neck which is relatively long;

the shaft is cylindroid, and the condylar end is expanded in all its diameters, but notably in its posterior diameter. Were a section of the condyles made by extending downward the plane of the posterior surface of the femur, the condyles would be removed in such manner as to retain in the removed segment the base of the inter-condyloid notch. If, however, the parts named be examined in the sloth, in the genus *Cylosthurus* (the two-toed arboreal ant-eater), in the bat and in the seal, the head of the femur is seen to be without a neck, or to possess a very small one. The shaft of the femur is flattened, and the condylar end is scarcely at all expanded. If a section be made as above described, the base of the condyloid notch is not removed with the section. The bone in its general features resembles the femur of the embryo.

The *fibula* in the genera bearing the weight of the body, exhibits two forms, one in which the bone is parallel to the tibia, and nearly equal to it in length, and a second in which the *distal* end is either anchylosed to the shaft of the tibia or is obliterated. In the genera which are suspended by the feet, or are otherwise free from the sustenance of weight, the fibula, when it departs from the type in which it is separate from, but co-equal with the tibia, is always reduced at the *proximal* end. In the seal the proximal end is anchylosed to the shaft of the tibia; in the bat the proximal end is entirely absent: in the sloth the proximal end, while free, is small, while the distal end is broad and highly specialized in function.

The *astragalus* is flattened and irregular in the types whose posterior extremities sustain weight, but in those free from such weight it is elongated. The tendency is seen in *Galago* and *Tarsius*, for both calcaneum and astragalus are seen to be elongated, but the tendency is carried to an extreme degree in the sloth, the bat, and in *Phoca vitulina*.

The manner of articulation in the gorilla of the fibula, with both the calcaneum and the astragalus, was dwelt upon, as well as the fact that the astragalus in that genus possesses a broad deflected fibular facet. This peculiar projection is rudimental in the astragalus of the skeleton of civilized man, but was found highly developed in an astragalus from an Indian grave found at Cooper's Point, New Jersey.

The following was ordered to be printed :—

ATTACK AND DEFENSE AS AGENTS IN ANIMAL EVOLUTION.

BY CHARLES MORRIS.

In considering the development of the dermal skeleton of animals, with its various modifications, we are led almost to the conception that nature has been controlled at successive periods by special ideas, each dominant during a long period, and then abandoned in favor of a new one. I have, in a previous communication to the Academy, advanced the hypothesis that in the primitive life era animals were destitute of hard parts, either external or internal, and that to this we must ascribe the lack of primitive fossils.

The development of an external skeleton, which seems to have long preceded that of an internal one, came like a new idea to nature, which was adopted almost simultaneously as it seems, though probably at considerable intervals, by the various types of life. We are quite sure that the first appearance of fossils in the rocks does not indicate the first appearance of life upon the earth. Early fossilization is due to the preservation of the dermal skeletons of animals of considerably advanced organization, and these were very probably preceded, during a long era, by soft-bodied forms of low organization. These could leave no trace of their existence, except in the case of the burrowing worms, or of impressions made by animal forms on beds of mud or other plastic material. Yet after the advent of armored animals, it is probable that the seas were still tenanted by numerous soft-bodied forms, mainly swimmers, the progenitors of the many naked ocean swimmers which still exist.

The earliest armored forms were principally surface dwellers, or sluggish swimmers. Swift-swimming armored animals came in with the fishes, and these increased in thickness and weight of armor to the end of the Devonian era. During this period all the higher forms of life seem to have acquired more or less dense dermal armor. Their agility must have been much reduced by the weight and rigidity of this armor. None but the fishes were active swimmers, and most of the armored animals were surface-dwellers.

If now we come down to a later era of life, we find in operation what seems a third idea of nature. The prevailing tendency in animal life is no longer to assume armor, but to throw off armor, and return towards the unprotected condition. This tendency was quite as marked in its operation as the others, as a hasty review will show.

In the antique type of vertebrate life, the fish, the thick armor of the primeval era has been in great part replaced by the thin scales of the Teleosteans. The Ganoids have nearly vanished. Many Elasmobranchs yet exist, but their armor never gained the dense and rigid character of the Ganoid scales. But the loss of the old condition is more particularly shown in the new forms of life. The Labyrinthodont amphibians were clothed in armor, their heads in particular being protected by hard bony plates. Modern amphibians are naked-skinned animals. The reptiles are usually scaled, but, with the exception of the crocodiles and turtles, and some few fossil types, do not seem to have ever been clothed in bony armor. In the later vertebrate classes, the birds and mammals, all defensive armor is lost, the covering of hairs and feathers being protective only against cold. Finally, in the human species, even the covering of hairs is nearly lost, and in external condition the highest form of animal life approaches the lowest.

A like tendency to pass from the armored to the unarmored condition appears in invertebrate life. In most of the invertebrates the dermal covering serves as a basis of muscular attachment, and cannot be dispensed with. The soft-bodied invertebrates of low orders, such as the worms, the medusæ, etc., are probably survivals of the primitive life condition, and may indicate the general character of pre-Cambrian life. But in the higher mollusks a very interesting variation appears. The Palæozoic cephalopods were all covered with a dense protective armor. In the Mezozoic period this class began to give way to an unarmored class, with a change in the character of its muscular attachment. To the tetrabranchiates, with muscles attached to the external shell, were added the dibranchiates, with naked surface, and an internal basis of muscular attachment. Since that period the evolutionary process has been highly interesting. The armored cephalopods have gradually disappeared, until only the Nautilus remains. The unarmored forms have rapidly increased, until they abundantly people the modern seas.

The process of modification I have here briefly indicated has another interesting feature, which may be pointed out. This is that the modification has not taken place by a simple change in the dermal structure of existing types, but that this change has been accompanied by a radical change in organic structure. The representatives of the old forms have retained much of their old surface structure. The radical variation in surface condition has been confined to new types of life.

In the case of the primitive soft-bodied animals, for instance, they have probably had representative forms throughout the whole era of life, and may be closely simulated by the soft-bodied ocean animals yet existing. The assumption of armor by certain forms was probably accompanied by a marked change in structure, the dermal variation being co-related with other important changes. Of this, of course, we cannot be sure, but in the parallel case of the discarding of armor this idea holds good. The Ganoids continue armored fishes to the present day. The prevailing thin-scaled fishes are of a new structural type. In the cephalopods we do not find a simple discarding of shells by the armored type, but the gradual disappearance of this type, and its replacement by a type of markedly different structure. In the vertebrata generally the antique types have preserved the scaled condition to a greater or less extent. It is in the new structural types, the birds and mammals, that this antique condition has been most fully discarded, and replaced by a radically distinct dermal covering. It would almost seem as if it had been impossible for any type of animal to completely dispense with a primitive structural feature except under the influence of a general organic change. In the assumption of armor the whole organic structure may have suffered a correlated change. In the discarding of armor a like radical change in structure has taken place, while the representatives of the ancient types have preserved their ancient dermal conditions.

I present these simply as a series of well-known facts. It is with the cause of these facts that I am mainly concerned. Why did animal life exist for a long period without protective covering; then adopt armor of defense, and develop it to an extraordinary degree; and finally slowly discard this armor, and return towards the unprotected condition? We have here a remarkable series of evolutionary changes. They undoubtedly had sufficient and powerful causes. What were those causes?

These we need not go far to seek. They are plainly evident. The variations described have taken place under the influence of one of the most active and efficient agents in evolution, that of the reciprocal influence of attack and defense on animal structure. To this agent in animal change there has not been given so much attention as it demands. It is, indeed, but one out of numerous agents which act to modify animal form and structure. But among these agents it has been one of the most active, efficient and unceasing.

The effort of food animals to escape from carnivorous foes, has given rise to a great variety of defensive tissues, functions, and habits. It has aided in the natural selection of armor of various kinds, of defensive weapons, of speed and flexibility of motion, of size and strength of body, of cunning and alertness, and of many other characteristics, each of evolutionary importance. And the study of animal development goes to show that these varied conditions have been assumed successively. Nature has apparently fully worked out the capabilities of one mode of defense before proceeding to another.

The effort to capture and destroy food animals has been equally important as an agent in evolution. It has caused the natural selection of weapons of offense, such as claws and teeth, of strength, swiftness, agility, alertness, cunning, and the like attributes of mind and body, together with many special habits, all of which form steps in evolution. The main cause of this advance has been the reciprocal action of these agencies. If a food animal gained some structural feature which gave it an advantage over its carnivorous foes, the latter would be at a disadvantage until they had gained equivalent features. So if a carnivorous animal gained some habit, motion or weapon which gave it an advantage in destroying, this must have acted as an incitement to a corresponding development in food animals. Natural selection has, in both cases, preserved the forms best adapted to the new conditions of attack or defense, and the carnivora and herbivora have, in a metaphorical sense, pursued each other up the ladder of evolution.

In this process now one class, now the other, may have taken the lead. If at any time the two classes were evenly balanced in powers of attack and defense, any new power of defense or escape in the food animals would undoubtedly be preserved by natural selection. It would give them an advantage in the struggle for existence, which could not be overcome until the carnivora had gained a correlated development. On the other hand any new offensive weapon or method would give the carnivora an advantage, which would render necessary some new defensive adaptation in food animals.

In this process of evolution we find several instances in which defensive appliances seem to have gained a special development, which were only slowly met by new methods of attack. Such I conceive to have been the case when the power of secretion of dermal armor was once attained, and to the high value of this defensive expedient I ascribe its rapid development. According to my theory of the case the preceding animals had been naked skinned, and the destructive weapons of the carnivora such as were adapted to the capture of soft-bodied prey. There is not a shred of evidence that any toothed forms existed preceding or during the Cambrian era, nor until well on in the Silurian. Yet toothless animals could not easily overcome animals with a strong covering of bone or other hard material. It is to this fact that I ascribe the rapid increase in number and variety of armored forms. Their armor gave them a special advantage in defense, and under this idea there is no difficulty in understanding the very rapid and general evolution of this structural feature of animal life.

In fact, as a result of the development of defensive armor, a discrepancy arose between the agencies of attack and defense. Defense had the best of it. A structural feature had been rapidly acquired, which could only be met by some corresponding new means of attack, and this new carnivorous weapon took a long time to develop.

The new weapon, through whose aid the aggressive again slowly matched the defensive appliances, made its appearance in the form of the tooth. It but slowly grew effective. The first evidence we find of teeth are the minute *conodonts*, which may or may not have had this function. Fish teeth at first appear in small and weak forms, but they gradually grow large and powerful, and well adapted for cutting and crushing. A race between aggressive and defensive powers apparently took place. Armor grew thicker and denser as teeth became more efficient. As one result of the race we have the great Devonian fishes, with their powerful armor and teeth. The toothless invertebrates probably still fed on small, unarmored prey.

In all cases, however, the most powerful animals would have little or no need of defensive armor. The armed Ganoids probably needed defense against each other. But it is likely that they were mainly defended against the great Elasmobranchs, which were the ruling tyrants of the seas, and which needed no defense beyond their osseous tubercles and spines, this type of armor permitting the utmost flexibility of motion. As Packard says of them: "Sharks and skates are engines of destruction, having been, since their early appearance in the upper Silurian age, the terror of the seas. Their entire structure is such as to enable them to seize, crush, tear and rapidly digest large invertebrates, and the larger marine members of their own class. Hence their own forms are gigantic, soft, not protected by scales or armor, as they have in the adult form few enemies." Such seems to have been the outcome of the agencies of attack and defense in the palæozoic era, a minor series of soft-bodied animals, an intermediate series of strongly armored animals, and a superior series of animals, adapted to break through the strongest defensive armor.

As a result of this evolutionary process the powers of assault and defense again became equalized, and armor lost its special value as a defensive agent. From that time forward defense seems to have adopted a new expedient, and a fresh series of modifications arose. If armor had become of little value in defense, flight remained useful. But armor impeded flight, both from its weight and the rigidity of body it produced. Thus for the development of speed, agility and flexibility of motion, it was necessary to get rid of armor; and during the whole of the later geological periods this has been the character of the evolutionary process, at least in the free-moving animals. Food animals have thrown off their armor, and trusted to speed and flexibility of motion for safety. Carnivorous animals have followed in the same direction, and got rid of their disabling armor.

If we pursue this subject further we can perceive the successive adoption of several other expedients. It is impossible to say whether flight or pursuit first aided in the development of winged animals. But it is evident that flying food animals would be nearly safe from the attacks of surface carnivora, and would gain a security which only the development of flying carnivora could overcome. The same may be said of tree-living and burrowing animals. It seems highly probable that all these expedients were first adopted in the effort to escape destruction, and that similar expedients were afterwards adopted by carnivora in their pursuit of prey. It would not be safe to declare that the various expedients mentioned were in every case first adopted by food animals, and afterwards by the pursuing carnivora, but the probability is that this was the case as a general rule.

I may briefly refer to one other and a highly important result of this evolutionary process. When powers of flight had become balanced by powers of pursuit, it is evident that this expedient, like that of armor, had lost its special utility. As a result another and final expedient began a special development. Cunning and shrewdness came into play as aids in escape. The mental powers of animals began to strongly unfold. This was the case in both classes of animals, and it is impossible to say which took the lead. In both classes cunning, concealment, reasoning powers, came into play, and blind flight and pursuit, or defense through sheer bulk and strength, became succeeded, in many cases, by the higher and more efficient agency of the mind. Instinct became less dominant in animal life; reason more dominant. In other words, the mind grew more active and varied in its operations.

The growth of this most recent animal modification is manifest in the character of the later geological life. The development of the brain becomes marked as we enter the tertiary era, and the capacity of the brain cavity steadily increases throughout this era. What is called cephalization is the most important characteristic of animal development throughout the tertiary age. In the recent era this has reached its culmination, and mental expedients have replaced physical conditions in the highest life types as the most efficient agencies of attack and defense.

Thus we seem to perceive four successive ideas emerging into prominence in the development of the animal kingdom. In the primeval epoch it is probable that only soft-bodied animals existed, and the weapons of assault were the tentacle, the thread cell, the sucking disk, and the like unindurated weapons. At a later period armor became generally adopted for defense, and the tooth became the most efficient weapon of attack. Still later armor was discarded, and flight or concealment became the main methods of escape, and swift pursuit the principle of attack, while claws were added to teeth as assailing weapons. Finally mentality came into play, intelligence became the most efficient agent both in attack and defense, and a special development of the mind began. As a culmination of the whole, we have man, in whom mentality has replaced all other agents in the struggle for existence. But side by side with man all the other types exist, the soft-bodied, the armored, the swift-moving, and those in which cunning precedes the higher mentality. In the existing conditions of life upon the earth we have an epitome of the whole long course of evolution.

NOVEMBER 17.

Mr. THOS. MEEHAN, Vice-President, in the chair.

Thirty-two persons present.

The deaths of Wm. G. Platt, a member, and of Wm. B. Carpenter, a correspondent, were announced.

NOVEMBER 24.

The President, Dr. LEIDY, in the chair.

Twenty-two persons present.

A paper entitled "Notes on the Lafayette Serpentine Belt," by Theo. D. Rand, was presented for publication through the Mineralogical Section.

The following were elected members:

John H. Campbell, W. G. A. Bonwill, M. D., Chas. S. Dolley, M. D., Chas. N. Davis and Wm. D. Averell.

The following was ordered to be printed:

A REVIEW OF THE AMERICAN SPECIES OF THE GENUS SCORPÆNA.

BY SETH E. MEEK AND ROBERT NEWLAND.

In the present paper is given the synonymy of the American species of the genus *Scorpæna*, with an analytical key, by which the species may be recognized. For purposes of comparison, the two European species are included in the key and their synonymy is given in part. *Scorpæna dactyloptera* is not included in this analysis, as with Dr. Gill, we refer it to a distinct genus *Sebastoplus*.

The specimens examined by us all belong to the museum of the Indiana University, most of them having been collected by Professor Jordan. To Professor Jordan we are under many obligations in connection with our study of this and other groups of fishes.

Genus **SCORPÆNA**, Linnæus.

Scorpæna, Artedi, Genera Piscium, 1738, 47.

Scorpæna, Linnæus, Systema Naturæ, 1766, 452 (*porcus*).

Pontinus, Poey, Memorias Cuba, ii, 1860, 173 (*castor*).

Sebastapistes, (Gill) Streets, Bull. U. S. Nat. Mus. vii, 1877, 62 (*guttata; strongia; cyanostigma*).

Analysis of Species of Scorpæna.

a. Occiput with a distinct quadrate pit, about as large as eye.

b. Breast not scaly; second anal spine decidedly stronger than the third; coronal spines present.

c. Scales rather large, thin, most of them with dermal flaps; about 40 scales in lateral line; a small distinct pit between the lower anterior margin of orbit and suborbital stay; dorsal fin high, its longest spine 1$\frac{4}{5}$ to 2 in head; longest anal spine 3$\frac{1}{5}$ in head; eye small, 4$\frac{3}{4}$ to 5 in length of head; supraocular tentacles less than the diameter of eye; pit at occiput rather shallow, nearly square. Head 2$\frac{1}{3}$; depth 3; D. XII–10; A. III–5. Axil dusky with no distinct spots. Fins all whitish, marbled with darker; irregular dark markings on sides. *Scrofa*. 1.

cc. Scales small, firm, a few below the lateral line with dermal flaps. About 65 scales in the lateral line; no distinct pit between the lower anterior margin of the orbit and suborbital stay; dorsal fin lower, its longest spine $2\frac{1}{4}$ in head; anal spine $2\frac{1}{4}$ in head. Eye larger, $4\frac{1}{4}$ in head. Supraocular tentacles about as long as diameter of eye. Head $2\frac{1}{2}$; depth $2\frac{2}{3}$; D. XII–10; A. III–5. Axil dusky, with one or more dark spots. Body brownish red, marbled with darker, and dotted with deep black, which sometimes forms edges around the darker spots. *Porcus.* 2.

bb. Breast scaly.

d. Coronal spines present; supraocular tentacles about equal to diameter of eye.

e. Third anal spine evidently longer and stronger than the second; suborbital stay armed with three spines; no distinct pit between lower anterior margin of orbit and suborbital stay; length of second anal spine $2\frac{1}{2}$ (young) to 3 (adult) in head; longest dorsal spine $2\frac{1}{6}$ in head. Head $2\frac{1}{2}$; depth $2\frac{2}{3}$; scales in lateral line about 48; some of the scales with dermal flaps. D. XII–10; A. III–5. Supraocular tentacles less than diameter of eye; axil dusky, with small round brownish spots. Color brownish, clouded with darker; a few darker dots behind pectorals. *Brasiliensis.* 3.

ee. Third anal spine shorter and weaker than second.

f. Suborbital stay not armed with spines; occipital pit evidently broader than long.

g. Cheeks scaly; fins low; longest dorsal spine $2\frac{1}{2}$ to 3 in head; no distinct pit between lower anterior margin of orbit and suborbital stay.

h. Scales large, some of them with dermal flaps; about 30 in the lateral line; supraorbital tentacles well developed. Head $2\frac{1}{10}$; depth $3\frac{1}{6}$; D. XII–10; A. III–5; longest dorsal spine 3 in head; longest anal spine 3 in head; eye $4\frac{1}{2}$ in head. Color gray or red, with broad, darker shades, irregular and variable; fins similarly colored; pectorals barred (*Günther.*) *Histrio.* 4.

hh. [1] [Scales smaller, without dermal flaps; about 46 scales in the lateral line. Head $2\frac{3}{4}$; depth $3\frac{2}{3}$; eye $3\frac{3}{4}$ in head; longest dorsal spine $2\frac{1}{2}$ in head; longest

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[1] These characters are taken from Valenciennes figure, and are all more or less doubtful.

anal spine $2\frac{1}{2}$ in head. D. XII–10; A. III–5. Head chiefly red; red markings on dorsal fin and on back; pectoral fins barred.] *Fucata.* 5.

gg. Cheeks not evidently scaly; fins higher; longest dorsal spine 2 in head; a distinct pit between lower anterior margin of orbit and suborbital stay; scales smaller; about 50 in the lateral line; no dermal flaps except along the lateral line, where they are small; supraorbital tentacles small; about $\frac{1}{2}$ diameter of eye. Head $2\frac{1}{2}$; depth $3\frac{1}{4}$; eye $4\frac{1}{2}$ in head; axil dusky, with round brownish spots on its upper part; body with many round brownish-black spots, some of which are nearly as large as eye. *Guttata.* 6.

ff. Suborbital stay armed with three or four spines; occipital pit about as long as broad.

i. No distinct pit between lower anterior margin of orbit and suborbital stay. Head entirely naked; supraorbital tentacles little developed. less than diameter of eye; a few scales with dermal flaps, lateral line with 42 scales.

Head $2\frac{1}{2}$; depth $2\frac{2}{3}$; D. XII–10; A. III–5. Longest dorsal spine $2\frac{1}{2}$ in head; longest anal spine $2\frac{1}{3}$ in head; eye 5 in head.

Reddish, marbled with darker, all of the fins light colored, scantily spotted (*Günther*). *Thompsoni.* 7.

ii. A distinct pit between lower anterior margin of orbit and suborbital stay; upper parts of opercle scaly; supraorbital tentacles well developed, longer than eye; most of the scales provided with dermal flaps; lateral line with 30 scales. Head $2\frac{2}{5}$; depth 3; D. XII–10; A. III–5. Longest dorsal spine $2\frac{2}{3}$ in head; axil of pectoral black with few white spots; olive-brown, excessively marbled with silvery and reddish; fins profusely variegated; caudal barred with brown and silvery; a dark blotch on spinous dorsal between the sixth and seventh spines. *Plumieri.* 8.

dd. Coronal spines absent. Supraocular tentacles high, more than twice the diameter of the eye; occipital pit rather deep; longest dorsal spine $2\frac{1}{4}$ in length of head; head $2\frac{1}{2}$; depth $2\frac{3}{4}$. About 38 scales in the lateral line; eye 4 in head; dermal flaps on lateral line longer than eye, a few of the scales on upper and posterior parts of the body with dermal flaps. Suborbital stay with a small spine near its centre, one on its posterior end; axil dusky, with small white dots on its upper portion; color reddish, marbled with brown. Head and body minutely dotted with white; caudal and anal fins with broad white bands. *Grandicornis.* 9.

aa. Occiput without evident pit; no pit between lower anterior margin of orbit and suborbital stay; cheeks scaly.

j. Pectoral rays all simple; opercle and subopercle well scaled; occipital pit obsolete; dermal flaps on scales of the lateral line and belly. Supraorbital tentacles not branched, $\frac{1}{5}$ the length of the body. Second anal spine moderate; spinous dorsal low, D. XII–10; A. III–5. Color uniform carmine-red, the fins somewhat clouded with orange. Supraorbital tentacle and lower pectoral with brown bands. Head $2\frac{1}{2}$ total length; eye 5 in head. *Castor.* 10.

jj. Pectorals with some of their upper rays branched.

k. Scales large, about 28 in the lateral line; occipital cavity almost obsolete; longest dorsal spine $2\frac{2}{3}$ in head; longest anal spine 3 in head; second and third anal spines subequal; few of the scales with dermal flaps. Eye about $3\frac{1}{3}$ in head. Suborbital stay armed with two small spines; supraocular flaps minute, a few small flaps on the head; depth of body 3 in length. Color dusky grayish, marbled with blackish; a black suborbital bar; a black bar at base of caudal; axil of pectoral whitish with dusky specks, a black spot on its upper edge; ventrals mostly black (*Goode and Bean*). *Occipitalis.* 11.

kk. Scales small, about 47 in the lateral line; longest dorsal spine $2\frac{1}{4}$ in head; longest anal spine $1\frac{2}{3}$ in head; second anal spine evidently longer and stronger than the third. Head $2\frac{2}{3}$; depth 3; eye

4 in head. Sides of body brownish, with darker brown marmorations; a black spot on upper part of spinous dorsal between the seventh and tenth spines. Supraorbital tentacles very small (*Steindachner*). *Fernandeziana.* 12.

1. **Scorpæna scrofa.**

Scorpæna scrofa Linnæus, Systema Natura, 12th ed., 1766, 455 (Mediterranean Sea); Gmelin, Systema Natura, 1788, 1215 (Mediterranean); Turton's Linnæus, Systema Natura, 1800, 756 (Mediterranean); Lacépède, Hist. Nat. Poiss., iii, 1800, 259, 280; Bloch & Schneider, Systema Ichthyol., 1801, 192 (Atlantic; Mediterranean); Risso. Ichth. Nice, 1810, 188 (Nice); Cuvier & Valenciennes, Hist. Nat. Poiss., iv, 1829, 288 (Mediterranean); Günther, Cat. Fish. Brit. Mus., ii, 1860, 108 (Mediterranean; Malta; Dalmatia; North Africa; Lisbon; River Niger; Azores; Madeira); Steindachner, Ichth. Notiz. & Berichte, iv, 1867, 75; (Barcelona; Tarragona; Valencia; Cadiz; Gibraltar; La Coruña; Vigo; Lisbon; Teneriffe; Sentubal); Bean, Proc. U. S. Nat. Mus., 1879, 23 (Gibraltar; and of authors generally).
Scorpæna barbata Lacépède, Hist. Nat. Poiss., iii, 1800, 274.
Scorpæna lutea Risso, Ichth. Nice, 1810, 190 (Nice).
? *Scorpæna ustulata* Lowe, Proc. Zoöl. Soc., 1849, 36 (Madeira); Günther, Cat. Fish. Brit. Mus., 1860, 110 (copied.)

Habitat.—Mediterranean Sea and the adjacent Atlantic.

The numerous specimens of *Scorpæna scrofa* examined by us were collected at Venice by Dr. Jordan.

2. **Scorpæna porcus.**

Scorpæna porcus Linnæus, Systema Natura, ed. x, 1758, 266 (Mediterranean); Linnæus, Systema Natura, ed. xii, 1766, 452 (Madeira); Turton's Linnæus, Systema Natura, 1800, 755 (Mediterranean); Bloch & Schneider, Systema Ichthyol., 1801, 192 (Mediterranean and Atlantic): Risso, Ichthyol. Nice, 1810. 187 (Nice): Cuvier & Valenciennes, Hist. Nat. Poiss., iv. 1829, 300 (Mediterranean, Teneriffe, Caen; New York ??); DeKay, N. Y. Fauna Fish., 1842, 58 (copied); Günther, Cat. Fish. Brit. Mus., ii, 1860, 107 (Mediterranean; Dalmatia: Adriatic; Bay of Naples; Lisbon; Lanzarote); Steindachner, Ichth. Notizen und Berichte, 1867, 74 (Barcelona; Tarragona; Valencia: Alicante: Malaga; Cartagena: Gibraltar; Cadiz; Setubal; Lisbon; La Coruña; Vigo: Algorta; Santa Cruz: Teneriffe); Bean, Proc. U. S. Nat. Mus., 1879, 23 (Constantinople; Marseilles); Jordan & Gilbert. Syn. Fish. N. A., 1883, 68 (Southern Europe).
Cottus massilensis Forskal. Desc. Animal. 1775, 24 (Marseilles).
Scorpæna massilensis Lacépède. Hist. Nat. Poiss., iii, 1829, 269 (Marseilles); Cuvier & Valenciennes, Hist. Nat. Poiss., iv, 1829, 303.

Habitat.—Mediterranean Sea and adjacent Atlantic. The locality "New York," given by Cuvier and Valenciennes, is doubtless an error.

The numerous specimens examined by us are from the market of Venice.

3. **Scorpæna brasiliensis.**

Scorpæna brasiliensis Cuvier & Valenciennes, Hist. Nat. Poiss., iv, 1829, 305 (Brazil); Günther, Cat. Fish. Brit. Mus., ii, 1860, 112 (South America; Rio Janeiro; Bahia); Kner, Novara Fische., 1865, 114 (Rio Janeiro); Jordan, Cat. Fish. N. A., 1885, 109.

Scorpæna stearnsi Goode & Bean, Proc. U. S. Nat. Mus., 1882, 236 (Gulf of Mexico); Goode & Bean, Proc. U. S. Nat. Mus., 1882, 421 (Pensacola); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 614 (Charleston); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 620 (Charleston); Jordan & Gilbert, Syn. Fish. N. A., 1883, 951; Jordan, Proc. Acad. Nat. Sci., Phila., 1884, 45 (Egmont Key).

Habitat.—Atlantic coast of America from Charleston to Rio Janeiro.

The specimens of this species examined by us are from Key West and Pensacola, Florida.

There seems to be no serious reason to doubt that *Scorpæna brasiliensis* is identical with the species known on our coast as *Scorpæna stearnsi.*

4. **Scorpæna histrio.**

Scorpæna histrio Jenyns, Zoöl. Voy. Beagle, Fishes, 1842, 35, pl. 8 (Chatham Island: Galapagos Archipelago); Günther, Cat. Fish. Brit. Mus., ii, 1860, 115 (copied); Steindachner, Ichthyol. Beiträge, ii, 1875, 8 (Juan Fernandez); Jordan, Proc. Acad. Nat. Sci. Phila., 1884, 292 (Chinchas Islands).

? *Scorpæna fucata* Valenciennes, "Voy. Venus, v, Zoöl., 1855, 313, Pl. 3, fig. 2" (Galapagos Archipelago).

Habitat.—Chatham Island; Galapagos Archipelago.

The figure of *Scorpæna fucata* differs in only a few minor characters from *S. histrio*, and was probably intended for that species. The differences may be due to the mistakes on the part of the artist employed by Valenciennes.

5. **Scorpæna guttata.**

Scorpæna guttata Girard, Proc. Acad. Nat. Sci. Phila., 1854. 145 (Monterey); Girard, U. S. Pac. R. R. Surv., 1859, 77, Pl. 17 (Monterey): Jordan & Gilbert, Proc. U. S. Nat. Mus., 1880, 455 (Santa Barbara; San Pedro; San Diego); Jordan & Jouy, Proc. U. S. Nat.

Mus., 1881, 6 (Wilmington, California; Santa Catalina; San Pedro; Santa Barbara); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1881, 278 (Ascension Islands; West Coast of Lower California); Jordan & Gilbert, Syn. Fish. N. A., 1883, 679; Jordan, Cat. Fish. N. A., 1885, 109.

Sebastopistes guttata (Gill) Streets, Bull. U. S. Nat. Mus., vii, 1877, 62 (generic diagnosis).

Habitat.—Coast of California, from Point Conception southward to Cerros Island.

We have examined two specimens of this species, both from Southern California.

6. **Scorpæna Thompsoni.**

Scorpæna thompsoni Günther, Voyage of the Challenger, Fishes, 1880, 24, pl. xii (Juan Fernandez).

Habitat.—Juan Fernandez.

This species is known only from Günther's description and figure.

7. **Scorpæna plumieri.**

Rascacio Parra, Dif. Piezas Je' Hist. Nat., 1787, 34, pl. 18, fig. 9 (Havana).

Scorpæna plumieri Bloch, Kon. Vet. Acad. Nya. Hand'gr. Stockholm, x, 1789, 234 (Martinique; on a drawing by Plumier); Bloch & Schneider, Systema Ichthyol., 1801, 194 (Antilles; Günther, Cat. Fish. Brit. Mus., ii, 1860, 113 (Jamaica; West Indies; South America); Kner, Novara Fische, 1866, 114 (Rio Janeiro; Jordan & Gilbert, Bull. U. S. Fish. Comm., 1882, 108 (Mazatlan; Jordan & Gilbert, Bull. U. S. Fish. Comm., 1882, 111 (Panama); Goode & Bean, Proc. U. S. Nat. Mus., 1882, 233 (Gulf of Mexico); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 377 (Panama; Jordan & Gilbert. Proc. U. S. Nat. Mus., 1882, 627 (Panama); Jordan & Gilbert, Syn. Fish. N. A. 1883, 680 (Mazatlan); Jordan, Proc. U. S. Nat. Mus., 1884, 137 (Key West; Jordan, Cat. Fish. N. A., 1885, 109.

Scorpæna bufo Cuvier & Valenciennes, Hist. Nat. Poiss., iv, 1829, 306 (Martinique; Brazil; Richardson, "Fauna Bor. Amer. Fishes, 1839, 200"; Newfoundland, by error for Florida.

Scorpæna bufo De Kay, N. Y. Fauna Fishes, 1842, 59, pl. 70, fig. 227 (copied).

Scorpæna rascacio Poey, Memorias Cuba, ii, 1860, 169 (Havana); Poey, Syn. Pisc. Cub., 1868, 303 (Havana); Poey, Enum. Pisc. Cub., 1875, 40 (Havana); Castelnau, "Anim. nouv. ou rares. Amer. Sud. Poiss., 1861, 7."

? *Scorpæna scrofina* Cuvier & Valenciennes, Hist. Nat. Poiss., 1833, 465 (Brazil).

Apistes exul. Gosse, "Natur. Soj. Jamaica, 1856, 207" (Jamaica).

Habitat.—West Indies; Atlantic and Pacific Coasts of Tropical America, north to Florida.

This species was studied from specimens varying in length from three to eight inches, collected at Havana and Key West, by Dr. Jordan.

The species may be known at once by the coloration of the pectoral axil, which is jet black, with large white spots.

Below is given a table of measurements of three specimens from Key West. The proportions are given in hundredths of length from tip of snout to the end of last vertebra:

Extreme length of fish in inches,	8	7½	4^1
Length of fish from end of snout to last caudal vertebra, in inches,	6	5¾	3^1
Greatest depth of fish (hundredths of the above),	34	34	35½
Greatest width of body,	28	32½	26
Length of head,	45	48½	46½
Length of maxillary,	22	23½	22½
Distance from snout to orbit,	13	13	13
Diameter of orbit,	9	10	11
Height of highest dorsal spine,	16	18	19½
Height of highest dorsal ray,	18	16	
Length of pectoral,	36	37½	34
Width of pectoral base,	19	17	18
Length of ventrals,	31	31	30
Height of second anal spine,	20½	21½	26½
Height of third anal spine,	18½	19	21

8. **Scorpæna grandicornis.**

Scorpæna grandicornis Cuvier & Valenciennes, Hist. Nat. Poiss., iv, 1829, 309 (Martinique: Porto Rico; Havana: San Domingo); Günther, Cat. Fish. Brit. Mus., ii, 1860, 114 (Jamaica); Poey, Syn. Pisc. Cub., 1868, 303 (Havana); Poey, Enum. Pisc. Cub., 1875, 40 (Havana); Jordan, Proc. U. S. Nat. Mus., 1884, 138 (Key West); Jordan, Cat. Fish. N. A., 1885, 109.

Scorpæna plumieri Lacépède, Hist. Nat. Poiss., ii, 1800, 282, pl. 19, f. 3 (not of Bloch and Schneider, based on a drawing by Plumier: Martinique).

Habitat.—West Indies, Florida Keys to Brazil.

Our study of this species was made from numerous small specimens, none exceeding five inches in length, collected at Key West by Dr. Jordan, and from a large example taken at Havana.

The species may be readily distinguished by the absence of coronal spines, by the great size of the supraocular tentacles, and by the small white spots in the pectoral axil.

Below is given a table of measurements of three specimens of *Scorpæna grandicornis* from Key West. The proportions are given in hundredths of the length from tip of snout to end of last vertebra.

Extreme length of fish, in inches,	4½	4½	2
Length of fish from end of snout to last caudal vertebra, in inches,	3½	3½	1½
Greatest depth of body (hundredths of the above),	40½	43	40
Greatest width of body,	21	22	22
Length of head,	42½	42½	43
Length of maxillary,	20	19½	20
Distance of snout from orbit,	9½	9½	10
Diameter of orbit,	10½	11	12
Height of highest dorsal spine,	21	19½	22
Height of longest dorsal ray,	19½	20	17
Height of second anal spine,	23	21	24
Height of third anal spine,	20	20	20½
Length of pectoral fin,	35½	34	35
Width of base of pectoral,	20	15½	15
Length of ventrals,	28	29	88½

9. **Scorpæna castor.**

Pontinus castor Poey, Memorias Cuba, ii, 1860, 173 (Havana); Poey, Syn. Pisc. Cub., 1868, 303 (Havana); Poey, Enumeratio Pisc., Cub., 1875, 4 (Havana).

? *Pontinus pollux* Poey, Memorias Cuba, ii, 1860, 174 (Havana); Poey, Syn. Pisc. Cub., 1868, 300 (Havana); Poey, Enumeratio Pisc. Cub., 1875, 4 (Havana).

Habitat.—Havana.

We know this species only from the descriptions of Professor Poey.

The genus *Pontinus* seems to be synonymous with *Scorpæna.* From Poey's description of *Pontinus pollux*, we are unable to find any positive characters by which to distinguish it as a species from *Scorpæna castor.*

10. **Scorpæna fernandeziana.**

Scorpæna fernandeziana Steindachner, Ichthyol. Beiträge, ii, 1875, 9 (Juan Fernandez).

Habitat.—Juan Fernandez.

This species is known only from Steindachner's description.

11. **Scorpæna occipitalis.**

? *Scorpæna inermis* Cuvier & Valenciennes, Hist. Nat. Poiss., iv, 1829, 311 (Martinique).

Scorpæna occipitalis Poey, Memorias Cuba, ii, 1860, 171 (Havana); Poey, Syn. Pisc. Cub., 1868, 303 (Havana); Poey, Enumeratio, Pisc. Cub., 1875, 41 (Havana); Jordan, Cat. Fish. N. A., 1885, 109.

Scorpæna calcarata Goode & Bean, Proc. U. S. Nat. Mus., 1882, 422 (Clear Water Harbor, Florida); Jordan & Gilbert, Syn. Fish. N. A., 1883, 952 (West Coast of Florida).

Habitat.—Havana; West Coast of Florida.

On comparison of Poey's description of *S. occipitalis*, with the description *S. calcarata* by Goode and Bean, we can find nothing by which to distinguish them as distinct species.

Scorpæna inermis, very briefly described by Cuvier and Valenciennes, resembles this species more than any other.

The following is a list of the nominal species referred to in the foregoing paper, arranged in chronological order, with our identification of each. Tenable specific names are printed in italics:—

Nominal Species.	*Year.*	*Identification.*
Scorpæna *porcus* Linnæus,	1758.	Scorpæna porcus.
Scorpæna *scrofa* Linnæus,	1766.	Scorpæna scrofa.
Cottus massiliensis Forskal,	1775,	Scorpæna porcus.
Scorpæna *plumieri* Bloch,	1789,	Scorpæna plumieri.
Scorpæna barbata Lacépède,	1800,	Scorpæna scrofa.
Scorpæna plumieri Lacépède,	1800,	Scorpæna grandicornis.
Scorpæna lutea Risso,	1810,	Scorpæna scrofa.
Scorpæna *brasiliensis* Cuv. & Val.,	1829,	Scorpæna brasiliensis.
Scorpæna bufo. Cuv. & Val.,	1829,	Scorpæna plumieri.
Scorpæna *grandicornis* Cuv. & Val.	1829,	Scorpæna grandicornis.
Scorpæna inermis Cuv. and Val.,	1829,	? Scorpæna occipitalis.
Scorpæna scrofina Cuv. & Val.,	1833,	Scorpæna plumieri.
Scorpæna ustulata Lowe,	1840,	? Scorpæna scrofa.
Scorpæna *histrio* Jenyns,	1842,	Scorpæna histrio.
Scorpæna *guttata* Girard,	1854,	Scorpæna guttata.
Scorpæna fucata Valenciennes,	1855,	? Scorpæna histrio.
Apistes exul Gosse,	1856,	Scorpæna plumieri.
Scorpæna rascacio Poey,	1860,	Scorpæna plumieri.
Scorpæna *occipitalis* Poey,	1860,	Scorpæna occipitalis.
Scorpæna *fernandeziana* Steindachner,	1875,	Scorpæna fernandeziana.
Pontinus *castor* Poey,	1875.	Scorpæna castor.
Pontinus pollux Poey,	1875,	? Scorpæna castor.
Scorpæna *thompsoni* Günther,	1880,	Scorpæna thompsoni.
Scorpæna stearnsi Goode & Bean,	1882,	Scorpæna brasiliensis.
Scorpæna calcarata Goode & Bean,	1882,	Scorpæna occipitalis.

DECEMBER 1.

The President, Dr. LEIDY, in the chair.

Thirty-eight persons present.

On a white-seeded variety of the Honey Locust.—Mr. **THOMAS MEEHAN** exhibited seeds of a tree of the Honey Locust, *Gleditschia triacanthos*, growing near Germantown, which were white instead of dark olive-brown as in the normal condition. The tree was of considerable age, and had evidently been bearing fruit for many years. He had had, he said, many opportunities of examining Honey Locust seeds, but had never seen or heard of a white seeded one before. The seeds instead of being narrowly ovate twice the length of the breadth as usual, were nearly orbicular, illustrating a point not new but worth emphasizing, that when a plant varied from its parent in any one respect, it was liable to have variations in others. A whole system of variations followed a single departure. But the best use of this departure was to illustrate a point not yet perceived in its full force, as he believed, that variation is not nearly as much dependent on environment as many eminent men believe. When variations occur it is difficult for some to believe that cross-fertilization, a return to some characteristic of an ancient parent, or some accident of climate or soil had not an agency in the change. In cases such as this, where there was no other shade of color to cross with, no known progenitor with any variation in the color of the seeds, no accident of climate or soil to influence this one tree more than others growing near, it was difficult to understand how anything as yet suggested could be a factor in the change. We have to use yet the indefinite and meaningless expression that the change was caused by the plant's own innate power to change, an expression, which, obscure as it might be, is yet of service by excluding much from the examination that might add to the complexity of the investigation.

Another interesting suggestion from these seeds was the hereditary power which a new variation possessed. There had been no time to ascertain whether these seeds would again reproduce trees with white seeds; but by analogy drawn from similar departures in other plants, there is no doubt the reproduction of the variety would be as continuous as in the best recognized species.

It could hardly be supposed that since the first appearance of the Honey Locust on the earth, this was the first time the tree had ever produced white seeds, though he had never seen one or knew of any recorded instance. In view of the hereditary character of these variations, it might be asked why has not some early white departure perpetuated and propagated itself so that such trees should be quite common in this era? The different abilities of various classes of plants to propagate themselves were pointed out. Of small seeds produced by such a plant as chickweed, hundreds get the chance to grow. Perennial plants, such as Aster, Golden Rods, also, in a general way, had great facilities for seed germination, hence any departure from a parental form had a good chance to perpetuate itself, the only great enemy being the struggle of the young living plants to get a portion of the nutrition necessary for life. Hence we had many variations among such genera very puzzling to naturalists, running the species together so that it was only with great difficulty the species of some genera could be classified. Among trees with larger seeds it was difficult to perpetuate the race, and it was providential in many cases that longevity was great, or the race would soon have become extinct. Of the hundreds of thousands of Acorns, Chestnuts, Beechnuts, and other similar seed produced in a forest in any one season, only a few score would get a chance to grow up to produce seeds again. Birds, quadrupeds, and insects ate the seeds by thousands, large numbers could not sprout for want of a proper covering of earth. Of those which sprouted, numerous were they that failed to get beyond the first year; and of these, shade, or the innumerable struggles they were subjected to, permitted them not to reach mature age. He had known Honey Locust trees, single specimens, bearing fruit annually for over a quarter of a century in some instances, and yet to be but solitary specimens of their kind in their immediate location. As a rule, the chance of a new departure perpetuating itself was small, but sometimes circumstances seemed to favor the production of seedlings. Once in a while, under the trees in a Pine, Oak, Maple, or other forest, or under large trees, numerous seedlings might be noticed. It was only when a new departure found itself under these exceptional cases, that enough trees would be produced to extend and perpetuate the race, and then it was that we had to recognize the distinct variety, or even species, as we often had to call the departure by reason of its great distinctness from its parental form.

Mr. Meehan referred to some recent discussions on variation in Indian Corn. Cross-fertilization often made great changes in the immediate coloring of the seeds. There were some who argued that change comes also from innate power to vary. Such instances as this of the Honey Locust confirmed this view.

DECEMBER 8.

The President, Dr. LEIDY, in the chair.

Thirty-one persons present.

A paper entitled, "On some new species of Psocidæ," by S. Frank Aaron, was presented for publication.

DECEMBER 15.

Mr. JOHN H. REDFIELD in the chair.

Twenty-five persons present.

A paper entitled "Methods of Defence in Organisms," by Chas. Morris, was presented for publication.

The following was ordered to be printed:—

NOTES ON THE LAFAYETTE SERPENTINE BELT.

BY THEO. D. RAND.

It is well known that two nearly parallel belts of Serpentine and Steatite cross the Schuylkill above and below Lafayette Station, and pass southwestwardly towards the Pennsylvania Railroad. The southeasternmost, or steatite belt, cannot be observed beyond a bend in the Black Rock road, about one-half mile north of the railroad, the other was conspicuous at Rosemont Station, but no outcrop was known southwestward until within three-fourths of a mile of Darby Creek, on Meadow Brook, whence southwestwardly it was continuous, or nearly so, to Palmer's mills on Crum Creek.

This line is not easily identified with either of the former, but I have recently found a distinct outcrop on the Roberts road, on the property of Col. Jos. F. Tobias, or of Dr. Edward H. Williams, with fragments in the soil of the fields of the former to the northeast. The belt is very narrow, and the valley of a small creek seems to occupy nearly the same line. This outcrop is about half way between the Rosemont and Meadow Brook outcrops, and seems to prove beyond question that the belt crossing Darby Creek is the Lafayette belt. On the Roberts road, northeast of the Serpentine and measured at right-angles to the strike, perhaps 100 to 200 feet distant, is a rock bearing great resemblance to the Eurite of Barren Hill, Wayne, etc., occupying here almost exactly the position relative to the Serpentine and the Laurentian axis that the Eurite does on the northwestwardly side of the Laurentian, near Radnor Station. Its strike is N. 30° E., dip 50° to S. E. Adjacent mica schist N. 40° E., dip 65° to S. E.

The position of this outcrop of Serpentine somewhat south of the line of the Lafayette belt, indicates either a change in the strike, or the echelon structure elsewhere observable in the Serpentine of the adjacent region.

DECEMBER 22.

The President, Dr. LEIDY, in the chair.

Twenty-nine persons present.

A paper, entitled "Inclusions in the Granite of Craftsbury, Vermont," by Calvin McCormick, was presented for publication.

Worms in Ice.—Prof. LEIDY referred to a former communication on the occurrence of organisms in ice (see Proc. 1884, 260), and stated that Dr. S. C. Thornton, of Moorestown, N. J., a couple of weeks since, had submitted to him for examination a bottle of water from melted ice, such as was habitually used in his family, and in which he said he had observed living worms. A number of these proved to be present in the specimen, but were all dead. Having expressed a desire to confirm the statement that the worms were observed alive in the fresh ice-water, Dr. Thornton last week had obligingly sent him a basket of the ice. This was part of the provision made nearly a year ago from the vicinity of Moorestown. The ice was full of air bubbles and water drops. On being melted a number of the worms were liberated and proved to be in a living and quite active condition. It is probable that while imprisoned in the ice they may not have been frozen, but perhaps remained alive in a torpid condition in water drops. It is a remarkable fact that these animals should remain so long alive in the ice, and yet die so readily in the melted water subsequently. The worms are of the same species noticed in the ice-water of the first communication, and which was derived from similar ice procured from a mill-pond in Delaware Co., Pa. These facts would indicate that it is desirable to avoid the spongy ice from stagnant waters, as being liable to retain organisms which would be detrimental to us. In the clear ice, such as is served in Philadelphia, no living organisms are detected. The little worms of the ice appear to be an undescribed species, and may therefore be characterized as follows:—

LUMBRICUS GLACIALIS. Worm from four to six lines long, translucent white, cylindrical, anteriorly acute, tapering most behind and obtuse, of from 35 to 50 segments; oral segment with a blunt conical upper lip, unarmed and eyeless; succeeding segments with four rows of podal-spines, in fascicles of three; spines pointed at the free end and hooked at the attached end, nearly straight or slightly sigmoid; generative organs occupying the interval of the third and seventh spine bearing segments.

Thickness of worm 0·15 to 0·25 mm.; podal spines 0·3 to 0·375 mm. long.

The length given in the former notice should be in lines instead of millimetres.

December 29.

Mr. Thomas Meehan, Vice-President, in the chair.

Thirty-three persons present.

The following were ordered to be printed:—

A CATALOGUE OF THE FISHES OF BEAN BLOSSOM CREEK, MONROE COUNTY, INDIANA.

BY CARL H. EIGENMANN AND MORTON W. FORDICE.

Bean Blossom is a small creek crossing Monroe County about six miles north of Bloomington. It is a tributary of White River and empties into it near Gosport, Indiana. It is a rather sluggish stream with gravelly bottom, and considerable grass and water-weeds. The specimens were collected by parties of students of the Indiana University, visiting the creek at different times. Thirty-two of the species were also obtained by us on the 12th of September, 1885.

1. *Ammocœtes branchialis* L. Abundant in spring.
2. *Noturus gyrinus* Mitchill.
3. *Noturus miurus* Jordan. Very abundant.
4. *Noturus flavus* Rafinesque. Very common. The last two species are very abundant in the weeds of shallow water; only two specimens of *gyrinus* were obtained.
5. *Noturus exilis* Nelson. One specimen.
6. *Leptops olivaris* Rafinesque.
7. *Amiurus melas* Rafinesque.
8. *Amiurus natalis* Le Sueur.
9. *Catostomus teres* Mitchill. Very abundant.
10. *Catostomus nigricans* Le Sueur. Abundant.
11. *Minytrema melanops* Rafinesque. Abundant.
12. *Moxostoma macrolepidotum* Le Sueur.
13. *Campostoma anomalum* Rafinesque.
14. *Chrosomus erythrogaster* Rafinesque.
15. *Hybognathus nuchalis* Agassiz.
16. *Notropis whipplei* Girard.
17. *Notropis megalops* Rafinesque.
18. *Notropis ardens lythrurus* Jordan.
19. *Rhinichthys atronasus* Mitchill.
20. *Hybopsis biguttatus* Kirtland.
21. *Hybopsis amblops* Rafinesque.
22. *Semotilus atromaculatus* Mitchill.
23. *Esox vermiculatus* Le Sueur.
24. *Labidesthes sicculus* Cope. One specimen.
25. *Aphredoderus sayanus* Gilliams. One specimen.
26. *Pomoxys annularis* Rafinesque. Very abundant.
27. *Pomoxys sparoides* Lacépède.
28. *Ambloplites rupestris* Rafinesque.
29. *Lepomis cyanellus* Rafinesque.

30. *Lepomis megalotis* Rafinesque. Abundant.
31. *Micropterus dolomiei* Lacépède. Abundant.
32. *Boleosoma olmstedi maculatum* Agassiz. Abundant.
33. *Diplesion blennioides* Rafinesque. Abundant.
34. *Percina caprodes* Rafinesque. Abundant.
35. *Hadropterus phoxocephalus* Nelson.
36. *Hadropterus scierus* Swain. Abundant. Several specimens were taken five inches in length. In these large specimens the serration of the preopercle is obsolete.
37. *Hadropterus aspro* Cope and Jordan.
38. *Etheostoma flabellare* Rafinesque. Abundant.
39. *Etheostoma cœruleum* Storer.
40. *Uranidea richardsoni* Agassiz.

LIST OF FISHES COLLECTED IN HARVEY AND COWLEY COUNTIES, KANSAS.

BY BARTON W. EVERMANN AND MORTON W. FORDICE.

About the last of May, 1884, Mr. Evermann made a small collection of fishes at Newton and Winfield, Kansas. The specimens from Newton are from a small stream called Sand Creek, which flows into the Little Arkansas, a tributary of the Arkansas. Those from Winfield were obtained from Timber Creek, a tributary of Walnut River, which flows into the Arkansas.

Sand Creek was seined just below a small dam near the town of Newton, where the water is clear and the bottom sandy. Farther down the creek was made up of numerous pools of various sizes, and with bottoms and shores more or less muddy.

Timber Creek is a sluggish stream, with usually muddy bottom and water not clear.

We here give a list of the species represented in the collection as identified by us. All are now in the museum of the Indiana University :—

1. *Amiurus melas* (Raf.). Found to be very abundant in Timber Creek, but no specimens were obtained at Newton.
2. *Moxostoma macrolepidotum* (Le S.). Sand Creek. Only one specimen.
3. *Campostoma anomalum* (Raf.). Common in both streams examined.
4. *Pimephales promelas* (Raf.). Eight very fine specimens (all males) were gotten from a small stream which flows into Timber Creek near Winfield.
5. *Pimephales notatus* (Raf.). A few specimens were obtained at Newton.
6. *Notropis lutrensis* (Baird and Girard). Very abundant in both streams.
7. *Notropis topeka* Gilbert. Sand Creek. Only two specimens were obtained.
8. *Notemigonus chrysoleucus* (Mitchill). Found only in Sand Creek. One specimen.
9. *Fundulus zebrinus* Jordan and Gilbert. This species was found to be common both at Newton and Winfield.
10 *Zygonectes notatus* (Raf.). A few specimens only were received—all from Timber Creek.
11. *Labidesthes sicculus* Cope. From Timber Creek only. Not common.
12. *Lepomis cyanellus* Raf.. Abundant in Timber Creek.
13. *Lepomis megalotis* (Raf.). But two specimens were obtained—one from Newton, the other from Winfield.
14. *Lepomis humilis* (Girard). Abundant in both streams.
15. *Etheostoma cœruleum* Storer. Very abundant in Timber Creek. None were obtained at Newton.

The following annual reports were read and referred to the Publication Committee:—

REPORT OF THE RECORDING SECRETARY.

The Recording Secretary respectfully reports that during the year ending November 30, 1885, fourteen members and one correspondent have been elected.

Resignations of membership have been received and accepted on the usual conditions, from J. H. Brinton, M. D., W. S. Baker, Jos. C. Wright, R. B. Haines, Jr., and Jos. G. Richardson, M. D.

The deaths of ten members and six correspondents have been announced, and duly recorded in the printed Proceedings.

Thirty-four papers have been presented for publication, as follows: Willis S. Blatchley, 3; Angelo Heilprin, 2; Herman Strecker, 2; Alan F. Gentry, 2; S. H. Scudder, 2; Charles Morris, 2; Carl H. Eigenmann and Morton W. Fordice, 2; S. E. Meek and Robt. Newland, 2; Walter R. Furness, 1; F. Lamson Scribner, 1; F. Warrington Eastlake, 1; Dr. Benj. Sharp, 1; Leonard Stejneger, 1; H. C. Lewis, 1; W. D. Hartman, 1; W. B. Scott, 1; W. N. Lockington, 1; Theo. D. Rand, 1; Morton W. Fordice, 1; B. W. Evermann and M. W. Fordice, 1; B. W. Evermann and S. E. Meek, 1; Seth E. Meek and Edw. A. Hall, 1; Edw. A. Hall and J. Z. A. McCaughan, 1; Charles Wachsmuth and F. Springer, 1; Ernst P. Bicknell and Fletcher B. Dressler, 1.

Twenty-nine of these have been printed in the Proceedings of the Academy, two have been withdrawn by the authors, and the remaining three have been reported on favorably and will form part of the next volume of the Proceedings.

Sixty-three pages of the volume for 1884, and three hundred and eighty-four pages of that for the current year, have been printed. The former are illustrated by two lithographic plates, and the latter by three.

Forty foreign societies have been added to the list of exchanges during the year, increasing the number of copies of the Proceedings sent abroad in exchange to 375.

The average attendance at the meetings during the past twelve months has been 25. Verbal communications have been made by thirty-four members. The greater number of these have been reported by the authors and printed in the Proceedings, constituting an important portion of the annual volume.

At the meeting of the Council held Nov. 23, Mr. Jacob Binder was reappointed Curator of the Wm. S. Vaux Collections.

All of which is respectfully submitted.

EDW. J. NOLAN,
Recording Secretary.

REPORT OF THE CORRESPONDING SECRETARY.

The correspondence of the past year shows a gratifying increase in the number of societies and institutions with which we are now exchanging our publications. The increase has arisen in many instances at the request of the Academy, and in a certain number at the solicitation of the societies.

The opening of correspondence with societies not previously on our list of exchanges brings with it in time a request from them for our earlier publications, more particularly the Proceedings. The earlier volumes are in very limited stock, and the Corresponding Secretary suggests the desirability of re-publication at as early a date as the ability of the Academy will admit.

During the year there has been but one correspondent elected, who has been promptly notified of his election. Responses have been received from nine correspondents, of which number eight were elected in the preceding year. Three have acknowledged the reception of the diploma. In a few instances official notice of the death of Correspondents has been received. Usually such information is obtained from the journals, and becomes part of the minutes of the Academy.

Letters and cards to the number of one hundred and twenty-two have been received acknowledging our publications, the large number being partly due to the increase before mentioned, and partly to the early distribution of our Proceedings in parts through the mails.

Letters of transmission numbering forty-seven have been received, the smallness of the number arising from the decreasing number of correspondents, who from preference or necessity transmit their publications through the Smithsonian Institution.

Miscellaneous letters, numbering thirteen, have been received, and, when necessary, have been answered.

The additions to the Museum will appear in the Curator's report. The donors have received prompt acknowledgment through the Curator-in-charge, who has kindly acted for me.

Respectfully submitted,

GEORGE H. HORN, M. D.,
Corresponding Secretary.

REPORT OF THE LIBRARIAN.

During the year ending November 30, 1885, 4100 additions have been made to the library of the Academy. This is an increase of 678 over the growth of last year, and of 1097 over that of 1883. The accessions have consisted of 986 volumes, 3047 pamphlets and parts of periodicals, and 67 maps.

They have been derived from the following sources:—

Societies,	2158	Thomas Meehan,	3
Editors,	793	John H. Redfield,	3
I. V. Williamson Fund,	574	Norwegian Government,	3
Authors,	266	Isaac Lea,	2
Department of the Interior,	35	Geological Survey of New Zealand,	2
Geological Survey of Michigan,	33	U. S. Civil Service Commission,	2
Wilson Fund,	25	W. P. Collins,	1
Treasury Department,	21	Mrs. J. Lawrence Smith,	1
Geological Survey of Russia,	19	Asa Gray,	1
Geological Survey of India,	16	Mrs. Emma Rogers,	1
Joseph Jeanes,	15	C. S. Sargent,	1
Geological Survey of Pennsylvania,	14	Bureau of Ethnology,	1
Geological Survey of Sweden,	14	Royal College of Surgeons,	1
Geological Survey of Canada,	14	Mining Registrars, Victoria,	1
University of the State of New York,	11	Navy Department,	1
Smithsonian Institution,	7	East Indian Government,	1
War Department,	7	Lea Bros. & Co.	1
Department of Agriculture,	7	U. S. Fish Commission,	1
Geo. W. Tryon, Jr.	7	Publishers,	1
Geological Survey of New Jersey,	6	Raffles Museum, Singapore,	1
California State Mining Bureau,	5	Geological Survey of Indiana,	1
H. B. M. Government,	5	Department of Mines, Nova Scotia,	1
Minister of Public Works in France,	4	Indian Museum,	1
Geological Survey of Minnesota,	4	Public Library, Cincinnati,	1
British Museum,	4	Minister of Works, Mexico,	1
		Geological Survey of Minnesota,	1
		Forestry Commission, New York,	1

These additions have been distributed to the several departments of the library as follows:—

Journals,	3225	Mineralogy,	13
Geology,	355	Education,	11
General Natural History,	110	Ichthyology,	8
Botany,	100	Agriculture,	7
Conchology,	71	Mammalogy,	5
Entomology,	37	Helminthology,	4
Physical Science,	23	Herpetology,	3
Anatomy and Physiology,	22	Chemistry,	3
Anthropology,	20	Encyclopedias,	3
Voyages and Travels,	19	General Literature,	2
Ornithology,	16	Medicine,	2
Bibliography,	16	Miscellaneous,	25

The year's improvement on the usual rate of increase has been mainly due to the generous response made by corresponding societies to our applications for exchanges and deficiencies. Our efforts to increase and perfect as far as possible the Academy's sets of scientific periodicals have been unremitting, with the gratifying result above noted. In compliance with our proposition made more than a year ago, many corresponding societies continue to send their publications promptly by mail when issued, instead of as formerly once or twice a year through the Bureau of Exchange. The publications of the Academy are, of course, sent in return by mail, and, although the cost of postage, amounting during the past year to $117.59, is a matter of considerable importance in the present cramped financial condition of the society, the outlay is believed to be a most judicious one.

Among the more important additions to the special departments of the library acquired during the year have been complete sets, as far as published, of Barrande's Système Silurien de la Bohême, Reichenbach's Icones Floræ Germanicæ, and Godman and Salvin's Biologia Centrali-Americana. For these, as for nearly all the other important additions apart from our exchanges, we are indebted to the liberality of Mr. Isaiah V. Williamson.

The rapid increase of the library has rendered inadequate the hand catalogues of the special departments in use for many years. No matter how much space may be left for additions, it has been found impossible to preserve the unbroken alphabetical arrangement upon which their usefulness depends, while the transcripts from the cards involve an unnecessary expenditure of time and labor. A copy of the present card catalogue has therefore been commenced with the efficient assistance of Sig. Emanuele Fronani, whose services I have been again enabled to avail myself of during the summer months. The entries have been made on cards of the best quality manufactured for the purpose by the American Library Bureau. They are perforated near the middle of the lower margin and will be held in their places in drawers or trays by rods, thus avoiding the possibility of accidental disarrangement. The chance of such an accident has made it inadvisable to open for general use the present catalogue, which is complete to date, as the cards are arranged in drawers without guards, and any confusion of the alphabetical arrangement would make it worse than useless.

A shelf catalogue has also been commenced. This consists of the briefest author and title entries of the books as they are at present numbered and placed in the cases. This will be a necessity of library administration when the card catalogue is alone in use for reference, as without it a great expenditure of time would be necessary to determine what books may be lost or misplaced.

I regret to say that for the same reason as that noted last year—lack of means—no books have been bound since my last report. The necessity for binding some of our accumulations has, however, become so great that during the coming year a portion of the income of the I. V. Williamson Fund will be appropriated for the binding of books credited to said fund.

A detailed list of accessions is herewith submitted.

Edw. J. Nolan,
Librarian.

REPORT OF THE CURATORS.

The Curators present the following statement from the Curator-in-charge, Prof. Angelo Heilprin, as their report for the year ending November 30:

During the past year, as in preceding years, much of the work accomplished in the Museum has been voluntary—this more especially in the departments of Conchology and Botany, to the special conservators of which the Academy feels itself under lasting obligation. A similar obligation attaches to the labors of the conservator of the Mineralogical department covered by the Wm. S. Vaux trust, a special report pertaining to which has been submitted to the Council. In the department of Entomology the partial services of a paid assistant, employed in joint association with the American Entomological Society, have been secured.

In departments other than those here specified the work accomplished has been under the immediate direction of the Curator-in-charge and his assistants who have received material aid in various ways from the several Jessup Fund beneficiaries. While it is believed much has been done toward bringing the collections into a relational sequence, and in the identification and labeling of specimens, years of labor still remain before, at the present rate of progress, the entire Museum can be brought into systematic order. Nor, it appears, will the attainment of this much-desired object be practicable until further and greatly-increased accommodation for the proper exposition of the steadily increasing collections be furnished. Reflectively, again, the want of space acts as a material check to the proper development of the collections, which, in the estimation of donors, can now no longer be exhibited to advantage. The following extract from the Report of the Professor of Ethnology and Archæology illustrates this condition: "The collections of the Academy in this department are substantially the same as noted in the last report. It would be easy to increase them were there ample accommodations for their favorable display as objects." The extensive series of rocks and fossils collected by the Second Geological Survey of the State of Pennsylvania, and contained in upwards of 200 cases, still remain boxed, awaiting the opportunity when an increase of space will permit of their classification and display.

It is earnestly hoped that the contemplated extension, either in part or in whole, of the present building, which is imperatively demanded by the needs of the institution, may be shortly realized, but toward the attainment of this end assistance, other than that which can be furnished by the Academy alone, is necessary. The present resources of the Academy are in themselves scarcely sufficient to maintain the institution as it is now situated, and much too limited to enable it to fully meet the requirements of scientific investigators and investigation. A Curator's fund for the liberal purchase of specimens may be indicated as a growing absolute necessity, and scarcely less so a fund to be used for the prosecution of zoo-geographical explorations. The interest derived from a principal fund of some $50,000 to $60,000 would fairly equip annual expeditions to regions that have been thus far little, or not at all, investigated —Florida, the West Indies, Mexico, Central America, or Labrador, for example—and permit of a large amount of material to be collected for the use of naturalists generally.

The special curatorial work during the past year has been mainly in connection with the departments of Vertebrate and Invertebrate Palæontology and Osteology. The entire collections of fossil fishes, reptiles and mammals have been brought together, properly arranged and classified, and constituted into distinct sections or departments. The specimens of osteology have been largely identified and classified, and are now in a condition to be advantageously used by the student and specialist. A special collection, intended to illustrate the type forms of animal life, from the highest to very nearly the lowest, designed to facilitate the work of the zoological student, is rapidly approaching completion, although still requiring a system of improved explanatory labeling.

The routine work connected with the curatorial office has been accomplished as heretofore, and requires no special enumeration of details. The institution has benefitted during the year through the services of five Jessup Fund beneficiaries, covering as many distinct departments.

Very respectfully,

ANGELO HEILPRIN,
Curator-in-charge.

JOS. LEIDY,
Chairman Curators.

REPORT OF THE CURATOR OF THE WILLIAM S. VAUX COLLECTIONS.

The Curator of the William S. Vaux collections respectfully reports :—

The collections are in good condition, no change having been made in the arrangement except that which was rendered necessary by the addition of one hundred and four mineral specimens, which have been purchased for the collection out of the funds provided for that purpose. The additions have been arranged according to the system of classification adopted.

According to the report of 1884, the mineral specimens numbered, ...	6,412
Additions purchased during the current year, ending Nov. 30, 1885, ...	104
Total, ...	6,516
Archæological specimens (same as noted in report of 1884), ...	2,940

The Mineralogical collection has a wide reputation, and has been visited by a large number of persons during the year, many of them prominent mineralogists. Those who had examined the collection previous to the decease of William S. Vaux, have noticed the absence of a number of the most remarkable specimens which it formerly contained and which added so much to its fame. It is to be regretted that those specimens should have been separated from the others, thereby decreasing its importance as a mineral collection, and as a memorial of the decedent.

The following specimens, numbering 104, have been purchased during the year and placed in the collection at the aggregate cost of $542.95 :—

1884, December 1.—Four specimens of tourmaline, two gold crystals, one fowlerite, cat's-eye (Ceylon), chalcopyrite, pisolite, zircon (white), jasper (from the Nile), crocidolite, ruby (cut spec.), N. J., sapphire (purple), sapphire (white), turquoise, turquoise (Persian), citron (Orange Co.), citron (pale yellow), amethyst.

1885, March 30.—One specimen of crocidolite, bastnäsite, two wulfenites (Nev.), one barite, wulfenite (red), vanadanite, anatase.

April 20.—One specimen of hematite, chiastolite.

April 30.—Tray of concretions.

May 4.—One specimen of chalcedony, chalcedony with bubble, hornblende.

May 5.—One specimen of corundum, moss agate, maconite, analcine on copper, jade, beryl, diaspore on corundum, cassiterite, two tourmalines (green), one lepidolite, pectolite, tourmaline on cookeite.

March 5.—Three specimens of rutile, one chiastolite.

March 24.—Nine specimens of small diamonds.

March 25.—One specimen of lepodolite, hornblende, staurolite.

May 27.—Two specimens of descloisite, one vanadanite, diamond on matrix, quartz (mod. crystal), calamine, smithsonite, smithsonite (geode).

September 10.—One specimen of quartz on hematite, azurite, colemanite, leidyite.

September 27.—Two specimens of obsidian or pearl spar, one fluorite (polished), opal.

October 13.—One specimen of apophyllite, polydelphite, dysluite.

October 13.—Two specimens of calamine, one franklinite, zincite, willemite, zincite, two rhodenites.

November 9.—Two specimens of topaz, one beryl (green cut), beryl (yellow cut), essonite.

Brush's Blowpipe Analysis and Dana's Text-book of Mineralogy were purchased for the use of the Curator.

Respectfully submitted,

JACOB BINDER,
Curator.

REPORT OF THE BIOLOGICAL AND MICROSCOPICAL SECTION.

The number of meetings held during the year ending December 1, 1885, was sixteen.

The average attendance was ten.

The following members were elected: Dr. Horace F. Jayne, Dr. J. Bernard Brinton.

The following members resigned: Dr. Persifor Frazer, W. T. Seal, Dr. J. D. Thomas, Dr. J. G. Richardson.

The following were some of the more important communications brought before the Section:—

December 15, 1884. By Dr. Benjamin Sharp, upon "Homologies of the Vertebrate Lens."

January 5, 1885. Dr. Benjamin Sharp, upon "The Formation of Teeth in Ancyllus."

January 5. By Miss Fielde, upon "The Process of Regeneration of Parts of the Earth Worm;" by Dr. Horace F. Jayne, upon "A Process of Staining."

January 19. Lecture by Dr. G. A. Rex, "Illustrations of the Genus Stilbum."

February 16. Lecture by Dr. W. X. Sudduth, upon "The Comma Bacillus;" exhibition by Messrs. Queen & Co. of Bacteria.

March 16. By Mr. Harold Wingate, upon "The Lens of the Triton."

April 6. By J. Bernard Brinton, upon "Opaque Mounting."

April 20. By Dr. J. Brewer Hall, upon "A Species of Ochlea."

May 4. By Dr. Benjamin Sharp, upon "The Eyes of the Pecten."

A microscopical exhibition was given to the public upon the evening of Thursday, December 3. It was attended by a large and appreciative company.

Very respectfully,

ROBT. J. HESS, M. D.,
Recorder.

REPORT OF THE CONCHOLOGICAL SECTION.

The Recorder of the Conchological Section respectfully reports that during the past year the Academy has continued to publish for the Section such papers on Conchology as have been presented. No new members or correspondents have been elected, neither has there been any change in the by-laws. Mr. Tryon, Conservator, reports as follows :—

"During the year there has been a marked increase over any recent one in the additions to our Museum. Sixty donations and purchases have been received from forty-four persons. The number of trays and labels added to the collection is 1484, of specimens 7237.

"The Conchological Museum now contains 43,932 trays and written tablets, and 158,352 specimens.

"A detailed list of the accessions for 1885 is hereunto subjoined. (See Additions to Museum.)

"A circular was issued early in the year soliciting collections of shells from localities not represented in our Museum. Numerous offers were received in response, and from them a number of selections have been made which have greatly enriched our geographical and varietal suites. The Singapore series (referred to in the last annual report) has been completed by Mr. Archer; Messrs. Bailey, Bedwall, Dupuy and Marie have added suites from Australia and New Caledonia; interesting collections from England, France and Sicily have been received from a number of collectors; our Florida series has been greatly enlarged by an important invoice from Mr. Henry Hemphill, who has spent two winters in dredging on the west coast of that State, and from other sources; many other American suites and specimens have been obtained, including particularly, a very fine suite of the shells of Philadelphia, presented by Mr. John Ford, and exhibited in our collection illustrative of Pennsylvania and New Jersey natural history.

"The additions for the year have all been labelled and mounted, mainly by Mr. Frank Stout, who has very satisfactorily performed this duty.

"The work of redetermining and arranging the collection, which goes on in connection with the publication of monographs of the genera in the 'Manual of Conchology,' progresses. The Cassididæ, Doliidæ, Ovulidæ, Strombidæ, Naticidæ, Vitrinidæ, Limacidæ, and a portion of the Zonitidæ, have thus been carefully studied by your conservator, and the Cypræidæ by Mr. S. R Roberts.

"In the last report attention was called to the overcrowding of the shell cases, as seriously interfering with the exhibition of all the species to the public. Having recently secured the assistance of Mr. Wm. B. Marshall, an enthusiastic student of conchology, your conservator has been able to commence the realization of plans, long since matured, by which this overcrowding will be remedied. All duplicates will be removed from the cases to the drawers under them, where they will be rearranged to constitute what may be called the Geographical Collection, illustrative of the distribution and variation of the several species. Part of the space thus gained in the cases will be occupied by colored figures (from the 'Manual of Conchology') of all the species of which we have no specimens. These figures, mounted and labeled like the specimens, will, together with the latter, represent all the species and varieties of shells and mollusks known to science, so far as they have been figured. In addition to these, a third, to be known as the Synoptical Collection, and introductory to the others, is intended to contain representatives of all the recent, and the most important of the fossil genera and subgenera, with printed labels, including the name, description, distribution, synonymy, etc. Figures of the animals, lingual dentition and other details are being added to make this series more complete.

"Enough has been accomplished to give a fair idea of the practical working of these plans; to complete them will require the labor of perhaps ten or twelve years.

"To enumerate them in order, the Conchological Cabinet of the Academy will consist of five distinct series or collections, so arranged as to facilitate comparison from one to another, yet each fully equipped for separate study, as follows: 1, Synoptical Collection, contained in table cases; 2, Alcoholic Collection, in wall cases (recently rearranged by Mr. Marshall); 3, Systematic Collection, in table cases; and in the drawers under these, 4, Geographical Collection, and 5, the Swift Collection, given to the Academy upon condition that it be kept intact."

The officers of the section are:—

Director, . . .	W. S. W. Ruschenberger, M. D.
Vice-Director, . .	John Ford.
Recorder, . . .	S. Raymond Roberts.
Secretary, . . .	John H. Redfield.
Treasurer, . .	Wm. L. Mactier.
Conservator. . .	George W. Tryon, Jr.
Librarian, . . .	Edward J. Nolan, M. D.

Respectfully submitted, by

S. Raymond Roberts,
Recorder.

REPORT OF THE ENTOMOLOGICAL SECTION.

The Recorder of the Entomological Section respectfully reports that nine meetings of the Section have been held during the past year. An increased interest in the proceedings of the Section has been shown by a larger average attendance at the meetings.

One member has been elected.

A synopsis of the Section meetings is published by the American Entomological Society, in connection with its Transactions. That society still continues the publication of the entomological articles presented to it, and has printed thirteen of the same during the past year, amounting to 300 pages, with 9 plates.

The papers published and their authors are as follows:—

Short studies of North American Coleoptera, by John L. LeConte, M. D. (posthumous).

A study of some genera of Elateridæ, by George H. Horn, M. D.

On the North American Asilidæ, Part II, by S. W. Williston, M. D.

On the systematic position of some North American Lepidoptera, by John B. Smith.

A study of the species of Cryptobium of North America, by George H. Horn, M. D.

Studies among the Meloidæ, by the same.

Descriptions of new North American Scarabæidæ, by the same.

Contributions to the Coleopterology of the United States, by the same.

On the species of Canthon and Phanæus of the United States, with notes on other genera, by Frederick Blanchard.

Descriptions of some new Cerambycidæ, with notes, by George H. Horn, M. D.

Synopsis of the Throscidæ of the United States, by George H. Horn, M. D.

A monograph of North American Chrysididæ, by S. Frank Aaron.

On the earlier stages of the Odonata, by H. A. Hagen, M. D.

In addition, shorter papers on Cynipidæ, by W. H. Ashmead, have appeared in the Proceedings.

The collections in the cabinets have received more attention during the past year than for some time previous. A great part has been thoroughly arranged and labeled where needed. Also a thorough process of disinfection has gone on, and the cases cleared of all troublesome matter. That this work might be better done, the American Entomological Society employed a custodian during nine months of the year, at a small compensation, to attend to the same.

A number of accessions to the cabinets have been received this year, from Messrs. R. H. Stretch, E. M. Aaron, S. F. Aaron, W. H. Ashmead, J. S. Johnson, and James Behrens. Many of these additions are rare, or new to the collections.

The officers elected for the ensuing year are as follows:—

Director, ...	George H. Horn, M. D.
Vice-Director, . . .	Rev. Henry C. McCook, D. D.
Recorder, . . .	J. H. Ridings.
Treasurer, . . .	E. T. Cresson.
Conservator, . . .	Henry Skinner, M. D.

Respectfully submitted,

J. H. RIDINGS,
Recorder.

REPORT OF THE BOTANICAL SECTION.

The Vice-Director of the Botanical Section of the Academy respectfully reports that the section continues its steady progress as in former years. 1687 species of phanerogamic plants and vascular cryptogams were added to the Herbarium last year, of which 395 were new to our collection; 395 species of lichens and fungi were also received. A complete count of the species in the Herbarium has been made and found to foot up 25,413, of which all but about 3075 are named and in place. These are exclusive of Fungi and Lichens. The details of the donations will be found in the Conservator's report attached.

The section is wholly free from debt, and has a balance of one hundred and seventy-six dollars in its treasury. We have lost the services of our late Recorder, Mr. F. L. Scribner, who has removed to Washington, to a wider sphere of usefulness.

Meetings have been held at every stated period during the year, and valuable contributions to botanical knowledge have been made by Messrs. Meehan, Redfield, Rothrock, Scribner, Brinton, Burk, Canby, Hoopes, and A. H. Smith—some of which, fully, or in brief, have been published in the *Proceedings of the Academy.*

The officers elected for the coming year are :—

Director,	W. S. W. Ruschenberger, M. D.
Vice-Director,	Thomas Meehan.
Recorder,	Charles Schaeffer, M. D.
Treasurer,	Isaac C. Martindale.
Cor. Secretary,	Isaac C. Martindale.
Conservator,	John H. Redfield.

Submitted,

THOMAS MEEHAN,
Vice-Director.

Conservator's Report for 1885.—Since the last annual report, the Conservator has completed the provisional lists of species contained in the Herbarium, so far as refer to the phanerogamic orders and the vascular cryptogams. These lists are strictly provisional and temporary, intended to facilitate ready access to the contents of the Herbarium, and in no way to take the place of such careful revision as is greatly needed, but which must necessarily require much time, and more careful study than can now be bestowed. It is greatly to be desired that the same work should be continued in the lower cryptogamic orders, and it may not be amiss here to suggest to those of our associates in the Microscopical Section who are directing their attention to the structure of these lower forms of vegetable life, that here is an excellent opportunity to utilize in systematic work the technical training they have received.

So far as the lichens are concerned, this work has been accomplished by our fellow member, Dr. J. H. Eckfeldt, who has not only catalogued the species of that order contained in the Herbarium, but has also contributed largely to supplying deficiencies.

The enumeration of the phanerogamic species contained in the Academy's Herbarium, which was referred to in the last report, has been completed, and the result is, . . 24,268 species.

To this add Ferns, Lycopods, Equisetaceæ, Marsiliæ and Isoeteæ,	1,145
Total phanerogams and vascular cryptogams,	25,413

Approximating very closely to the estimate in the last report.

The attention to the proper mounting of the specimens in the Herbarium has been continued, with the efficient aid of Mr.

Burk. A large part of the new accessions have been mounted, and the same work has been prosecuted in the North American Herbarium, of which now about one-half has received this care, so necessary to the permanent preservation of the specimens.

The donations received during the year amount to 1687 species of phanerogams and ferns, and 383 species of lichens and fungi, in all 2070 species. Of the former, 395 species are new to our Herbarium, while probably a large part of the fungi and lichens are also new to us. The total number of species presented is less than in some former years, but it will be seen that the proportion of *new* accessions is not materially diminished. Of the 2070 species received 1366 are North American, 37 South American, and 667 are from the old world.

Among the donations we may specify the valuable contribution of exotic plants received from Dr. Asa Gray of the Cambridge Herbarium; a series of 365 species collected by Mr. Meehan in Western North America in 1883; and a valuable collection of 388 species of S. African, Australian and European plants from Mr. Wm. M. Canby.

A complete list of the donations accompanies this report, and will appear in its proper place in the list of Additions to the Museum.

JOHN H. REDFIELD,
Conservator.

REPORT OF THE MINERALOGICAL AND GEOLOGICAL SECTION.

The Director of the Mineralogical and Geological Section of the Academy of Natural Science would respectfully report that meetings of the Section have been regularly held, but that owing to the absence of active members, and other causes, the attendance has not been as large as in former years. Considerable accessions to the cabinet have been made—a number of desirable specimens having been purchased with the funds of the Section.

Respectfully submitted,

THEO. D. RAND,
Director.

REPORT OF THE PROFESSOR OF INVERTEBRATE PALEONTOLOGY.

The Professor of Invertebrate Paleontology respectfully reports, that during the year he has delivered a course of twenty-seven lectures (with practical demonstration) on paleontology, which, as heretofore, has been attended largely by teachers of the various city schools. A special course on geology, arranged at the request of the Teachers' Institute of Philadelphia, was also delivered in the Hall of the Academy, as a continuation of a similar course given before the same body in the spring and autumn of 1884. The attendants at these lectures numbered between 100 and 150. Both courses of instruction in the class-room were supplemented by a number of field excursions in the region about Philadelphia, ranging to Orange, N. J., and the Atlantic coast, and by a twelve days' trip to the Valley of the Upper Delaware.

The collections of the Academy in the department of Invertebrate Paleontology have received no very material accessions during the year; special mention may be made of a beautiful slab of crinoids, from the Carboniferous Limestone of Iowa, generously given to the Society by Mr. Charles Wachsmuth, whose important papers on the Paleocrinoidea, prepared in conjunction with Mr. Springer, are being published in the Proceedings of the Academy.

Through a re-arrangement of the collections contained in the Museum opportunity has been afforded for the proper arrangement and display of the collections illustrating European paleontology, which have up till now been largely inaccessible and placed in drawers. The proper identification and labeling of species will, however, be a matter of time.

Very respectfully,

ANGELO HEILPRIN,

Prof. of Invertebrate Paleontology.

REPORT OF THE PROFESSOR OF INVERTEBRATE ZOOLOGY.

The Professor of Invertebrate Zoology respectfully reports that during the past year he has delivered a course on some of the Principles of Zoology, consisting of about twenty (20) lectures.

He further reports that the collections under his charge have somewhat increased, the increase not being as great as that of the previous year.

The principal donation was a collection of Echinoderms, presented by Mr. John Ford.

A few crustaceans were presented by Mr. C. McCormick.

A course of ten lectures will be given in the spring of the coming year (April and May), the subject being, "Special Senses."

Very respectfully,

BENJAMIN SHARP,
Professor of Invertebrate Zoology.

REPORT OF THE PROFESSOR OF ETHNOLOGY AND ARCHÆOLOGY.

I have the honor to report that during the year 1885 a course of ten lectures was delivered in the hall of the Academy, on the ethnology and archæology of America. They were illustrated with maps, drawings, and by means of specimens obtained from the various collections within the rooms of the Academy. The lecture hall was usually well filled, and quite as much interest was manifested by the audience as could be expected from the nature of the topics discussed.

The collections of the Academy in this department are substantially the same as noted in the last report. It would be easy to increase them, were there ample accommodations for the favorable display of objects.

Respectfully,

D. G. BRINTON, M. D.,
Professor of Ethnology and Archæology.

SUMMARY OF THE REPORT OF WM. C. HENSZEY, TREASURER,

For the Year ending Nov. 30, 1885.

Dr.

To Initiation Fees	$ 100 00	
“ Contributions (semi-annual contributions)	1635 76	
“ Life Memberships	400 00	
“ Admissions to Museum	264 59	
“ Sale of Guide to Museum	8 00	
“ Publication Committee	525 55	
“ Fees, Lectures on Palæontology	68 00	
“ “ “ “ Mineralogy	83 00	
“ “ “ “ Ethnology	48 50	
“ “ “ “ Zoology	6 00	
“ Duplicate Books	2 00	
“ Biological Section (for gas)	50 00	
“ Miscellaneous	97 24	
“ Correction of Proof (B. Sharp)	3 60	
“ Interest from Mortgage investment, Joshua T. Jeanes' Legacy	1000 00	
“ Wilson Fund. Toward Salary of Librarian	300 00	
“ Publication Fund. Interest on Investments.	355 00	
“ Barton Fund. “ “ “	240 00	
“ Life Membership Fund. “ “ “	165 00	
“ Maintenance Fund. “ “ “	155 00	
“ Eckfeldt Fund. “ “ “	125 00	
“ Stott Legacy Fund. “ “ “	100 00	
“ Maintenance Fd. Transf. by resolution of Academy	1013 14	
“ Life Membership Fd. “ “ “ “ “	1500 00	
“ Book Fund. “ “ “ “ “	3 13	
“ Instruc. and Lec. Fd. “ “ “ “ “	86 65	
“ Interest	16 25	
		$8351 41

Cr.

By Balance overdrawn per last account	$1238 44	
“ Salaries, Janitors, etc	3236 62	
“ Freight	43 50	
“ Repairs	85 67	
“ Insurance	55 00	
“ Printing and Binding Proceedings, etc	1055 36	
“ Plates and Engravings	71 75	
“ Printing and Stationery	92 40	
“ Trays and Cards	71 47	
“ Postage	195 26	
“ Mounting Swan	5 00	
“ Coal	55 00	
“ Gas	88 77	
“ Glass Jars and Vials	77 97	
“ Subscription to U. S. Publication	2 00	
“ Water Rents, 1885	33 35	
“ Miscellaneous	452 20	
“ Dr. D. G. Brinton. Fees from Lectures	48 50	
“ Prof. H. C. Lewis. “ “ “	83 00	
“ Prof. A. Heilprin. “ “ “	68 00	
“ Life Memberships transferred to Life Membership Fund	400 00	
		$7459 26
Balance, General Account		892 15

THOMAS B. WILSON LIBRARY FUND.

By Balance per last statement	$ 277 28
For Books	220 05
Transferred to General Account, toward Salary of Librarian	300 00
	$797 33
Income from Investments	525 00
Balance overdrawn	$272 33

LIFE MEMBERSHIP FUND. (For Maintenance.)

By Investment, Bond and Mortgage		$1500 00
Transferred to General Account		165 00
		$1665 00
To Balance per last statement	$1000 00	
Interest on Investments	165 00	
Life Memberships transferred to this account	400 00	
		1565 00
Balance overdrawn		$100 00

BARTON FUND. (For Printing and Illustrating Proceedings.)

Interest on Investments	240 00
Transferred to General Account	240 00

JESSUP FUND. (For Assistance of Students.)

Balance per last statement	620 01
Interest on Investments	560 00
	1180 01
Disbursed	946 00
Balance	$234 01

MAINTENANCE FUND.

Balance per last statement		1013 14
Interest on Investments		155 00
		$1168 14
By Investment, Lehigh Valley Coal Co.'s Bonds	$1013 14	
Transferred to General Account	155 00	
		1168 14

PUBLICATION FUND.

Income from Investments	$ 355 00
Life Subscriptions to Proceedings and Journal	225 00
	$580 00
Transferred to General Account	355 00
Balance for Investment	$225 00

ECKFELDT FUND.

Income from Investments	$ 125 00
Transferred to General Account	125 00

I. V. WILLIAMSON LIBRARY FUND.

Balance per last Statement		$2094 65
Rents Collected		994 90
Ground-rents Collected		872 02
Cash received. Principal of yearly ground-rent for $52\frac{50}{100}$ Dollars. E. S. Mount Holly Street, 30 feet north of Dickinson St	$875 00	
Seventy days' Interest at 5 per. cent	9 63	
Notary's Acknowledgment	1 00	885 63
		$4847 20
For Books	$2105 56	
Taxes and Water-rents	195 43	
Repairs to Properties	378 92	
Collecting	93 34	
Miscellaneous	57 45	
		2830 70
Balance		$2016 50

$1750.00 of the above balance to be re-invested.

INSTRUCTION AND LECTURE FUND.

Balance per last Statement		$ 142 70
Miscellaneous	$56 05	
Transferred to General Account	86 65	
		142 70

MUSEUM FUND.

Balance per last Statement	$ 5 00
Income from Investments	50 00
	$55 00

VAUX FUND.

Balance per last Statement		$ 477 30
Income from Investments		600 00
		$1077 30
Minerals	$550 63	
Miscellaneous	14 59	
		565 22
Balance on hand		$512 08

Mrs. STOTT FUND.

Income from Investment	$ 100 00
Transferred to General Account	100 00

BOOK ACCOUNT. (Jos. Jeanes' Donation.)

Balance per last Statement		$ 37 13
Books	$34 00	
Transferred to General Account	3 13	
		37 13

HENRY N. JOHNSON FUND.

By Cash paid Collateral Inheritance Tax		$1089 70
" " Refunded Penna. Co. for Ins. on Lives, etc., overpaid in settlement		35 50
" " Expenses Attending the Settlement of Est. H. N. Johnson, dec'd		12 03
" " Grading side-walk in Upsal St		167 37
" " Repairs to Properties		518 25
" " Collecting		37 69
		$1860 54
To Cash received Penna. Co. for Ins. on Lives, etc., in Settlement of Est. H. N. Johnson, dec'd	$859 93	
" Rents Collected	618 80	
" Ground-rents Collected	94 50	
" Mortgage Interest and Tax collected	40 50	
" Six months' Int. on $1000 Lehigh Valley's Bonds	25 00	
		1638 73
Balance due by Academy		$221 81

The election of Officers, Councillors, and Members of the Finance Committee, to serve during 1886, was held, with the following result:—

President,	Joseph Leidy, M. D.,
Vice-Presidents,	Thomas Meehan, Rev. Henry C. McCook, D. D.
Recording Secretary,	Edward J. Nolan, M. D.
Corresponding Secretary,	George H. Horn, M. D.
Treasurer,	Wm. C. Henszey.
Librarian,	Edward J. Nolan, M. D.
Curators,	Joseph Leidy, M. D., Jacob Binder, W. S. W. Ruschenberger, M. D., Angelo Heilprin.
Councillors to serve three years,	Thos. A. Robinson, Edw. Potts, Isaac C. Martindale, Theo. D. Rand.
Finance Committee,	Isaac C. Martindale, Aubrey H. Smith, S. Fisher Corlies, George Y. Shoemaker, Wm. W. Jefferis.

ELECTIONS DURING 1885.

MEMBERS.

January 27.—Mrs. Cornelius Stevenson, J. Addison Campbell, Burnett Landreth.

February 24.—Charles Harrod Vinton, M. D., Henry Leffman, M. D., S. Frank Aaron, Edward Longstreth.

April 28.—Philip Laurent, Rev. J. R. Danforth, D. D.

November 24.—Charles S. Dolley, M. D., Chas. N. Davis, John H. Campbell, W. D. Averell, W. G. A. Bonwill, M. D.

CORRESPONDENT.

May 26.—Antonio de Gregorio of Palermo.

ADDITIONS TO MUSEUM.

Ethnology and Archæology.—A. L. Siler. Netting from Pueblo ruins, Utah.

M. Huffnagle. Mummy (and accessories) of the XIX dynasty, collected by Dr. Charles Huffnagle (on deposit).

Mrs. Thomas Say. Leather stockings worn by Wm. Maclure.

Mammalia (Recent and Fossil).—H. C. Chapman. Skeleton of elephant.

S. F. Aaron. *Lepus callotis* (skull and skin), Texas; *Spermophilus grammurus?* (skin), Texas.

G. Raphael. *Blarina?* Beverly, N. J.

W. W. Jefferis. Tooth of fossil horse, Orange Co., Fla.

Florida Land and Improvement Co. (J. J. Dunne). Fragments of manatee bones, Manatee River, Fla.

Birds.—S. F. Aaron. 16 trays of eggs of North American birds.

T. G. Gentry. 181 nests of North American birds.

Zoological Society of Philada. *Cyanocorax chrysops*, Brazil; *Micrathene Whitneyi.*

T. L. Harrison. A collection of North American birds (no stated localities).

M. J. Middleton. Hooded merganser and whistling swan, Chesapeake Bay.

J. H. Carr. Impeyan pheasant, India.

W. H. Jones. *Aulacorhamphus albovitta*, *A. hæmatopygius*, *Sturnella* sp.? *Cotinga maynana* and *Tanagra lunulata*, from Colombia, S. A.

Reptiles (Recent and Fossil).—H. C. Chapman. *Ceratophrys cornuta*, Surinam: *Ungalia maculata*, *Diadophis rufescens*, *Hyla septentrionalis*, *Hylodes planirostris; Anolis Sagræi* and *A. principalis*, Nassau, New Providence.

W. W. Jefferis. Carapace of *Chelydra serpentina*, Lenni Dam, Pa.

Fishes (Recent and Fossil).—R. D. Casterline. Two specimens from the Green River Shales (Eocene), Wyoming.

W. Dougherty. *Fistularia tabacaria.*

Purchased. 45 species of fishes from the southern and western waters of the United States, collected by D. S. Jordan and S. E. Meek. 75 bottles of fishes from the waters of the southern and western United States, collected by D. S. Jordan and S. E. Meek.

Mollusca.—Rafael Arango. 7 species marine shells from Cuba, etc.

S. Archer. 158 species marine shells, Singapore.

J. F. Bailey. 19 trays marine shells from Australia.

W. T. Bednall. 11 species marine shells from Australia.

W. G. Binney. *Helix germana*, Santa Cruz, Cal.; *Helix Levettei*, Santa Fe Canyon, New Mexico.

Rev. W. M. Beauchamp. 10 species fresh-water shells from the State of New York.

J. J. Brown. 2 species fresh-water shells from the Bermudas and Bahamas.

H. F. Carpenter. *Amnicola grana*, near Providence, R. I.

H. C. Chapman. 8 species marine shells from the Bahamas.

Conchological Section (by purchase). 97 species shells new to the collection, many types; 48 species of marine, land and fresh-water shells from Sicily; 72 species marine and fresh-water shells from Australia, Cape of Good Hope, India, etc.; 100 trays land, marine and fresh-water shells from France, collected by M. Bidard; 16 trays land and fresh-water shells from Missouri, collected by O. A. Crandall; 175 species land, marine and fresh-water shells from England, collected by H. Crowther;

78 species of land and fresh-water shells, principally from New Caledonia, collected by G. Dupuy; 103 species of land, marine and fresh-water shells from France, collected by A. Granger; 217 species of land, marine and fresh-water shells from Florida, collected by H. Hemphill; 38 species of land shells from France, collected by M. Locard; 39 trays land and fresh-water shells from Asia, Africa, Tasmania and New Caledonia, collected by E. Marie; 42 species marine shells from Florida, collected by M. A. Mitchell; 137 trays land and fresh-water shells from France, collected by Lieutenant Wattebled.

John Ford. 8 trays of marine shells from Rhode Island and Massachusetts; suite of land and fresh-water shells from Philadelphia county, Pa.; *Helix Stimpsoni; Teredo navalis*, in ebony wood from Macassar, Java; *Pholas truncata* and *P. crispata* from Sea Isle City, New Jersey; 5 species marine and fresh-water shells from Narragansett Bay, etc.; *Melo Indica; Hippopus maculatus* and *Trochus pica; Littorina irrorata* Say (young) and *Modiola plicatula* Lam. from Atlantic City, New Jersey.

Dr. F. M. Hamlin. 2 species marine shells from Bermuda.

Dr. Hartmann. 5 photographs of type species of *Partula*.

Benton Holcomb. 11 species of land and fresh-water shells from Connecticut.

F. W. Hutton. 11 species marine shells, New Zealand.

W. W. Jefferis. *Helix pomatia* and *Helix hortensis* from Heidelberg.

C. W. Johnson. *Columbella avara, C. lunata* and *Odostomia impressa* from Florida.

C. R. Keys. *Sphærium sphæricum* Anth. from Kennedy's Lake, Iowa.

G. W. Lichtenthaler. 23 species marine shells from the Sandwich Islands, Alaska, etc.; *Sphærium sulcatum* Lam. from Salem, Oregon.

C. R. Orcutt. *Lymnea humilis* Say from Todas Santos Bay, California.

H. L. Osborn. 31 species marine shells from Beaufort, N. C.

G. Howard Parker. *Sphærium striatum* Lam., Ridley Creek, Delaware Co., Pa.

H. A. Pilsbry. *Gundlachia Meekiana*, Rock Island, Ill.

J. B. Quintard. 3 species of fresh-water shells from Silver Lake, Kansas.

J. H. Redfield. *Pecten Magellanicus*, Mt. Desert, Maine: *Littorina littorea*, Martha's Vineyard, Mass.

U. C. Smith. *Pholas truncata*, Anglesea, N. J.

Hon. F. E. Spinner. *Unio Buckleyi* Lea, Lake Monroe, Fla.; *Planorbis glabratus* Say, St. John's River, Fla.

R. E. C. Stearns. 4 species of marine and fresh-water shells, from California, Tehuantepec and Peru.

L. H. Streng. *Purpura hæmastoma*, Panama; *Nerita fulgurans*, Nicaragua; *Unio nasutus* and *Physa integra*, Michigan; 2 fresh-water species from Vancouver Island.

G. Test. Egg capsules of *Fulgur canaliculatus*, from Sea Isle City, N. J.

J. H. Thomson. 7 species of land and fresh-water shells, from Merida, Yucatan, and New Mexico; *Helix alauda* Fér., Cuba.

Henry A. Ward. Glove woven from the byssus of *Pinna pernula*, Mediterranean Sea.

Wm. Wheeler. *Cypræa angustata* and *C. edentula*, from Algoa Bay, South Africa.

J. Willcox. Egg cases of *Fulgur perversus*, Tampa Bay, Fla., and of *Fasciolaria*, Charlotte Harbor, Fla.: *Vivipara lineata* Val., and *Unio fuscatus* Lea, Orange County, Fla.

INVERTEBRATA (recent, exclusive of mollusks).—J. Ford. *Echinanthus rosaceus* and *Meoma ventricosa*, Elbow Key, Fla.; *Meoma ventricosa*, Nassau, New Providence; *Asterias ochracea*, Santa Cruz, Cal.; *Strongylocentrotus purpuratus?* California; *Oreaster*, Nassau; *Meyenia Leidyi*, Philadelphia.

H. C. McCook. A collection of Cicada architecture.

G. Günther. A collection of insects, Buenos Ayres.

C. Test. *Balanus eburneus*, Sea Isle City, N. J.

J. B. English. *Serpula dianthus*, Barnegat Bay, N. J.

G. J. Corson. Serpuloid worm burrows, Morris Cove, N. J.

C. McCormick. *Xanthodes nitidula* and *Apus longicaudatus*, Texas; *Gelasimus pugilator*, Atlantic City, N. J.; *Ixodes*, sp.? Texas.

E. Potts. *Pectinatella*.

INVERTEBRATA (Fossil).—J. Ford. *Orthis testudinaria*, from New York and Ohio.

W. W. Jefferis. Casts of *Venus*, Miocene of James River, Va.: a collection of Silurian and Carboniferous fossils from the west.

J. Wilcox. A collection of fossils, partly chalcedonized, from Tampa Bay, Fla. (Oligocene ?)

C. McCormick. *Acidaspis tuberculatus*, Bushkill, Pa.; *Phacops Logani*, Dingman's Ferry, Pa.

Chas. Wachsmuth. Slab containing Crinoids. Carboniferous of Marshalltown, Iowa.

Florida Land and Improvement Co. (J. J. Dunne). *Conorbis*, n. sp. (*princeps*), Oligocene, of Manatee River, Fla.

PLANTS (Recent).—Prof. Thomas C. Porter, Lafayette College, Easton, Pa. *Holosteum umbellatum* L., from Harrisburg, Pa.

Mrs. Maria L. Owen, Springfield, Mass. 7 species rare plants, from Nantucket, Mass., and an abnormal form of *Kalmia latifolia* L., from Deerfield, Mass.

Dr. J. W. Eckfeldt, Phila. 160 species Lichens from Scandinavia, Austria, Hawaian Islands and N. America, all named and mounted, of which 91 are new to the collection.

Wm. M. Canby, Wilmington, Del. *Isoetes melanospora* Engelm., Stone Mt., Ga., new to the collection: 388 species from Europe, S. Africa and Australia, of which 77 are new to the collection.

Dr. Asa Gray, Cambridge, Mass. 217 species from China, Formosa, Siam, S. Africa, Australia, S. America and United States, of which 76 are new to us.

Prof. N. L. Britton, Columbia College, N. Y. 17 species Cyperaceæ, from Texas, of which 4 are new to us; Also *Montia Howellii*, Washington Territory.

J. B. Ellis, Newfield, N. J. 14th and 15th centuries of N. American Fungi.

Thos. Meehan, Phila. 365 species collected by him in 1883, in Western Colorado, Utah, California and Nevada, of which 13 are new to the collection: 21 species, mostly cultivated exotics, of which 17 are new to us.

Mrs Fanny E. Briggs, La Center, Washington Terr., through Thomas Meehan. 51 species, collected by her in Washington Terr.

California Academy of Natural Sciences, by Rev. E. L. Greene and Mrs. Mary K. Curran, Curators. 24 species of rare California plants, of which 18 are new to the collection.

Isaac C. Martindale, Camden, N. J. 5 species plants from western North America, of which 3 are new to us.

Isaac Burk, Philadelphia. *Helianthus giganteus* L. *Helianthus* (doubtful sp.). *Senecio tomentosus*, from Cape May, N. J., and 19 species from ballast deposits at Kaighn's Point, mostly of South American origin, of which 6 are new to the collection.

Mrs. Flora E. Haines, Bangor, Me. *Petasites palmata* Gr., from near Bangor, Me.

Aubrey H. Smith, Phila. *Silphium perfoliatum* L., and *Gordonia pubescens* L'Her., with its fruit, from Bartram's Garden, Phila.

Dr. Emil Bessels, Washington, D. C. 13 species arctic plants, collected on Voyage of Polaris in July, 1872, Lat. 81°–82° N., and Long. 61° W.

J. Donnell Smith. Baltimore, Md. 26 species from southern United States, of which 3 are new to us.

John H. Redfield. 67 species from western N. America, of which 56 are new to us.

299 species, collected by C. G. Pringle, in Arizona and Iowa, in 1884, of which 114 are new to the collection.

16 species N. American grasses, mostly from Florida, of which 6 are new to us.

143 species, collected by him on N. England coast, mostly from Maine. *Friesia refracta* Klatt, Cult., new to us.

PLANTS (Fossil).—J. Ford. 5 trays coal plants, Schuylkill Co., Pa.

L. H. Lighthipe. A collection of fossil plants and plant impressions, from the Cretaceous clay of Woodbridge, N. J.

ROCKS AND MINERALS.—W. W. Jefferis. Dog-tooth spar, Mineral Point, Wis.; magnetic sand, Lake Champlain; iron pyrites, changing into limonite, Berks Co., Pa.; corundum, Chester Co., Pa.; fossiliferous limestone, Cincinnati; iron pyrites, E. Whiteland, Pa.; silurian limestone, Ohio; blende and galena, Cumberland, England; quartz, from dolomite of Poorhouse Quarry, Chester Co., Pa.; quartz, from Lewis Co., N. Y.; gneiss and limestone, from Van Arsdalen's quarry, Pa.; leucite, from Vesuvius; quartz, Hot Springs, Ark.; calamine, pseudomorph after calcite, Mineral Point, Wis.; granular quartz, Dixon's, Del.; corundum, Newlin, Pa.; pyroxene, Burgess, Can.; garnet, Lancaster, Mass.; fluor spar, Philadelphia; massive garnet, Birmingham, Pa.; granite, Triassic shale, no loc.; Potsdam sandstone, Gouverneur, N. Y.; lignite, Bonn, Germany; amygdaloidal melaphyre, Oberstein, Germany; melaphyre, Hettstadt, Germany; trachyte, Siebengebirge, Germany; lithographic slate, Bavaria; toadstone, Newburyport, Mass.; buhrstone, Paris, France; amygdaloid, Round Hill, Mass.; blue quartz, Chester Co., Pa.; schist with magnetite (loc. ?); wavellite, E. Whiteland, Pa.; blue quartz, East Creek, N. Y.; actinolite, Delaware Co., Pa.; hematite, Bernisof; mica slate, Warren, N. H.; corundum (altered), New Lynn, Pa.; hornblende, apatite and sphene, Rossie, N. Y.; limonite, Algeria; muscovite, Pennsburg, Pa.; muscovite, Chandler's Hollow, Del.; hornblende, Russell, N. Y.; cadmiferous blende, Wilkenradt; pyrite, smithsonite and sphalerite, Mineral Point, Wis.; quartz, Media, Pa.; polyadelphite, Franklin, N. J.; red-spotted porphyry, Lynn, Mass.; polyadelphite and rhodonite, Franklin, N. J.; corundum in Indianite, Delaware Co., Pa.; danburite (loc. ?); talc, East Bradford, Pa.; phlogopite, Rossie, N. Y.; phlogopite, Burgess, Can.; talc, Rochester, N. H.; radiated mica and damourite, Chester Co., Pa.; cerussite, Mineral Point, Wis.; calcite, Bilbao, Spain; rutile and dolomite, Chester Co., Pa.; scapolite, Bolton, Mass.; almandine, Dixon's, Del.; tourmaline, Thousand Islands.

D. S. Martin. Carrara marble bored by sponge, Long Island; marmolite, Hoboken, N. J.; crust from Saratoga "Geyser Spring;" crust from "Champion Spring," Saratoga; Eozoon rock, Thurman, N. Y.

S. E. Hudson. Lignite, from Egg Harbor, N. J.

J. Ford. Fossiliferous pebbles, Fairmount Park, Pa.

I. Lea. A series (51 trays) of Triassic rocks and organic impressions from Pennsylvania; a series (35 trays) of rock fragments and plant remains from the Permian, Trias and Lias of Alsace-Lorraine and southwestern Germany, named in part by Prof. Schimper.

Dr. Rice. Wollastonite, Martinsburgh, N. Y.

J. M. Hartman. Hematite, Jaragua, Chili; hematite, Jefferson Co., Ala.; quartz, iron, and copper pyrites, from Concord, N. C.; do, from Rima Mine, N. C.; do, from Rowan Co., N. C.; gold, Concord, N. C.

S. E. Paschall. Fossiliferous Triassic shale, Phœnixville, Pa.; Triassic shale, with calamites, Bucks Co., Pa.

J. Eyerman. Stilbnite, Mount Kosang, Japan.

J. C. Sanderling. Gold gangue (loc.?)

A. W. Dickson. Coal (with "eyes"), Kingston, Pa.

T. D. Rand. Chromite, Radnor, Pa., quartz, Chester Co., Pa.; trap column, from Conshohocken dike, Wayne, Pa.

D. B. Bruner. Chabazite, Fritz's Island; do. from Reading, Pa.; datholite and brucite, Reading, Pa.; aragonite, Berks Co., Pa.; apophyllite, thomsonite, calcite, and mesolite, Fritz's Island, near Reading, Pa.

S. Tyson. Chabazite, Fritz's Island, Pa.; apophyllite, Reading.

A. O. Deshong. Zoisite, Leiperville, Pa.

E. W. Pine. Quartz geode, Keokuk, Iowa.

H. C. Lewis. Cuprite, Frankford, Pa.; calcite, Wheatley Mine, Pa.; genthite, Lafayette, Pa.; hypersthene gabbro, Mt. Hope, Md.

L. Woolman. Erythrite, Wheatley Mine, Phœnixville, Pa.; Triassic shale, with plant impressions, Phœnixville, Pa.; milky quartz, Overbrook, Pa.

C. U. Shepard. Lazulite, Georgia; asbestiform bronzite, Pelham, Mass.; keatingine, Ft. Sparta; elroquite, Elroque, W. I.; phosphorite, Spain; indianite, Pelham, Mass.; wilsonite, templeton and uralite, Conn.; antillite (loc.? ; pelhamine, Pelham, Mass.; keatingine, Franklin, N. J.; monite, Island of Mona; monetite, Island of Moneta; staurolite, Morgantown, Ga.; staurolite, S. Car.

L. Garrison. Clinton ore. S. Pittsburgh, Pa.

C. McCormick. Granite, with nodular mica, Craftsbury, Vt.; Clinton shale, with glacial striæ, and Hudson River slate, Delaware Water Gap, Pa.; uranotil (?) and autunite, from Avendale quarries, Pa.

G. H. Parker. Glaciated pebbles, clay, etc., from the glaciated region near Boston, Mass.; autunite and torbernite (?), Avendale quarries, Pa.

W. H. Schiveley. Cryolite, siderite, and galena, Ivigtut, Greenland.

M. A. Walsh. Concretions formed in ferruginous gravel, of Perryville, N. J.

E. J. Wheelock. Slickensided shale (Triassic), Newark, N. J.

C. Brock. Eocene rock, Eutaw Springs, S. Car.

J. W. Pike. Pebbles from fossiliferous gravel of New Jersey.

H. C. Chapman. Shale, with fossil leaves, Wyoming; fragment of fossiliferous boulder, Mt. Desert.

Mineralogical and Geological Section, A. N. S. Hornblende, Renfrew Co., Can.; pyroxene, var. Jeffersonite, Sussex Co., N. J.; obsidian, near Pinas, Mexico; kyanite, Norwich, Conn.; stilbite, Nova Scotia; quartz in limonite, New York; apophyllite and stilbite, Frankford, Pa.; wernerite, Sussex Co., N. J.

Purchased. Elæolite (var. nephelite), Magnet Cove, Ark.; nephelite, Löban, Saxony.

In Exchange. Kyanite, Black Horse, Del. Co., Pa.; orthoclase, albite with beryl, hyalite, and beryl, Avondale, Del. Co., Pa.

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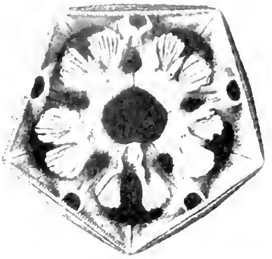

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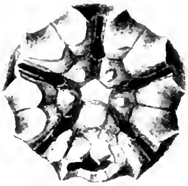

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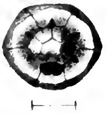

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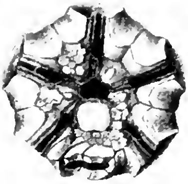

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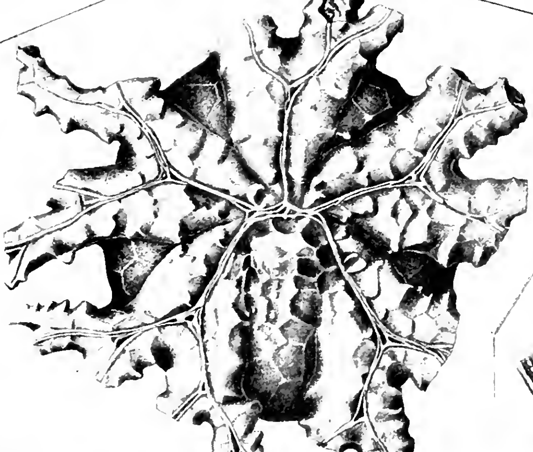

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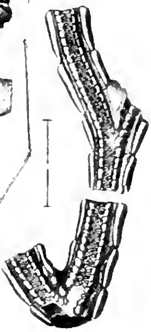

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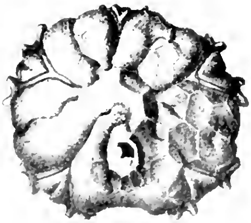

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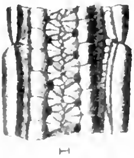

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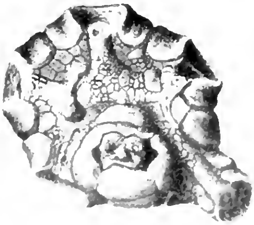

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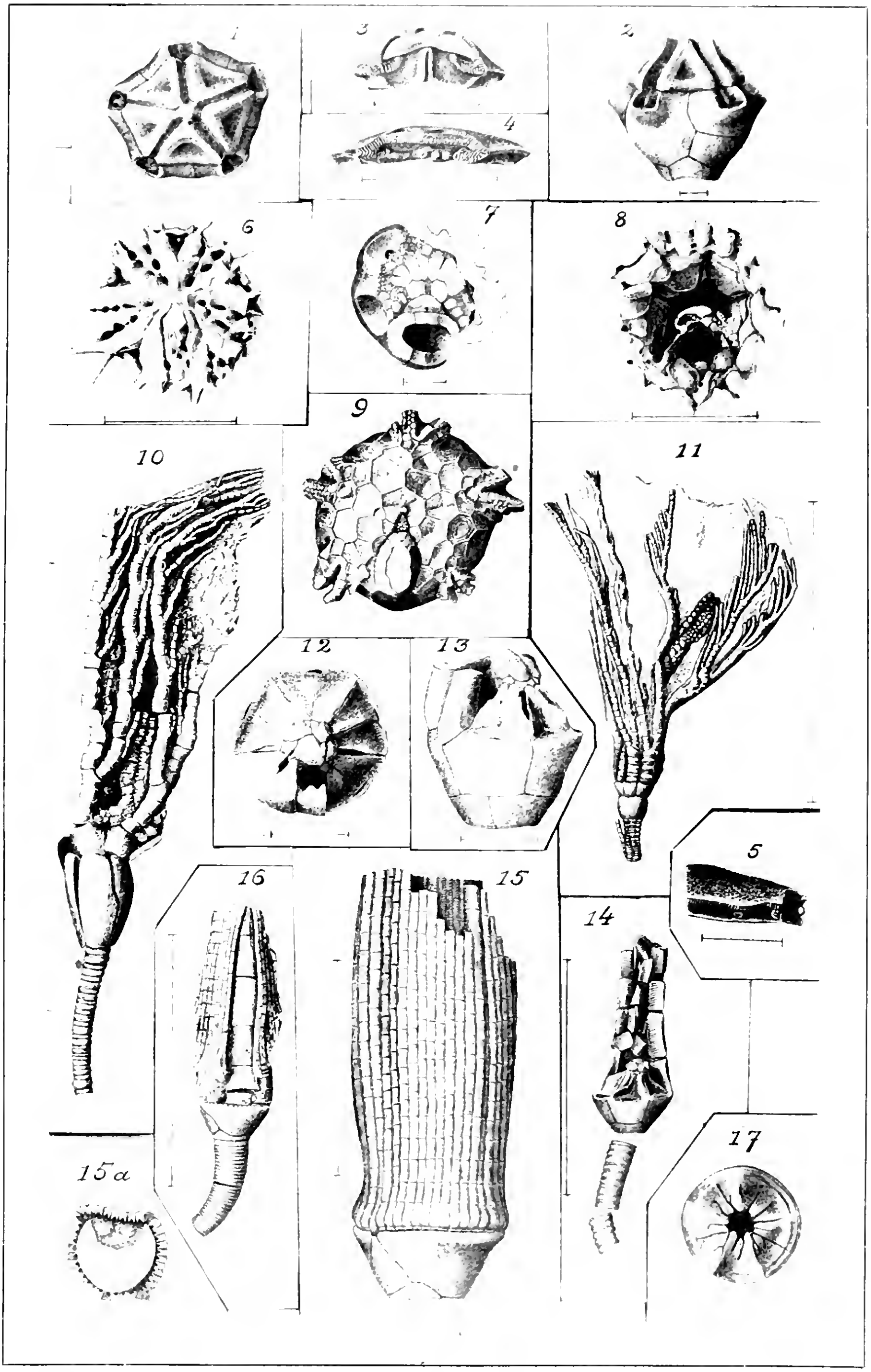

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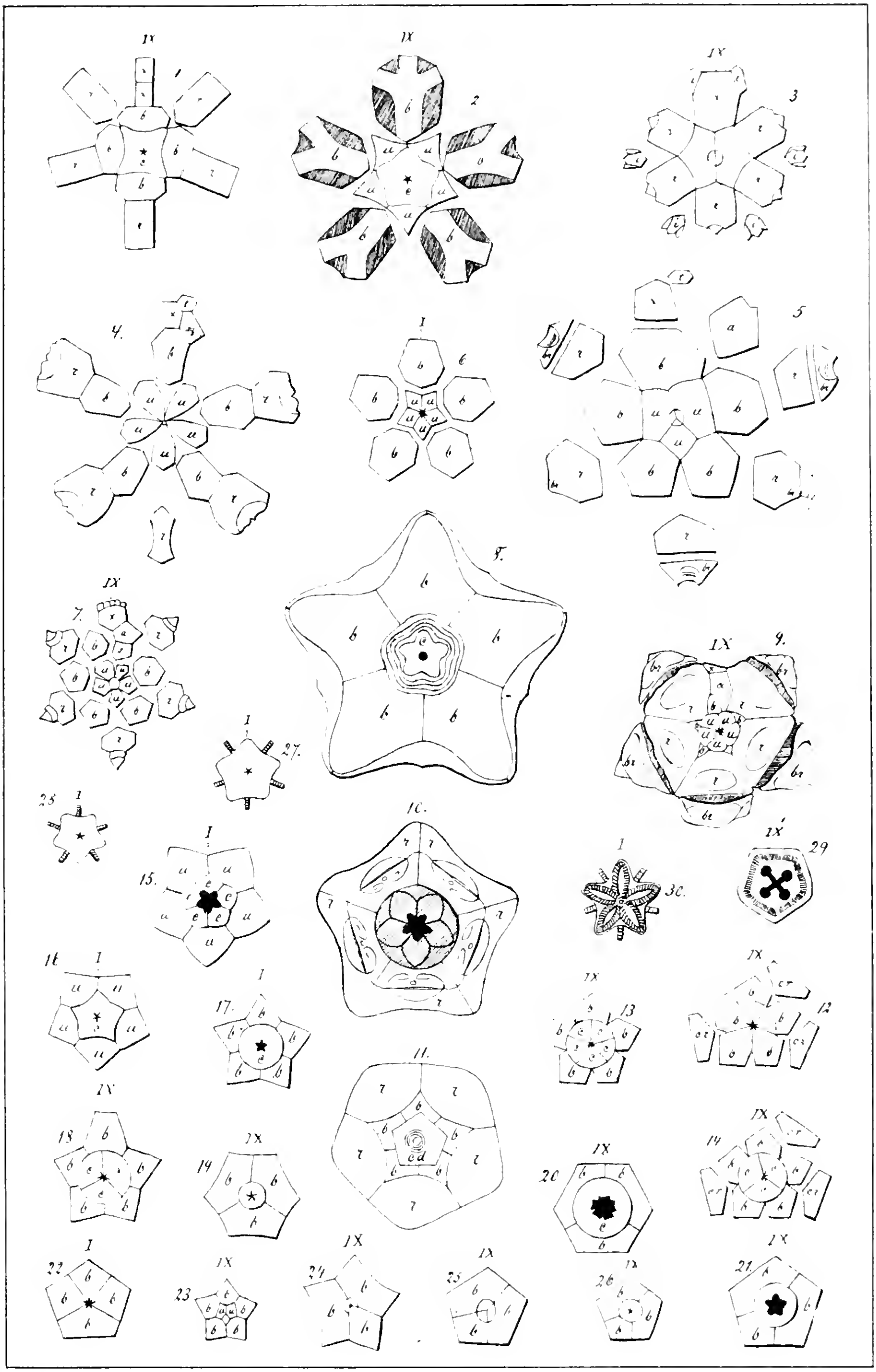

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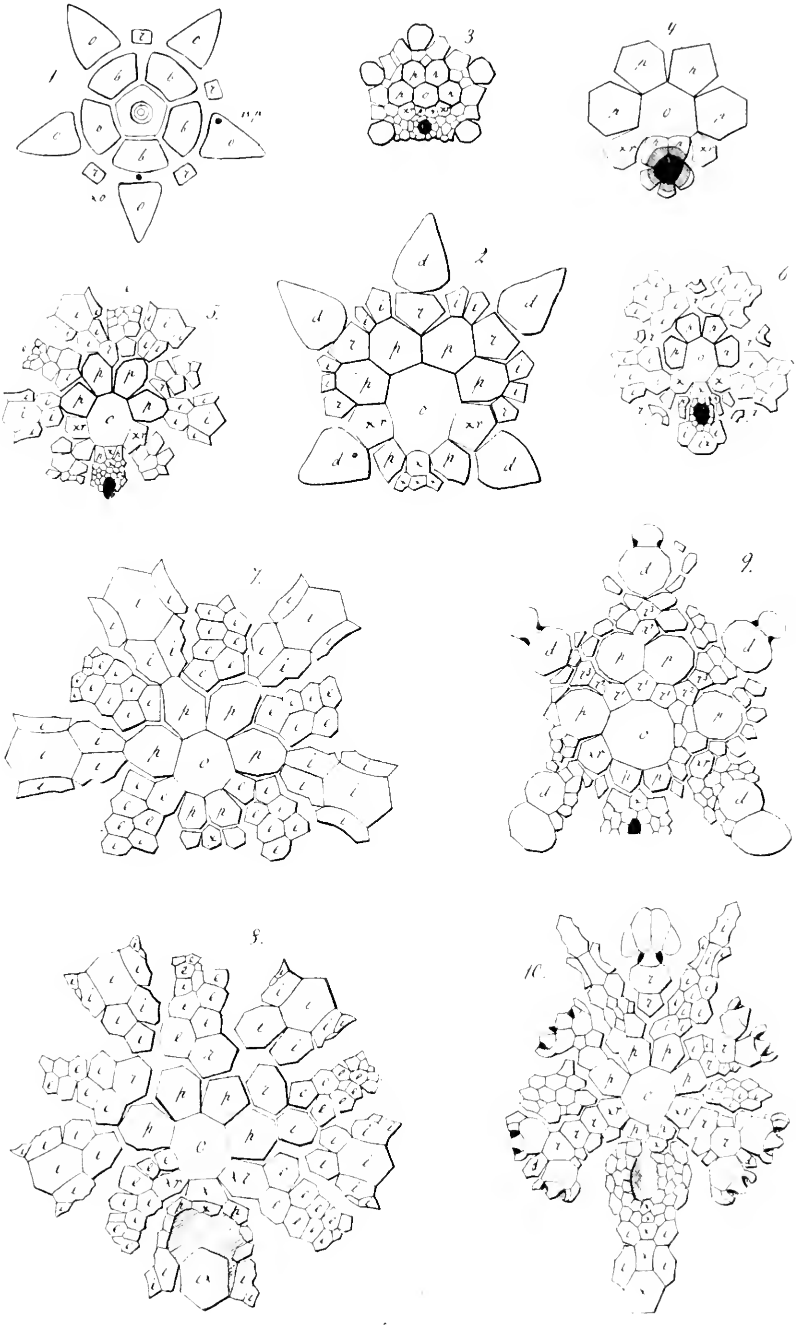

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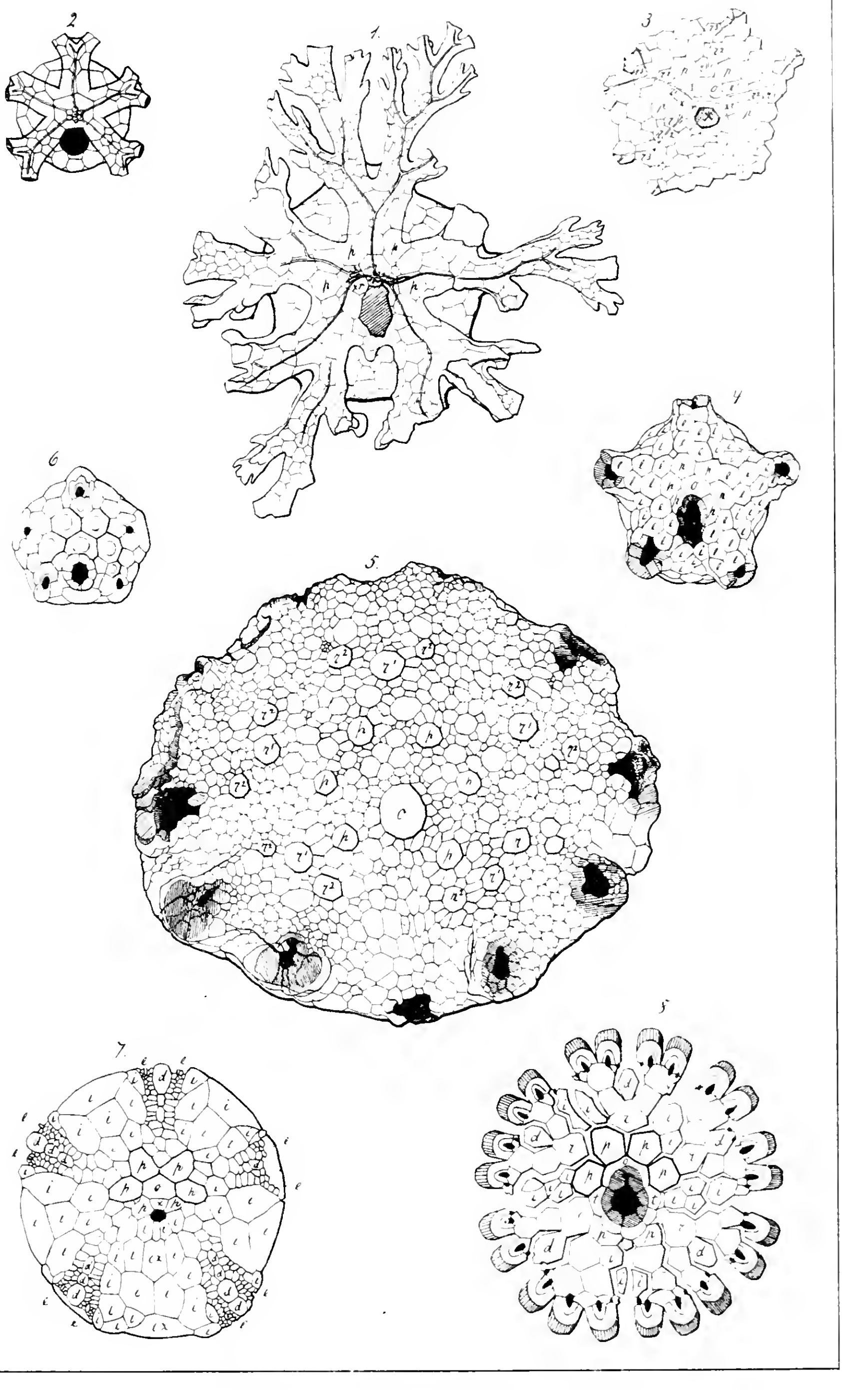

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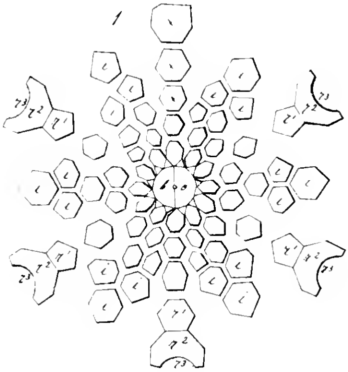
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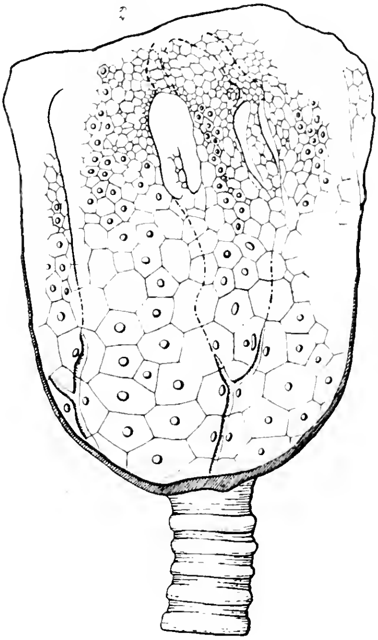
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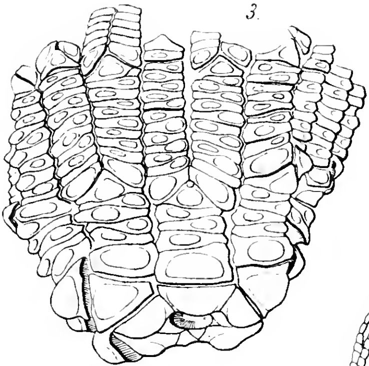
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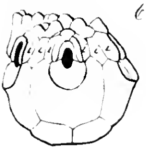
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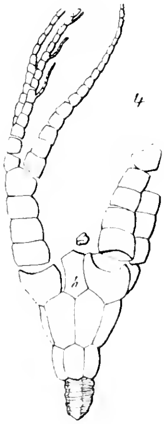
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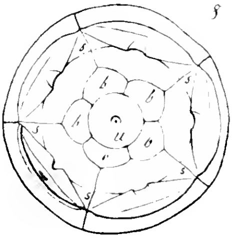
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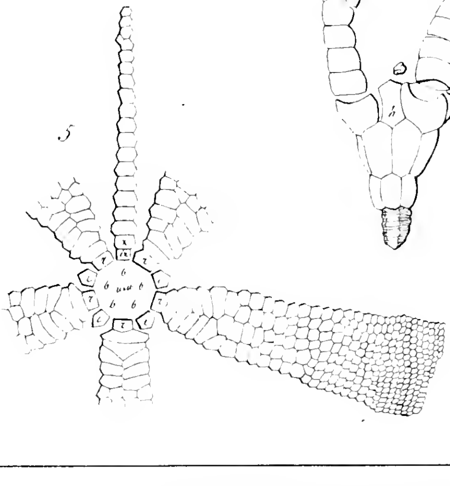
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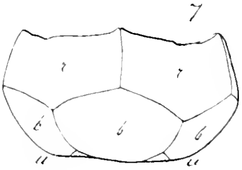
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OF

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PART I.—JANUARY, FEBRUARY, MARCH, 1885.

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1885.

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