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PROCEEDINGS

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OF

PHILADELPHIA.

1886.

COMMITTEE OF PUBLICATION:

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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.

1886.

January 5, 1886.

The President, Dr. Leidy, in the chair.

Twenty-six persons present.

The death of J. B. Lippincott, a member, was announced.

January 12.

Mr. Charles Morris in the chair.

Fifteen persons present.

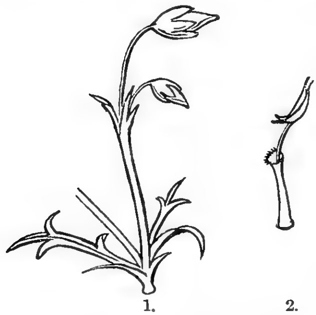
A paper, entitled "New Species of Partula from the New Hebrides and Solomon Islands," by Wm. D. Hartman, M. D., was presented for publication.

On the Morphology of superimposed Stamens.—At the meeting of the Botanical Section on January 11, Mr. Thomas Meehan remarked that Sachs teaches that stamens "must be considered morphologically as foliar structures, and make it convenient to term them Staminal Leaves,"[1] and Dr. Asa Gray defines a stamen to be "one of the elements or phylla of the andrœcium."[2] So far

[1] Text Book, English ed., p. 473. [2] Structural Botany, p. 435.

as the speaker knew, no botanist regards the stamen as an axial development, yet there are occasional phenomena that seem to be inexplicable on any other hypothesis. We have to admit that a flower is not merely composed of modified leaves, but is a modified branch;—the branch, arrested in its development, produces sepals and petals in the order and in the place where leaves might have been. Occasionally, however, the usual order of phyllotaxis seems broken. Stamens will spring from the base of petals, and opposite, where we looked for them to alternate; and then for the sake of consistency with the phyllal hypothesis, we have to assume that one theoretic whorl has proved abortive, or that there has been a multiplication of whorls, the superimposed one being the extra. This introduction of an extra series, immediately over the lower, not provided for in the original phyllotaxy, has, I think, never been seen in the normal condition of the branch, and it is difficult to conceive how this could occur under the arrestation of axial growth that transforms the branch into a flower. On the other hand, if we take the petal to be the analogue of the leaf on the elongated branch, there seems no reason why there should not be, theoretically, an axial bud to the petal; and, should this bud develop, it would be the superimposed stamen. Branching and articulated stamens are frequent in those families that have these organs spring, as it were, from an axial bud at the base of the petal, as in a diminutive or suppressed secondary branch we might expect them to do.

The flowers of *Mahernia verticillata* Cav., a well-known Byttneriaceous plant from the Cape of Good Hope, common in cultivation, which he exhibited this evening, seem to indicate that its superimposed stamens are really arrested branches. The genus is separated from *Hermannia* chiefly by a cup-shaped gland at the middle of the stamen (see Fig. 2). A comparison with the axial development of the inflorescence shows the stamen to be formed on precisely the same plan as the biflowered peduncle (Fig. 1). Really the flowers are axillary—a single flower being produced from the axil of each leaf. What appears to be the "two-flowered peduncle" of authors is simply a diminutive branchlet. After forming one node the longitudinal development becomes nearly arrested, and we have only a shortly-pedicillate and slowly developing flower, representing the shorter of the two in the cut. The bud in the axil of the bracteolate leaflet, however, makes another and stronger attempt at growth, and pushes up and over the one which terminates the first growth.



1. 2.

Mahernia verticillata Cavanilles.
1.—Two-flowered branchlet.
2.—Stamen, magnified.

In the development of the stamen we read in the same language. The lower leaf from which the short though main peduncle in the inflorescence appears, is typified by the petal. The common peduncle is represented by the filament, and the cup-like gland at the middle stands for the bracteole of the bipedicels. Here one of the flower buds—probably the outermost and weakest in the normal development—wholly disappears, the innermost becomes the upper part of the filament, the next node may be at the connective, and then the theoretical floral leaves proceed to form the anther. The incised bract is reduced to the fringed cup-like gland from which the stamen proper springs.

A close examination of the stamen gives some further facts in support of this theoretical view. When a branchlet is produced from a branch, it is necessarily more slender than the parent branch. The upper half of the *Mahernia* filament is more slender than the part beneath the gland, and, while the lower portion is smooth and membranous, the upper is minutely hispid—variations which we might only expect in distinct internodes. Only for its actual office in supporting and appearing in the direct line of the stamen, we might critically call the lower portion a peduncle, and the portion above the gland the stamen proper.

And we may conclude, after a whole study of the subject, that in many cases superimposed stamens are the development of theoretical axial buds at the base of the petals, and not the result of an interjection of an extra whorl of leaves for which there would be no warrant in phyllotaxy.

January 19.

The President, Dr. Leidy, in the chair.

Fourteen persons present.

Mastodon and Llama from Florida.—Prof. Leidy directed attention to some fossil bones, being part of a collection now at the Biological Department of the University, recently received for examination from the Director of the U. S. Geological Survey. The collection was made by Mr. W. H. Dall, near Archer, Florida, in a locality discovered by Dr. J. C. Neal, who had previously sent specimens to the Smithsonian Institution, and others directly to Prof. Leidy for identification. Some of these specimens had been brought to the notice of the Academy, as indicating a species of rhinoceros and of a horse, to the former of which the name of *R. proterus* was given, and to the latter that of *Hippotherium ingenuum.* In the collection recently received are numerous bones and well-preserved teeth of the rhinoceros, mostly limb bones, among which are fourteen well-preserved astragali.

Some of the specimens exhibited are those of a mastodon, apparently a previously undescribed form, although upwards of a half dozen distinct species have been characterized as pertaining to North America. An unworn crown of a last inferior molar tooth resembles most nearly that of the *Mastodon angustidens* of Europe, but is much larger. It has the same number of crests, but the fifth is proportionately much more developed, being divided into two lobes, about two-thirds the size of those of the fourth crest. It is also much larger than in *M. andium*, and has its lobes proportionately more robust, and is provided with a well-produced external basal ridge.

The following are comparative measurements of what appear the most closely allied forms :—

	Fore and aft.	Transverse.
Florida mastodon, . .	9 inches.	$3\frac{1}{2}$
M. angustidens, . .	$7\frac{1}{4}$ inches.	$3\frac{1}{2}$
M. andium, . . .	8 inches.	3

Small fragments of tusks indicate the possession of a band of enamel, as in the *M. angustidens*. For the species, the name of MASTODON (TRILOPHODON) FLORIDANUS was proposed.

Among the fossils are several isolated teeth, and bones apparently indicating three species of Llama. Judging from the astragali, one was about the size of the existing South American species; another, of which there are five astragali, as large or larger than the camel, and a third of intermediate size. The measurements of the astragali are as follows :—

Large species,	Length, 100 mm.	Breadth, 70 mm.
Medium do.	" 65 "	" 42 "
Small do.	" 50 "	" 35 "

The three species may be distinguished by the names of AUCHENIA MAJOR, MINOR and MINIMUS.

Among the fossils is an astragalus of *Megatherium*.

JANUARY 26.

The President, Dr. LEIDY, in the chair.

Twenty-four persons present.

The following were presented for publication :—

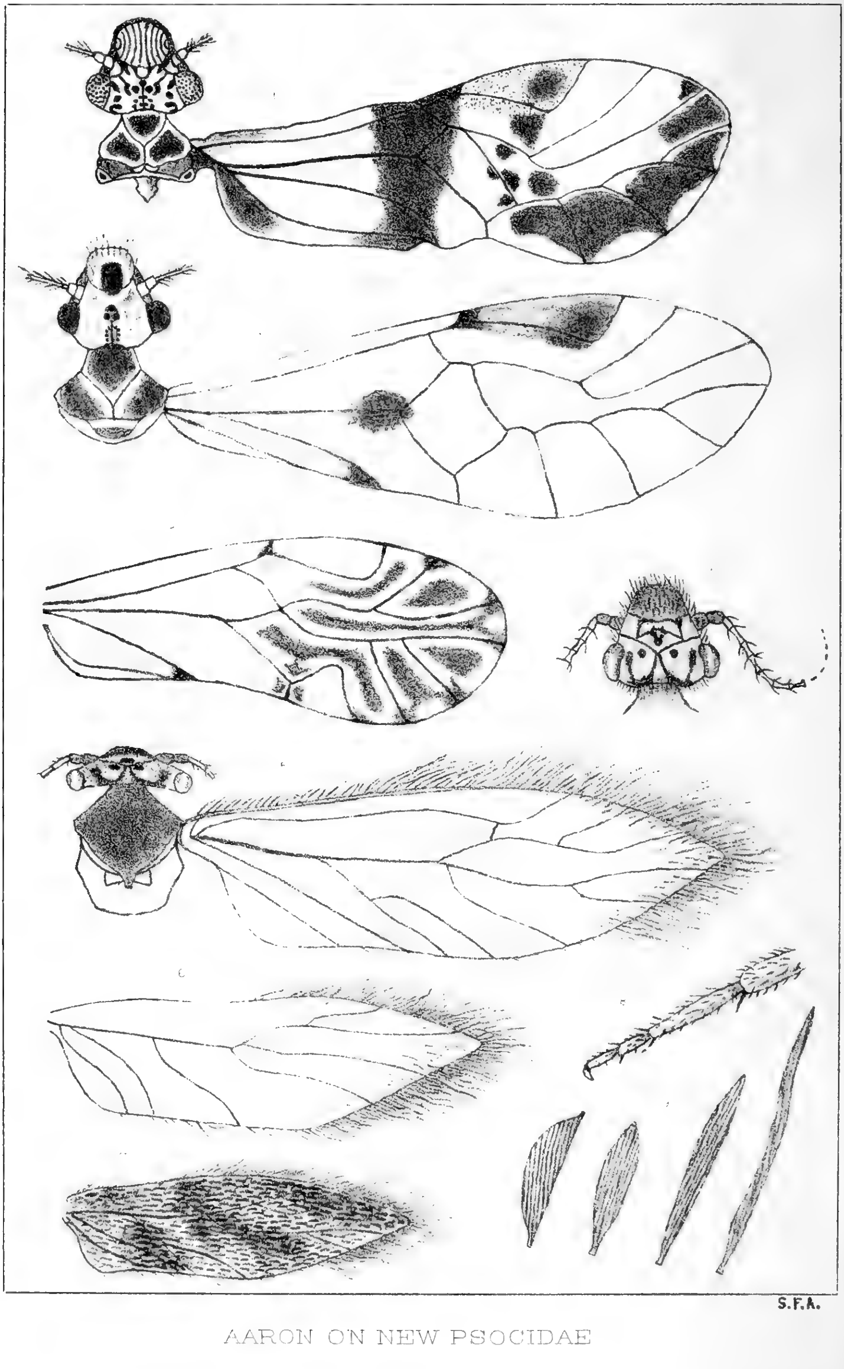
"On a Giant Conorbis from the Oligocene Deposits of Florida," by Angelo Heilprin.

"Notes on the Tertiary Geology and Paleontology of the Southern United States," by Angelo Heilprin.

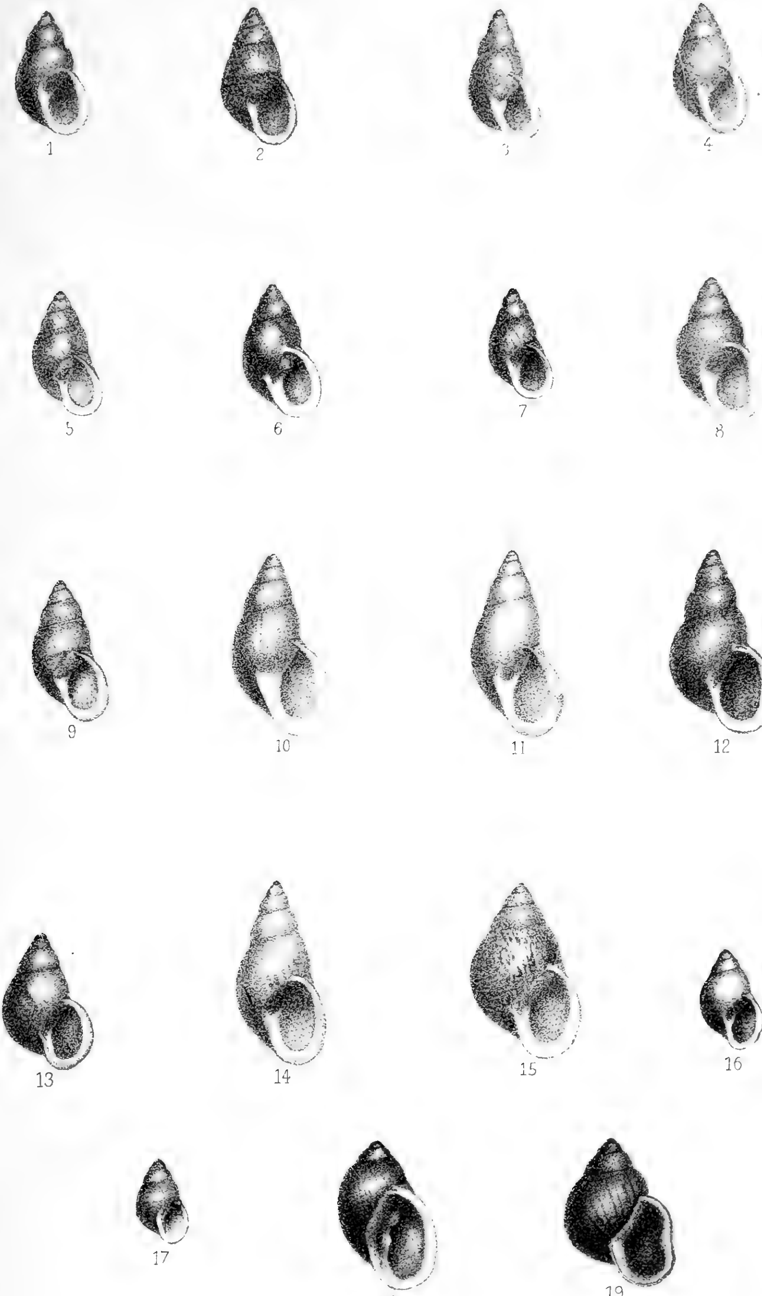
Roland D. Jones, M.D., was elected a member.

Charles Wachsmuth, of Burlington, Iowa, and Alfred M. Mayer, of Hoboken, N. J., were elected correspondents.

The following were ordered to be printed :—



AARON ON NEW PSOCIDAE



Hartman on New Species of Partula.

ON SOME NEW PSOCIDÆ.

S. FRANK AARON.

The several new species described here are in the collections of the American Entomological Society.

Cæcilius subflavus.

Almost entirely pale yellowish, or bright luteous, very sparsely pilose. Antennæ and palpi very pale, the former slightly fuscous on the basal joints. Eyes black and yellow. Ocelli rufous brown, small. On each side of the occiput, from and behind the eye, a fuscous cloud or band, not joining in the middle. Thorax and abdomen yellowish, the anterior lobe of the former with a faint darker spot, and the latter with some fuscous markings; appendages brighter yellow. Feet pale, semitransparent. Wings hyaline, very slightly clouded in the cells with pale luteous, and with a nucleated darker spot directly below the posterior angle of the pterostigma. Veins luteous, and with the pterostigma, having a few fuscous hairs, each springing from a black point. Length to end of wings about 2–2·5 millim.

Southern Texas. I collected this species from live oak trees along the river bottoms; found only two specimens, male and female. The male is smaller, eyes black and large, the thorax fuscous (probably discolored by drying), and the clouds in the wings pale brown.

Cæcilius nubilis. Plate I, fig. 3.

Pale luteous. Antennæ and palpi entirely pale. Nasus somewhat indistinctly clouded. Ocelli dark brown. An irregular maculate pale brown line on each side of the head, extending from within the margin of the eyes to the posterior central portion of the occiput, and a double maculate paler brown line dividing the occiput and almost reaching the ocelli. Eyes pale, with a yellowish green reflection. Thorax pale, the lobes clouded with pale brown. Abdomen paler, the sutures, in part, brown. Legs very pale, the last tarsal joint fuscous. Wings hyaline, pterostigma the same, not more opaque; veins brown, the larger ones, on the basal half of the wing, paler, and on the apical half, wherever they join the margin of the wing, they are, together with the marginal vein at that point, black, or deep fuscous, surrounded by a small pale brown clouded spot. Each cell in the apical half of the wing has, midway between the veins, a pale brown cloud, approximately taking the shape of its cell. At the base of the pterostigma a small black spot, and another at the junction of the cubitus and posterior margin. Length to end of wings about 2 millim.

Southern Texas. One specimen discovered while beating a live oak thicket on the prairies.

Cæcilius impacatus.

Pale yellow and brown. Antennæ much shorter than wings, fuscous, the basal joints and the first long joint in part, pale; palpi fuscous. Nasus pale, somewhat clouded with brown; rest of head yellow with brown markings, the space before and directly around the separated golden colored ocelli, brown; a brown band on each side bordering the inside margin of the eyes, and another on each side of the dividing occipital suture, reaching each posterior ocellus. Eyes brown and pale, about concolorous with the other parts. Mesothoracic lobes brown, deeper colored anteriorly, the sutures pale yellowish; rest of thorax pale yellow and brown. Abdomen pale, the sutures brown, and brown markings at the apex. Legs pale, the apical tarsal joint darker. Wings clear hyaline, the seemingly delicate veins pale brown. A small black spot at the base of the pterostigma, and another at the junction of the cubitus and posterior margin. Otherwise the wings are entirely unmarked. About 3·5 millim. long to end of wings.

Penn. (near Philadelphia).—I beat one specimen from the branches of a beech, and, on account of its constant activity found it very difficult to capture, almost hopelessly mashing it in doing so.

Psocus campestris.

Luteous and pale brown. Antennæ about as long as the wings, fuscous, the basal joints luteous; palpi pale, fuscous on the extreme apex. Nasus short, lineated with brown, and sparsely pilose; rest of head luteous, a brown irregular patch on the margin of nasus before the ocelli; a narrow black line dividing, the occiput; faint fuscous maculose markings on each side, within the margin of the eyes. Ocelli black; eyes brown, with paler reflections. Lobes of the thorax brown, the sutures luteous. Abdomen pale brown, the sutures and underneath in part pale. Legs pale, femora somewhat yellowish. Wings perfectly hyaline, the veins pale brown, semitransparent luteous in parts; pterostigma, a narrow space directly beneath it, and the indication of a small spot at the junction of the cubitus and posterior margin, pale brown. Length to end of wing about 2·5 mill.

Southern Texas. One specimen taken from the live oak trees that compose the small groves (motts) on the prairies. It is allied to *Ps. quietus*, of Hagen (many specimens of which I also found in the same locality, but in different situations, viz.: on yellow berry bushes), but differs from that species in being considerably smaller, in having the nasus shorter, not reaching the ocelli, and by having fewer markings on the head.

Psocus Leidyi. Plate I, fig. 2.

Pale yellowish and black. Antennæ nearly as long as the wings, subfuscous, the basal joints pale; palpi pale, the apical joint subfuscous. Head pale yellowish, deepest on the nasus, which is faintly lineated with paler; a large shining black rounded spot in the middle of the upper part of the nasus, bordering the suture; beneath the antennæ, on each side, a small black spot; ocelli black; occiput with a brown band on the dividing suture containing a double row of darker spots almost reaching the ocelli. Eyes black. Lobes of the thorax black, shining, the sutures and the rest of the thorax pale yellow. Abdomen pale yellow, the sutures black, merging into a longitudinal row of irregular spots on each side of the dorsum; a large, irregular, shining black patch on the dorsum of the apical segment, with a smaller black spot on each side below it. Abdomen beneath partly fuscous. Apical appendages, yellow and black. Legs very pale, the base of the tibia with a black spot beneath, and the tarsi subfuscous, the apical joint black. Wings clear hyaline, veins mostly fuscous, that enclosing the pterostigma yellow, and the veins enclosing the discoidal cellule, with certain of their branches, in part pale yellowish and light brown. Pterostigma subopaque, a small black spot at its base, a rounded clouded brown spot posteriorly within its apex, and another brown spot directly below and contiguous to its posterior angle; at the basal angle of the discoidal cell a large rounded brown spot, and another smaller at the junction of the cubitus and inner margin. Hind wing immaculate. Length to end of wings about 5·5–6 mill.

Rhode Island and Pennsylvania. From two specimens collected many years ago by Dr. Joseph Leidy in Rhode Island, and two specimens taken by myself near Philadelphia, on the trunks of chestnut trees, where they appeared to be solitary. For some time I had, somewhat doubtfully, supposed this species to be *Ps. canadensis*, of Prov., until I received a letter from Dr. Hagen, referring *canadensis* to the genus *Elipsocus.*

Psocus texanus.

Pale yellow, with brown markings. Antennæ longer than the wings, fuscous, pale at the base. Nasus lineated with brown; rest of head above with irregular markings, viz.: a horseshoe spot before the ocelli, an irregular line on each side from near the base of the antennæ to the ocelli; a line of spots within the margin of the eye, occiput with a line of spots on each side of the dividing suture that come together just behind the ocelli. Eyes brown, with a slight golden tinge; ocelli black. Lobes of the mesothorax clouded with fuscous, the sutures pale yellow. Abdomen marked with fuscous, and the anal appendages yellow. Legs luteous, the apical tarsal joints fuscous. Wings hyaline, the veins brown; pterostigma less clear, a fuscous spot within its apical half, and another just below it; a fuscous band crosses the entire wing in the middle, its outer margin reaching from the base of the pterostigma to the junction of the cubital and postcostal veins and the posterior margin, passing through the basal angle of the discoidal cell. Hind wings hyaline, no markings. Length to end of wings about 4 mill.

Var. **submarginatus.** Plate I, fig. 1.

Characterized by having the fore wings with additional markings in the form of a submarginal fuscous band or cloud, reaching from the second apical nervule to the posterior apical extremity of the discoidal cell, and with a few somewhat rounded spots between the nervures bordering upon and beyond the discoidal cell. Length about 3 mill. Otherwise like *texanus.*

Southern Texas. I took fifteen specimens of *texanus* and four of var. *submarginatus* entirely by beating from yellow berry bushes, black chaparral and live oak, over the prairies. It is probably the commonest species in its locality.

ECHMEPTERYX nov. gen.

Head much as in *Psocus*, etc., the ocelli more widely separated. Antennæ with the two basal joints short and stout, the others rather slender, each joint attenuated in its middle, swollen somewhat at its apex. Dorsum of mesothorax entire, not divided into lobes, extended into a projection posteriorly. Tarsi three-jointed. Wings covered with scales of various forms. *Apex of wings pointed*, and furnished somewhat densely with long hair. Neuration peculiar, as shown in Plate I, figs. 5–6.

Belongs to a group with *Amphientomum* and *Perientomum*, probably most closely allied to Dr. Hagen's *Amph.* (*Syllysis*) *candatum;* differs in the neuration.

Echmepteryx agilis. Plate I, figs. 4–9.

Antennæ much shorter than the wings, pale fuscous; palpi fuscous. Nasus fuscous, pilose; rest of head somewhat pilose, pale, with dark brown markings, a bent brown line across the head, transversely, separating the anterior from the posterior ocelli; before the ocelli, in the middle, some irregular brown markings and bands (varying in different specimens), and between the ocelli, connecting with the transverse line, two convergent brown lines, extending to a brown patch on each side upon the occiput; on each side, within the margin of the eyes, another brown spot, becoming a line, and also joining the occipital patches. Ocelli black, each one within a small brown spot; eyes brown and golden yellow. Thorax brown, portions pale luteous, dorsum of mesothorax dark brown, somewhat scaled, and very pilose. Abdomen pale yellowish or luteous (in some specimens fuscous, probably discolored by drying), with some brown markings. Legs fuscous, somewhat paler or luteous; tarsi luteous, fuscous towards base. Wings fuscescent or smoky when denuded, becoming hyaline towards the apex; veins darker, semitransparent. Scales mostly fuscescent, paler towards the base; when upon the wing seemingly fuscous, and when thickly placed appearing almost black; other scales luteous upon the wing. These scales cause the wing to be covered with black, fuscous and luteous patches. The long apical hair mostly fuscous, luteous in patches. Hind wings hyaline, slightly infuscated, no scales, the long apical hair fuscous. Length to end of wing about 3 millim.

Pennsylvania. I found this species on the trunks of beech trees in a woods near Philadelphia. It is very active, quick and difficult to secure. I believe it represents a group entirely new to our fauna.

EXPLANATION OF PLATE I.

Fig. 1. *Psocus texanus* var. *submarginatus*.
" 2. " *Leidyi*.
" 3. *Cæcilius nubilus*.
" 4. Head. ⎫
" 5. Denuded fore wing and thorax. ⎪
" 6. " hind wing. ⎪
" 7. Fore wing covered normally with scales. ⎬ of *Echmepteryx agilis*.
" 8. Tarsus. ⎪
" 9. Forms of wing scales greatly magnified. ⎭

THE INCLUSIONS IN THE GRANITE OF CRAFTSBURY, VT.

BY CALVIN McCORMICK.

The inclusions usually found in granites are observed to vary to a marked extent in outline, structure and mode of occurrence. Very often they resemble imbedded fragments of older rocks. They are usually darker than the including granite, and are either circular or angular. When rounded they resemble an enclosed pebble; when angular, a fragment of slate or mica schist. They sometimes merge into the surrounding rock by thrusting out minute connective particles. They are generally finer in texture, and hence less easily decomposed by atmospheric agencies than the enclosing granite.

A reference to the recorded observations on granitic inclusions will doubtless assist materially in the study of the subject. In 1821, Dr. John Macculloch, in his "Geological Classification of Rocks," p. 230, refers to inclusions as "irregular patches or veins of a fine texture, spheroidal in arrangement, imbedded in coarse granite." In 1858, Dr. Carl F. Naumann refers to "pseudo-fragmentary concretions resembling sharp-angled fragments common in crystalline siliceous rocks." (Lehrbuch der Geognosie, 2 Auf., Band I, S. 422, 560; B. II, S. 203.)

In the same year Dr. F. Hochstetter states that "the granites of Billston Island contain micaceous fine-grained, dark, globular enclosures." (Jahrb. k. k. geolog. Reichsan., S. 285.)

In 1863, Dr. F. V. Andrian, referring to the hornblendic granites of Central Bohemia, mentions "innumerable fine-grained enclosures, sharply segregated from the surrounding rock, varying in size from $\frac{1}{20}$ to 4 inches in diameter. These enclosures contain small quantities of hornblende crystals. From their abundance and identity of constituents they were produced during the solidification of the rock mass, by a process of segregation, the exact nature of which is unknown." (Beit. z. Geolog. d. Kaur. Tab. Krei. Böhmen, S. 166.)

In an article on the "Metamorphic Origin of certain Granitoid Rocks and Granites in the Southern Uplands of Scotland," Prof. James Geikie describes "nests of altered rock in a gray granite. These are distinctly laminated, fine-grained, micaceous and imparting a dark shade to the rock. They are irregular in shape, and scattered indiscriminately throughout the mass." (Geological Magazine, 1861, vol. 3, p. 533.)

All of these observations relate to the external appearance of these inclusions. No one of these writers has given us an intimation of the microscopic or chemical nature of their internal structure. In this respect Prof. J. A. Phillips has greatly surpassed his predecessors.

In the Quarterly Journal of the Geological Society, vol. 36, p. 1, this author describes granites and their inclusions from numerous British localities. The Cornwall granites at Lamorna, Zennor, and Luxulyan contain numerous black patches, angular, fine-grained and composed of quartz and mica. The granite of Shap in Westmoreland encloses numerous well-defined, dark, round patches, fine-grained and varying in size from ½ to 15 inches in diameter.

In Scotland, the Aberdeen granites (metamorphic, Haughton) contain foliated, subangular inclusions of black mica.

In Ireland, the granite of Newry (metamorphic, Hull; igneous, Kinahan) affords inclusions which are apparently concretions. The Mourne granite (eruptive) contains ovoid and angular, fine-grained dark masses of mica and quartz.

This author derives the following conclusions from these observations:

These granitic inclusions are of two distinct kinds. The first is the result of an abnormal arrangement of the constituent minerals. The second represents the enclosed fragments of other rocks. Of the first, the outline is more or less ovoid, and they are essentially a part of the including granite. The dark color is due to the quantity of mica and hornblende. A second nodule contained in the first, is indicative of concretionary origin.

The formation of rounded inclusions in granites is believed to be contemporaneous with the solidification of the mass, and similar to that of the well known Napoleonite or orbicular diorite of Corsica.

Of the second class, the inclusions are irregular in outline, schistose in structure, traversed by quartz veins or divided by strings of granite. They are frequently unaltered, and are easily recognized as fragments of gneiss, hornblendic and micaceous rocks.

In our own country, Professor Irving, in his report "On the

Copper-Bearing Rocks of Lake Superior" (U. S. Geol. Survey, vol. v, p. 125), refers to a hornblendic granite containing an augitic core, and the entire mass showing minute flakes of biotite. Mr. Clarence King, in his "Systematic Geology" (U. S. Survey, p. 120), graphically describes the remarkable granitic wall of El Capitan, in the Yosemite Valley. This presents a vertical face 3200 feet high, dotted with irregular cloud-like masses and lenticular bodies, apparently segregations of the component minerals (brilliant black hornblende, quartz, biotite and orthoclase). This segregation he considers to be the result of mechanical accidents.

Having thus hastily glanced at observations relating to granitic inclusions in other localities, we are better prepared to understand those of the Craftsbury region. In the following considerations we will observe, first, the including granite itself; second, the included nodules, their external appearance and internal structure, and the relation of the rock-mass to its inclusions.

This nodular granite consists of the usual ingredients of a true granite—quartz, feldspar and mica. The quartz is the most abundant constituent. It possesses the properties of ordinary quartz as to color, lustre and hardness. The feldspar is the common orthoclase, every light in color—even resembling the quartz in this respect. The mica is the black variety (biotite), and is sparingly scattered through the mass. It is in striking contrast with the white components, and gives the rock the appearance of syenite. But no hornblende is present, nor have accessory minerals been observed. These constituents are disseminated irregularly throughout the rock-mass, and since they occur in small dimensions, this mass is fine-grained in texture. According to Prof. H. A. Cutting, State Geologist of Vermont, this granite occurs in place like other granites, but south of the beds it consists of numerous large bowlders.

Professor C. H. Hitchcock refers this granite to the Coös group, which he places directly below the Lower Helderberg division of the Upper Silurian.

The Inclusions.—These are spheroidal or elongated nodules of biotite, from one-half to two inches in diameter, with the long axis sometimes four inches. They are more or less flattened, and frequently consist of only a few plates. Their surface is smooth or sometimes plicated, the folds corresponding to the long axis. Then they resemble a dried butternut, stripped of its epicarp. Several convex scales may be detached from a flat specimen, placed on edge, with a sharp blow of the hammer.

They are distributed irregularly through the rock-mass. In some portions they are more abundant than in others. Some parts of the Craftsbury beds are composed entirely of nodules, slightly cemented by grains of quartz and mica. It appears that there is no law as to their distribution. From this locality to the Canadian line it is stated that these inclusions are very rare, in the beds extending over this area of about forty miles. (C. H. Hitchcock, Geology of Vermont, vol. 2, pp. 564, 721).

The Internal Structure.—But few microscopic sections of these nodules have been prepared. In studying the lithology of New Hampshire, Mr. G. W. Hawes, formerly of the Sheffield Scientific School, made a section of the centre of a nodule, and observed that the biotite is dichroic, that a small portion of muscovite and some quartz are present. No nucleus was apparent, but a concentric arrangement of the mica scales, which he considered to be the basis of the formation of the inclusion. (Geology of New Hamp., vol. 3, pt 4, p. 203.) On account of the limited observations of this peculiar formation, I attempted to prepare some sections of the internal structure. Of these, two were through the centre, and parallel to the longitudinal axis. These show that the biotite is in concentric layers, with grains of quartz scattered irregularly through it. No feldspar is present. These layers of biotite are made up of flakes or long bands. Along the thin edges they are of a light brown color, while the thicker masses are dark. The flakes are of different sizes respecting length and width. They are arranged very much like the scales on a fish. The biotite constitutes the greater part of the surface. It forms fully four-fifths, and doubtless even more in some cases. The quartz is remarkably translucent and very distinctly vitreous. During the grinding process, frequent observations with a lens indicated that the quartz increases in abundance towards the centre.

Several transverse sections parallel to the lateral axis were attempted, but the brittle nature of the biotite prevented success. This, it is thought, may be accomplished by hardening a specimen in shellac dissolved in alcohol. Sections through other portions of the nodule denote the laminated structure of the biotite.

The Relation of the Nodule to the Rock Mass.—The line of contact between the inclusion and the including rock is not always distinct. But it is possible to extract the former with comparative ease. The remaining cavity, however, is usually lined with biotite, which, adhering to it rather than to the nodule, indicates that the inclusion was originally formed from the rock mass. Sections across this line of contact, show considerable quartz and a small quantity of biotite. These minerals are apparently interlocked, further denoting that the biotitic mass belongs to the surrounding rock.

General Conclusions.—First, concerning the nodules: These are not micaceous rolls, for their structure internally shows distinct bands. Nor are they concretions, for no nucleus is observed. But they are masses of flakes of biotite cemented with quartz, abnormally segregated from the original granitic mass. These flakes, although originally concentric, were afterwards arranged radially, hence producing the nodular form. (Dr. Zepharowich, Mineralogical Lexicon, Austria, p. 59.)

Second, concerning the granite: The presence of these nodules indicates the igneous origin of the granite. Were the original mass in aqueous solution, the material would have been evenly distributed, and the nodules could not have occurred. Were it of metamorphic origin, the nodules would scarcely be so uniform in outline and microscopic appearance, but would be more or less contorted. These nodules denote a state of fluidity of the entire mass which resulted from igneous agencies. While in this fluid condition, the nodules first formed, and were enclosed by the surrounding mass. This is sustained by the wrinkled and folded surface of the nodules, which doubtless was occasioned by the contraction of the surrounding mass as it cooled.

The fact that biotite is a frequent constituent of igneous rocks, has its influence in sustaining the igneous origin of this granite. This is also sustained by the investigations of local phenomena. (Geology New Hamp., vol. 1, p. 538.)

The inclusions at Craftsbury are unique in type, differing from those of all other localities.

These observations may be modified by further investigations, but it is hoped that they may elicit an extended interest in the subject.

Appendix.—Since the preceding pages were written, my attention was directed to inclusions in certain flaggings in Philadelphia, on Chestnut Street above Third Street, and on Filbert Street above Thirteenth Street. It was desirable to trace the localities of these rocks.

By the assistance of the City Commissioner of Highways, and the dealer who furnished the stone for the Chestnut Street pavement, the locality was ascertained to be Connecticut or Maine.

The doubt in the case arises from the fact that the stone was furnished about twenty-five years ago, no record of its locality was kept, and the dealer is unable to recall with any degree of certainty the exact location. The granite in external characters closely resembles that of New London, Conn., as well as that of Sullivan, Maine. Hence this feature is comparatively valueless in the determination. But the resemblance of the inclusions to those in the Sullivan granite, favors the view that this location is the home of the Chestnut Street flags.

These inclusions are not numerous, nor regular in size and outline. They are made up of biotite, are elongated elliptically, frequently terminating in acute points. The length is eight or ten inches, and the width two or three inches. These masses blend into the surrounding rock, without affording any distinct line of separation, hence suggesting that their extraction would involve considerable difficulty. That these were produced in a way similar to those of Craftsbury, is apparent from external observations, and doubtless sections of the internal structure will sustain this supposition.

No evidence was obtained concerning the locality of the Filbert Street rock. Its worn condition denotes a long period of service. These inclusions tend to detract from the value of granites, as they afford an easy access for destructive agents (moisture, frost, heat), and hence such granites having a limited use, are not apt to be seen along public thoroughfares.

METHODS OF DEFENSE IN ORGANISMS.

BY CHAS. MORRIS.

Some weeks ago I presented a paper on this subject to the Academy. I wish to add a few suggestions to the considerations there taken, and particularly to speak of the evolution of the sponge, considered from the point of view of defense. As is well known, the sponge type of organism is one that it has proved difficult to classify, since it only partly conforms to the type of the Cœlenterates, while it is widely divergent from any other animal type. I may briefly point out these divergent features.

In all other animals above the Protozoans, except those parasitic forms which are destitute of an intestine, the mouth is a single aperture, which constitutes the main opening into the body. In the sponge type this single aperture is replaced by a multitude of minute openings, in connection with a single large anal opening. In one other respect the sponge is different from and more simplified than other animal types. Its digestion is entirely cellular. It has developed no organ answering to the stomach of other types.

The sponge is, moreover, destitute of any organs of offense or defense. Its nearest relatives, the polyps, have their tentacles and thread-cells, in connection with a single aperture, which is both oral and anal in function, and with a digestion which is intermediate between the cellular and the stomachal methods, and can be properly classed with neither.

The method of obtaining food, by the aid of water currents, is not peculiar to the sponge. It may be found in other animal types, such as the bivalve mollusks, the Tunicata, *Amphioxus*, etc. But in the sponge it is far more simplified than in these higher forms. In the case of the mollusks, the water current is confined to the branchiæ, and only its food particles are taken into the intestine. In the Tunicates and in *Amphioxus* respiration is intestinal, but the water current is confined to the branchial half of the intestine, while its food particles enter the stomachal half, where they undergo digestion. In the sponge the water currents permeate every portion of the body, and respiration, as well as digestion, is a function of the separate cells. Thus the most interior regions of the organism are visited by this water current and its contents.

Of all animal types, therefore, that of the sponge is least protected by defensive appliances. There is nothing in the make-up of the organism to prevent enemies from entering and penetrating to every portion of the body. They cannot be confined to an intestinal tube, and exposed to the action of its digestive juices, as in most organisms, but the whole interior of the body is open to assault.

Yet the evolution and long-continued existence of the sponge type is evidence that it has possessed some defensive adaptation. This adaptation, in its original phase at least, I take to be the peculiar system of inhalent and exhalent apertures. It is evident that the entrance of the water currents at the large aperture would greatly facilitate the entrance of the foes of the sponge, since they would be drawn from a distance and carried into the body on these currents. As it is, the currents enter at minute apertures, only adapted to the passage of microscopic food particles, and closing completely when not in use. The spicules may also act defensively, to prevent any larger creature from forcing an entrance at these oral apertures.

On the other hand, there is a strong current of outflow from the large aperture, well adapted to drive away the foes of the sponge, unless possessed of considerable swimming power. In this fact we seem to have an explanation of the peculiar organization of the sponge. The primeval ancestors of the Cœlenterates probably developed in two directions. In one type tentacles and thread-cells appeared, the oral opening was defended, and the internal cavity took on the function of an incipient stomach. In the other type the simple gastrula form was retained, and water was drawn in by ciliary action through pores in its cellular wall, and discharged at the mouth opening, after yielding its food particles to the individual cells. Thus a multitude of minute currents were combined into a single protective outflowing current of considerable strength.

This formation seems beneficial to the sponge from an aggressive as well as from a defensive point of view. The extension of the oral apertures over the whole surface of the body very considerably increases the water space from which food particles are drawn in, and thus may add materially to the food supply. As the microscopic creatures which serve the sponge for food are somewhat thinly disseminated, this extension of the space swept by the inflowing currents is certainly an advantage.

These remarks, however, are intended to apply principally to the primitive sponge. In the earliest stage of this type of organism it probably lacked the spicular and fibrous defenses now possessed, and was but a step above the simple gastrula. At this remote era, however, it is probable that muscular action had not yet been evolved, and that cilia formed the only agents of animal motion. Against creatures swimming by aid of cilia the water current of the sponge must have been fully efficacious as a defense. The development of the fibrous framework, and of the pointed spicules, was probably a subsequent adaptation to meet new dangers, after muscular organs of motion had been evolved. At present prowling animals have no difficulty in making their way to the interior of the sponge. The spicule is now probably its most efficient defense, and the continued existence of the sponge type shows that it is sufficiently defended against such animals as might seek to prey upon its protoplasmic substance.

I may offer, in conclusion, a further application of the hypothesis presented in my former paper. The interaction of attack and defense presents a feature of distinction between animals and plants, in addition to those usually recognized. This distinction I may briefly indicate.

If we consider the defensive appliances of animals from a general point of view, they may be reduced to two categories. They are either mechanical or motor. These exist together, but to the extent that the one method is developed, the other remains undeveloped. If we take such an animal as the oyster, for instance, we find that its defense is almost wholly mechanical. Its only defensive motion is one of withdrawal within the shell. If we take man, the defence is almost wholly motor. Scarcely a trace of mechanical defense exists. In my former paper I spoke also of mentality as a defensive attribute. But the defensive action of the mind yields really a motor effect. It simply produces more intricate and diversified motions, both in attack and defense, than those displayed by unintelligent animals.

If we examine the whole range of the animal kingdom, we find every phase of combination of mechanical and motor defense, the motion growing more sluggish as the defensive armor grows more efficient. But in the whole kingdom, motion persists as one of the defensive agencies. No animal exists without some power of motion, by whose aid it withdraws or otherwise escapes from danger.

In the plant kingdom, on the contrary, no defensive motion exists. Mechanical defense exists alone. This does not apply to those minute swimming organisms which lie near the root of the plant and animal kingdoms. But in all the higher plants no motion exists, so far as I am aware, that is useful as a protection. Thus the possession of protective motions by all animals, and the lack of them by all plants, serve as a point of distinction between the two kingdoms.

In regard to aggressive motions, this rule does not so fully hold good. All animals have aggressive motions. Nearly all plants are destitute of them. Yet a few plants possess them. We have instances of aggressive motions in the case of the creeping Fungi, and of the Insectivorous plants. Yet apart from these cases, the plant kingdom seems devoid of motions useful either for attack or defense, and trusts wholly to mechanical appliances. With the mechanical, however, must be included chemical appliances, as in the case of poisonous or disagreeable juices.

One more query remains. Why, in the early days of the animal kingdom, as known to us, was there such a marked tendency to trust to mechanical defense, while in the later era the tendency has been towards motion as the main protective agent? If we consider the early conditions of animal life, this is not difficult to comprehend. There is every reason to believe that the various organs of animals were very slowly evolved. In a former communication I have advanced the hypothesis that the early animals were for a long time naked forms, partly, at least, through lack of the evolution of glands necessary to produce hard coverings. These early animals also moved by means of cilia only, if we can trust the evidences from embryology, and from the lower existing forms. The development of nerves and muscles was a very slow process. The evolution of a form and of swimming organs giving high efficiency to muscular action, was probably much slower. The early animals possessed of muscles had probably a very inefficient motor apparatus, and were very sluggish in their movements. With the development of armor-producing power, therefore, this seems to have been very generally employed as a defense of the sluggish against such swifter moving carnivorous animals as may have arisen. One great superiority of the vertebrate type has always been the superior suitability of its form and motor organs to swift movement, and it seems quite likely that the great variety of mechanically defended lower forms in the early fossiliferous beds, is due to the existence of swift-moving antique vertebrates, which were themselves nearly or quite destitute of hard parts, capable of preservation. Though a later "struggle for existence," between vertebrates themselves, caused the weakest and least active of these to develop armor, yet it was succeeded by a general tendency in this type of life to discard mechanical defenses, and trust to motion for protection. The same has been the case with the actively aggressive members of some of the lower types, such as the higher mollusks, which have thrown off their armor, and developed other defensive appliances.

Throughout the whole history of the organic realm one principle holds good. There has been a continued evolution of more rapid and varied powers of motion. To this, every advance in organization has tended, while the hindrances to speed and flexibility have been successively discarded by the higher forms of life. In correspondence with this has been the development of mentality, since mentality, as outwardly displayed by the animals below man, is indicated by a greater intricacy of motions, in combination with ambush and concealment. For the attainment of the highest possible speed and strength, little mentality was requisite, and brain development is manifested rather by intricacy than by speed of motion—or rather by that well-ordered correlation of rest and diversified motion suited to the best good of the organism. Yet we must regard mentality as rather the effect than the cause of motor evolution. Probably the power of diversified motion appeared first, while the exercise of any new power of this kind acted as an agent in the development of the brain. In other words, the evolution of the brain is a consequence of that of the body—not the reverse.

NEW SPECIES OF PARTULA FROM THE NEW HEBRIDES AND SOLOMON ISLANDS.

BY W. D. HARTMAN, M. D.

The new species of *Partula* herein described, are almost all of one type. The shells of most species from the Solomon Islands are thin, and more or less translucent, with numerous waved spiral striæ, a compressed umbilicus, a moderately reflected and concave lip, and (when viewed through a glass) the embryonic whorls of the apex are rounded or dome-shaped. Like other Partulæ, individuals of the different species are often variable, especially in the greater or less obliquity of the aperture. These thin shells possess so many features in common, that it is often difficult, in the absence of illustrations, to frame a diagnosis sufficiently distinctive to enable the reader to recognize a species from the description alone. I have embraced the present opportunity to figure a few species not heretofore delineated, amongst which is the lost species, *P. rufa*, Lesson.

This shell has been found on the banks of the Lella River, Chabroul Harbor, Uhalan or Strong's Island, by Capt. Brazier, C. M. Z. S. I have seen three examples. It is very distinct from *P. Guamensis*, Pfr., with which it has been confounded; the latter is an arboreal species from Ponape, one of the Caroline group. *P. rufa*, Less., is a much smaller species than *P. Guamensis*, Pfr., which it resembles in color, contour and texture. Farther explorations in the New Hebrides and Solomon Islands will doubtless reveal many new species of *Partula.*

P. similaris, nobis. Plate II, fig. 1.

Shell dextral, oblong ovate, thin and translucent; whorls 5, convex, spire half the length, oblique lines fine and decussated by coarse spiral striæ, umbilicus compressed; aperture rounded ovate; lip white, color yellowish white, with the apex very pale rose. Length 17 mill., diameter 9 mill.; length of aperture 6 mill., diameter 4 mill.

Hab.—Woodlark Island, near *New Guinea* (Capt. Brazier).

Obs.—For size and contour this shell is near *P. Carteriensis*, Pfr.; it is thinner and less solid, with a more rounded aperture, and concave lip.

P. perlucens, nobis. Plate II, fig. 2.

Shell dextral, oblong, ovate, very thin and pellucid; whorls 5, well rounded, body-whorl somewhat inflated, spire more than half the length. Suture well impressed, spiral striæ numerous and fine, umbilicus compressed, aperture oblique, round oval, lip white, concave and moderately reflected. Color a very pale green. Length 18 mill., diameter 9 mill.; length of aperture 9 mill., diameter 4 mill.

Hab.—*Uji* or *Golfe Island*, *Solomon Islands* (Arboreal).

Obs.—Compared with *P. similaris*, herein described, it is a larger, thinner and more inflated shell. Capt. Brazier sent me two examples, the smaller measured: length 14 mill., diameter 8 mill.

P. incurvum, nobis. Plate II, fig. 3.

Shell dextral, ovate, elongate, thin and translucent, spire slender, elongate, more than half the length; whorls 5, rounded, suture impressed, spiral striæ numerous, subperforate, with the umbilicus slightly compressed, columella slightly nodose. Aperture ovate, very oblique, lip white, moderately reflected and concave. Color yellowish white. Length 18 mill., diameter, 8 mill.; length of aperture 7 mill., diameter 4 mill. Arboreal.

Hab.—*Rubiana Island*, *Solomon Islands* (Capt. Brazier).

Obs.—This is a distinct species, with a very oblique aperture, giving the shell a bent appearance at the middle.

P. regularis, nobis. Plate II, fig. 4.

Shell dextral, ovate elongate, thin and translucent; spire half the length; whorls 5, rounded, suture impressed, spiral striæ numerous, waved and very fine, umbilicus compressed, aperture direct, lip white, concave and slightly expanded, margins of the peritreme connected by a very thin callus. Color yellowish white. Length 17 mill., diameter 8 mill.; length of aperture 8·5 mill., diameter 5 mill. Arboreal.

Hab.—*Savu*, *Galeria Island*, *Solomon Islands* (Capt. Brazier).

P. minor, nobis. Plate II, fig. 5.

Shell ovate, somewhat oblong, thin and feebly translucent, spire as long as the aperture; whorls 5, slightly rounded, suture impressed, oblique striæ coarse, spiral striæ obsolete, umbilicus compressed, lip white, flat and moderately reflected, aperture direct, margins of the peritreme connected by a stout callus.

Color a soiled white, apex rufous. Length 16 mill., diameter 8 mill.; length of aperture 6 mill., diameter 3½ mill.

Hab.—Erromango Island, Solomon Islands.

Obs.—I possess two examples of this species from Dr. Cox, of Sydney, Australia. They were collected by Dr. Turner at the above island; it differs from *Carteriensis* especially in the margins of the peritreme approximating more closely than in that species.

P. corneola, nobis. Plate II, fig. 6.

Shell dextral, ovate conic, smooth and polished, corneous, translucent; whorls 5, slightly rounded, spire half the length, spiral striæ numerous, waved and very fine, umbilicus compressed, aperture ovate, with a rounded pillar tooth, and a small tubercle on the columella, lip thick, white, and almost flat, with the margins connected by a callus. Color pale horn, with the apex pale rufous. Length 17½ mill., diameter 9 mill.; length of aperture 7 mill., diameter 4 mill. Smaller example: Length, 16 mill.; diameter, 8 mill.

Hab.—Eimeo, Morea? (Mr. Geale).

Obs.—Several years ago I obtained two examples from Mr. Geale, who accompanied Hugh Cuming. This shell is not found in the British Museum, or the Jardin des Plantes, and I have only met with it twice in private collections. It differs from all the Marquesas species with which I am acquainted, and it possesses the dome-like apex of the Solomon Island group.

P. Coxi, Angas MS. Plate II, fig. 7.

Shell dextral ovate, slightly elongate, thin and translucent; whorls 5, rounded, suture impressed, oblique lines of growth fine, and sparsely decussated by waved spiral striæ; aperture ovate, direct, umbilicus compressed, lip reflected, white and concave, color yellowish white; apex slightly rufous. Length 15 mill., diameter 7 mill.; length of aperture 5 mill., diameter 3 mill.

Hab.—Ysabel Island, Solomon Islands (Capt. Brazier).

Obs.—This shell was collected at the above locality by Captain Brazier, and he has kindly given me a number of examples. In 1867, Dr. Cox sent me examples of *P. pellucida*, Pse., for *Coxi*. These were pronounced *micans*, Pfr., at the British Museum, causing the error in my Bibliographical Catalogue. *P. micans* is a much larger shell.

According to the observations of Capt. Brazier, *P. pellucida* and *P. Coxi* are arboreal species. My examples were pronounced *Coxi* by Mr. Angas; it is a larger shell than *P. pellucida.*

P. Woodlarkiana, nobis. Plate II, fig. 8.

Shell dextral, ovate, thin and translucent; body-whorl inflated; whorls 5, rounded, suture impressed, lines of growth decussated by numerous waved spiral striæ, spire short, columella slightly arcuate, wide and smooth, compressly umbilicate, aperture round ovate, lip concave, white and moderately reflected; color yellowish, apex very pale rose. Length 19 mill., diameter 11 mill.; length of aperture 9 mill., diameter 6 mill.

Hab.—Woodlark Island near *New Guinea* (Capt. Brazier).

P. hastula, nobis. Plate II, fig. 9.

Shell dextral, elongate, oval, hastulate, thin and pellucid; spire acute, half the length; whorls 5, slightly rounded, suture moderately impressed. Oblique striæ prominent, and crossed by numerous minute spiral lines. Umbilicus compressed, aperture oval, more or less oblique, margins of the peritreme connected by a very thin deposit, lip white, reflected and concave. Color yellowish. Length 19 mill., diameter 9 mill.; length of aperture 8 mill., diameter 4 mill.

Hab.—Erromango Island, Solomon Islands.

Obs.—I am indebted to Captain Brazier for several examples. He informs me that Mr. Pease considered it identical with *P. spadicea*, Rve., from which it is certainly distinct; it is more elongate and thinner than any known species from this island.

P. eburnea, nobis. Plate II, fig. 10.

Shell dextral, ovate, very elongate, solid. Spire half the length; whorls 5½, oblique striæ coarse, spiral striæ obsolete, aperture a wide oval, more or less oblique; umbilicus compressed. Columella wide above, lip reflected, white and flat, margins of the peritreme connected by callus. Color ivory-white. In fresh examples sometimes the whole shell is tinged with pale rose. Length 26 mill., diameter 13 mill.; length of aperture 11 mill., diameter 6 mill. *Hab. unknown.*

Obs.—Captain Brazier sent me two examples of this shell, given him by a friend; it is larger and more solid than *Pfeifferi*, Crosse.

P. proxima, nobis. Plate II, fig. 11.

Shell dextral, thin, ovate, very elongate, spire half the length; whorls $5\frac{1}{2}$, surface smooth, oblique lines of growth fine; spiral striæ obsolete, aperture ovate, oblique, umbilicus compressed; columella wide above, and slightly nodose, lip white and slightly concave, margins of the peritreme connected by a thin callus; color white. Length 23, width 10; length of aperture 12, width 6 mill.

Hab.—*Vanna Levu Island, Banks Islands*, near the *New Hebrides.*

Obs.—Capt. Brazier sent me two examples (weatherbeaten) collected at the above island by himself in 1865; it has the outline of *eburnea*, nobis, but is a smaller, thinner and more slender shell.

† **P. pyramis** nobis. Plate II, fig. 12.

Shell dextral, solid, perforate, spire elongate, acute, longer than the aperture; whorls $5\frac{1}{2}$, rounded, suture well impressed, surface smooth, obliquely striate, fine spiral striæ almost obsolete, aperture a wide oval, slightly oblique, lip white, moderately reflected and flat, margins of the peritreme connected by a thin deposit; color pale yellow. Length 25, width 13; length of aperture 10, width $5\frac{1}{2}$ mill.

Hab.—*Vate, Efate*, or *Sandwich Island, New Hebrides.*

Obs.—I have three examples from Mr. Layard and Captain Brazier. They are the size of *Macgillivrayi*, from Tanna, but the spire is more elongate and acute, the whorls more rounded, the sutures are deeper, and they want the dark band at the periphery of that species.

P. Newcombianum, nobis. Plate II, fig. 13.

Shell dextral, ovate, rather thin; spire acute, half the length; whorls 5, rounded; suture deeply impressed; body-whorl somewhat inflated; oblique lines of growth fine and crossed by numerous waved spiral striæ, compressly umbilicate; aperture very oblique, rounded, ovate; lip white, moderately reflected and concave; the outer margin partaking of the color of the epidermis; columella wide above; margins of the peritreme connected by a thin vitreous deposit; a broad, flat, pillar tooth far within the aperture. Color light fawn, with dark brown oblique striæ, apex dark brown. Length 17 mill., diameter 11·5 mill.; aperture, length 7 mill., width 4 mill.

Hab.—Island of Salisbaboe, one of the Falow Islands, between Gilolo and Mindanao.

Obs.—I received this shell from Mr. Layard, through Mr. A. Garrett; in outline and general appearance it resembles some varieties of *P. varia.* I have named it in honor of Dr. Wesley Newcomb, one of our oldest American conchologists, well known for his writings on the allied genus *Achatinella* of the Sandwich Islands.

P. eximia, nobis. Plate II, fig. 14.

Shell dextral, ovate, elongate, solid; spire elongate, half the length; body-whorl large, sutures well impressed; whorls rounded, oblique lines fine, and decussated by almost obsolete spiral striæ; umbilicus slightly compressed; aperture direct, oval; lip white, moderately reflected and flat; columella wide above; margins of the peritreme connected by a thin deposit. Color of the epidermis a soiled pale green, when separated leaving the shell white. Length 23 mill., width 11 mill.; length of aperture 11 mill., width 5 mill.

Hab.—Aneiteum Island, New Hebrides.

Obs.—I received one example of this fine species from Mr. Layard, through Mr. Jno. H. Thomson.

Partula rufa, Less. Plate II, fig. 15.

Partula concinna, Pease. Plate II, fig. 16.

Partula pellucida, Pse. Plate II, fig. 17.

Partula Layardii, Braz. Plate II, fig. 18.

Partula (Diplomorpha) De la Touri, nobis, Plate II, fig. 19.

Shell dextral, solid, short conic; whorls $4\frac{1}{2}$, rounded, suture deep, body-whorl inflated, almost two-thirds the length, surface with coarse oblique striæ, umbilicus wide, aperture perpendicular, lip white, moderately reflected and revolute, the external margin slightly indented, encroaching on the aperture; color of the epidermis light brown, color of the aperture dark orange. Length 20, diameter 14; length of aperture 12, diameter 8 mill.

Hab.—Aura Island, in the *Malo Pass*, *Santo Espirito Group.*

Obs.—This shell has recently been discovered by Mons. De la Tour, an enthusiastic young naturalist, who writes that this little island teems with molluscan life. But one other species is known; *P. (Diplomorpha) Layardii*, Brazier, herein figured. It is found at Vate or Sandwich Island, New Hebrides. The habits of the animals are terrestrial.

February 2.

Mr. John H. Redfield in the chair.

Twenty-six persons present.

On a Post-tympanic Ossicle in Ursus.—Dr. Harrison Allen called attention to an ossicle in the skull of the bear. It is situated over the point of junction of the squama and the opisthotic elements as these bones enter into the formation of the mastoid. The bone was seen in the skull of young individuals only. The species examined were *Ursus Americanus*, *Ursus horribilis*, and *Ursus maritimus*.

The posterior prolongation of the tympanic elements which are so conspicuously developed in *Mephitis* and *Taxidea* are absent in *Ursus*. It is every way probable that the new element described is a member of the tympanic series, but instead of being found in the space between the mastoid and the paramastoid it is placed at the tip of the bones which enter into the composition of the mastoid. The name *post-tympanic* is accordingly proposed for this bone.

February 9.

Mr. Edw. Potts in the chair.

Seventeen persons present.

February 16.

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

Nineteen persons present.

The following papers were presented for publication:—

"On the Minute Structure of Stromatopora and its allies," by Dr. C. Rominger.

"On the Problem of Reversed Vision," by Charles Morris.

February 23.

The President, Dr. Leidy, in the chair.

Twenty-four persons present.

An Extinct Boar from Florida.—Prof. Leidy exhibited a specimen consisting of two fragments of a tooth, which together are over three inches long, and form the greater portion of the worn extremity of a lower tusk, with the point broken off, apparently of a huge suilline animal. The fragments were mingled with other small ones of tusks of *Mastodon floridanus*, recently collected in Florida. The specimen nearly accords in shape with the corresponding part of the tusk of the hog, but approximates in proportionate size that of the hippopotamus. The worn surface in the entire tooth has been about three inches long, and is an inch wide. Thin enamel invests the tooth, excepting on the posterior surface, as in the hog. Near the broken base of the specimen in one position, extending a short distance from the post-external border, the enamel is defined by a sinuous edge, and appears to show that it ceased about four inches from the point of the tooth, instead of extending the whole length of the tusk as in the hog. The anterior or internal, and the posterior surfaces of the tooth are transversely convex, and the external surface is convex and slightly flattened. In transverse section the tooth is ovate, instead of triangular as in the hog, the inner pole forming the sharp edge of the worn surface. The surfaces of the tooth are smoother even than in the hog, being less marked by longitudinal striæ and transverse

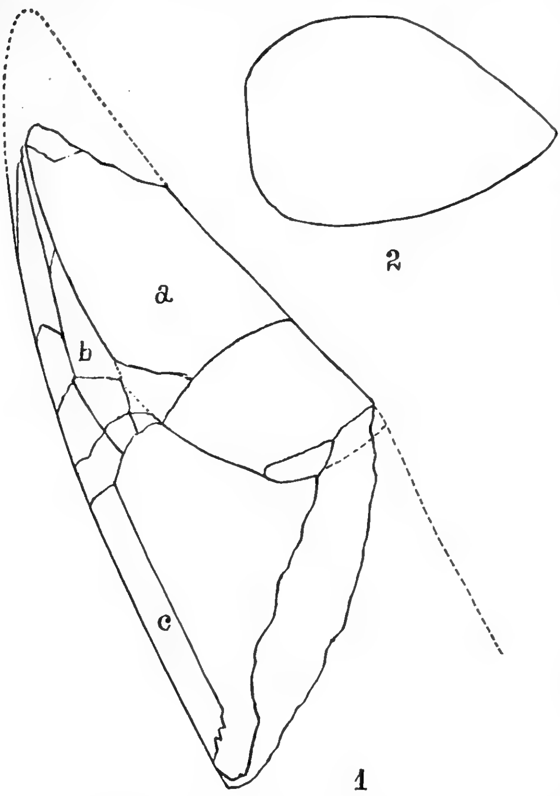


Fig. 1.—Posterior view of the right lower canine tooth; *a*, worn surface; *b*, broken surface; *c*, enamel.

Fig. 2.—Transverse section of the same.

lines of growth. They show no trace of the fluting in the tusk of the hippopotamus, nor of the strong external ridge of the peccary. The specimen is nearer in character to the tusk of the hog than that of any other related animal, but is sufficiently different to render it probable that it may pertain to another genus. No undoubted remains of the genus *Sus* have yet been discovered in America, and the same is the case with the genus *Hippopotamus.* The peccary appears to be the American representative of the hog. The fossil may provisionally be referred to a new genus, related with the latter, with the name of *Eusyodon*, distinguishing the species as EUSYODON MAXIMUS.

The transverse diameter of the section of the tusk, about three inches from the point, is an inch and two-thirds; and the fore and aft diameter an inch and a quarter.

Caries in the Mastodon.—Prof. LEIDY directed attention to a specimen consisting of the posterior portion of a last upper molar tooth of the Mastodon, which he had attributed to a species under the name of *M. floridanus.* It is remarkable from the circumstance that it apparently exhibits the result of caries, a condition of which he had never previously observed an instance in extinct animals. The supposed caries appears as an irregular excavation immediately above the crown of the tooth, about four lines in depth. The mouth of the cavity is elliptical, extending one and one-fourth inches transversely, and one-fourth of an inch vertically. The surface of the cavity appears irregularly eroded.

F. L. Harvey and Miss Mary A. Campbell were elected members.

The following were ordered to be printed:—

ON THE MINUTE STRUCTURE OF STROMATOPORA AND ITS ALLIES.

BY DR. C. ROMINGER.

I had only recently the opportunity of reading the joint essay by Prof. Alleyne Nicholson and Dr. F. Murie on the structure of *Stromatopora*, published in 1879, in the Journal of the Linnæan Society of London. The communication treats for the most part to the structure of the Stromatoporas found on the American continent.

As I had paid attention for a number of years to the study of *Stromatopora* and had gathered extensive collections of them in most of the localities from which the type specimens described by these authors came, I had no difficulty in identifying the forms they had under consideration. While I was enabled in this way to confirm the correctness of some of their observations, I found that in other instances they labored under erroneous conceptions, partly because their material was insufficient, partly because they did not recognize the things as they actually were.

Of most of the forms described by them and of a number of others I had over fifteen years ago worked out descriptions, accompanied by sixteen plates of magnified photographic figures, intending to have them published under the auspices of the Smithsonian Institution. Those to whom the paper was referred for examination, however, reported adversely, in view of the recent publication of Baron v. Rosen's monograph on *Stromatopora* and the undesirability, as they believed, of issuing so many plates with such a comparatively small amount of text.

Messrs. Nicholson and Murie commence with an historical exposition of the different opinions held by writers on the nature and affinities of *Stromatopora*, and after discussion of the arguments for and against such opinions, they declare themselves with some reserve in favor of the most popular of them, which was also held by Goldfuss, the founder of the genus, that is to say, they think the nearest relationship of *Stromatopora* is with the sponges having a calcareous skeleton. The authors think they have recognized in *Stromatopora* systems of channels destined for the circulation of water to and from the organism, analogous to those permeating the mass of sponges ; but we shall see hereafter that these supposed water-channels are not a part of the organism, and prove on accurate examination to be either accidental perforations of the skeleton by boring animals, or else, are the stems of certain corals, particularly of *Syringopora*, which have grown up simultaneously with the *Stromatopora*, parasitically enveloping them.

At the time I wrote the before-mentioned manuscript I also believed a close affinity existed between the sponges and *Stromatopora*, but since Carter and others have pointed out the similarity existing between the calcareous skeleton of *Hydractinia* and *Stromatopora* I am convinced that the similarity between the calcispongiæ and *Stromatopora* is merely an external one. The mode of growth and organization of the sponges essentially differs from that of *Stromatopora*. The sponges are through their entire mass permeated by a system of channels systematically arranged so as to make it evident that all parts of the sponge are destined to perform simultaneously a vital function in the compound organism. There is nothing in their structure which could with propriety be compared with the uniform periodicity in the growth of a *Stromatopora*, which forms layer after layer in endless succession, one being the exact analogue of the other. The layers in many instances are almost entirely shut off from communication with the subjacent portion of the laminated skeleton. We have to infer, therefore, that the live portion of a *Stromatopora* was confined to the uppermost superficial strata, while the interlaminar cell-spaces towards the interior gradually were abandoned and became dead portions of the skeleton, as is the case with the skeletons of *Hydractinia*, and generally with all true corals producing a calcareous stony skeleton.

In a second chapter the authors give the characteristics of *Stromatopora*, considering as type of the genus the Goldfussian species *Str. concentrica* and *polymorpha*, both found in the Eifel, Germany.

Their description reads: "Stromatopora is composed of a succession of thin, close-set laminæ, arranged concentrically round one or more imaginary centres. These concentric fundamentally horizontal laminæ are separated by interspaces, which are crossed by more or less numerous vertical pillars; hence the vertical section of a Stromatopora exhibits a number of approximately horizontal layers and intervening spaces, the latter divided by upright pillars into a number of vesicular compartments. The entire laminated mass has sometimes grown as an incrustation of a central nucleus, a shell or coral; other times it forms a more or less thick expansion with a small point of attachment, and otherwise a free underface covered by a wrinkled dense epithelial crust."

After this, in a general way correct description, they discuss the original nature of the hard structures of Stromatoporoids, which in fossilized condition are found calcareous, other times siliceous, or partially calcareous and partially siliceous; and demonstrate the originally calcareous nature of the skeleton of *Stromatopora* particularly by the circumstance that the specimens of *Stromatopora* are always found in a calcareous condition, when the associated fossils are likewise calcareous; but if the associated primitively calcareous fossils are to any large proportion silicified, then also the skeletons of *Stromatopora* are found more or less completely silicified. The various modes of preservation are then enumerated: *a*, skeleton wholly calcareous; *b*, skeleton calcareous, interlaminar spaces infiltrated with silica; *c*, skeleton silicified but the interlaminar spaces infiltrated with calcite; *d*, both former conditions of preservation represented in one and the same specimen; *e*, both skeleton and interlaminar spaces transformed and filled with silica.

Entering into description of the more minute particulars of the structure of *Stromatopora* the writers state that of the before-mentioned pillars not all reach from lamina to lamina, but that rudimentary shorter ones occur between. The pillars and laminæ are represented as composed of granular carbonate of lime, which shows no structure, except occasionally an indistinct indication of reticulation. According to my own observation, in all well-preserved calcareous specimens of *Stromatopora*, the substance of the laminæ and of the pillars, being composed of a network of interwoven delicate fibres, can be recognized with the greatest distinctness, with a good simple lens, although not so distinctly with the higher powers of a microscope, both the organic structure and the crystalline mineral structure then becoming visible, thus causing a blurred image.

The pillars are described as either simple rounded prominences or else as vermicular and anastomosing crests which are imperforate, solid, not tubular. The writers, however, observed on the surface of weathered silicified specimens sometimes a part of the exposed pillars perforated by a central opening, which they try to explain by an incomplete silicification of the central portion of these pillars and by subsequent lixiviation of the unchanged calcareous centre on exposure to atmospheric influences.

I have, likewise, frequently observed a central perforation of cross-fractured pillars in calcareous, as well as in silicified specimens, but while I perfectly agree with their representation of the pillars as generally being solid, not tubular, I do not think that the central perforation of the pillars in the mentioned cases is the result of weathering of the imperfectly silicified skeleton substance. I believe it is caused by funnel-shaped inflexions of the laminæ at the base of these pillars, which excavation shows itself as a central opening, if the apical part of the pillars which is solid is broken off.

The laminæ of some forms of *Stromatopora*, such as *tuberculata*, and *granulata* of Nicholson, are described as continuous leaves, without any visible perforations placing the superimposed interlaminar spaces in communication. It may be suggested that such openings of communication may exist. I had frequently occasion to observe this to be the case, although, in many instances, the laminæ of these species of *Stromatopora* appeared perfectly free of larger perforations than the minute pores of the tissue itself.

In other forms, such as *Strom. nodulata*, and *densa*, the existence of such larger openings for communication between the superimposed interlaminar spaces has been recognized by the writers.

According to my own observations, a part of these pores of communication, and at the same time the largest ones, can be determined to be portions of the ramified horizontal channel expansions radially converging towards certain centres, and uniting there in one larger central canal, ascending vertically. These horizontal canals in their extension slowly ascend from one interlaminar space into another. They have, as Messrs. Nicholson and Murie correctly observed, no proper walls, and cannot be considered as canals horizontally intersecting the substance of the laminæ, but with more propriety are described as furrows on the surface of the laminæ, which, finally, by the formation of a new lamina above the older one, become roofed over and are transformed into closed tubular spaces. This opinion I fully indorse.

All Stromatoporas do not exhibit such radical channel expansions well developed, but faint indications of radially arranged furrows converging to certain centres can be discovered in almost every form of *Stromatopora* if we examine a sufficient number of well-preserved specimens. Certain forms show them always most beautifully, particularly those in which the tissue of the lamellæ and the pillars has an open porous texture, which increases their bulk, and diminishes the size of the interstitial spaces proportionately. These forms have been pointed out by Winchell under the generic name of *Cœnostroma*, which distinction is not accepted by Messrs. Nicholson and Murie, as the principal generic character of *Cœnostroma* is said to be the occurrence of the radial channel expansions which, being present in forms of very different affinitives, cannot, in their opinion, be used as a generic mark. This is, in one way, true; but if we consider that the forms comprehended under *Cœnostroma* are distinguished not only by their radiated surface, but by the before-mentioned bulkiness of their laminæ and pillars, and the minuteness of the interlaminar cavities, from the ordinary typical forms of *Stromatopora*, which have compact, well-defined laminæ and pillars, I think these two characters combined allow a subdivision of *Stromatopora* into two groups, which at the first glance are distinguishable by even an inexperienced observer, although, as I admit, numerous transitory grades from one group to the other exist, which make it difficult to draw a line of demarkation between them.

The characters by which Prof. Nicholson distinguishes *Stylodiclyon* from *Stromatopora* most assuredly stand on a weaker basis than those of Winchell's *Cœnostroma*, as I will demonstrate hereafter when Messrs. Nicholson and Murie's newly created genera are reviewed.

After having described these radiating horizontally expanded channels, the authors give a description of certain so-called *vertical water canals*, observed in many different forms of *Stromatopora.*

There are two essentially different kinds of such canals vertically traversing the laminated masses, and considered by the authors as parts of the organism. In one of the cases we find the mass of the Stromatopora perforated by comparatively large, generally round, but sometimes elliptical canals, which have no walls for themselves, and are evidently perforations by boring animals. The nature of the channels and their totally irregular distribution in the masses, proves this in a large number of specimens examined by me.

As representing this kind of channels, or oscula, as they term them, the authors mention the following forms: *Stromatopora striatella*, *Hindei*, *tuberculata*, *ponderosa*, and *ostiolata*. In the first four mentioned forms, the true nature of these perforations is without difficulty demonstrable. In *St. ostiolata*, of which specimens from Guelph, Canada, are transformed into a coarsely crystalline dolomite, the organic structure of these masses can scarcely be ascertained, and it is impossible to decide definitely on the nature of the tubular casts traversing them. One of the other examples mentioned, the so-called *Stromatopora Hindei*, is unfortunately selected, as it is in reality an *Alveolites*, perforated by some boring animal. The figures and description given leave no doubt as to this point. Similar silicified specimens are, moreover, not rarely met with in the Niagara group of Michigan.

The second kind of vertical tubular channels supposed to have the function of conducting water through the organism of *Stromatopora* has distinct walls with imbricating wrinkles of growth on the outside, and frequently from their interior a circle of longitudinal rows of spinules projects; more rarely invaginated funnel-shaped diaphragms interrupting the tube-channels can be observed, all of which proves that we have before us inclosed stems of a *Syringopora* and not canals making part of the skeleton of the associated *Stromatopora*. Specimens of each are quite abundant in the Devonian strata of Michigan, Ohio, Kentucky, and Canada. Some pebbles found on the shore of Lake Superior represent the same parasitical investment of clusters of *Syringopora* stems on *Stromatopora*.

In the Niagara group we also find various kinds of *Stromatopora* similarly intergrown with stems of a delicate *Syringopora*, which I have described in the Michigan Geological reports under the name *Syringopora filiformis*. In other cases we find colonies of *Diphyphyllum multicaule* invested in the same way by *Stromatopora*.

In this connection also *Stromatocerium* of Hall is cited by the authors as an example of the first class of vertical water canals, without any proper walls. In a chapter headed "*Departures from the Ordinary Type of Stromatopora*," as the first of these, *Stromatocerium* is enumerated, and the following description given: "It has the general aspect of *Stromatopora*, and possesses crowded concentric laminæ characteristic for Stromatoporoids. The laminæ are of considerable thickness, and are separated as usual by well-marked interlaminar spaces, but the latter are quite open, and there is a total absence of the vertical calcareous pillars which occur in the normal Stromatoporoids; but the whole mass is perforated by innumerable vertical canals, which are destitute of walls, and open directly into the successive interlaminar spaces which they penetrate, as well as into open irregular laminæ in the general laminated skeleton."

This is an erroneous conception of the structure of that family, as these supposed tubules are in reality casts of actual solid tissue pillars which vertically intersect the laminated mass, sometimes without interruption in the different intersected layers, sometimes in each band (consisting of a group of subordinate delicate layers), these pillars start anew from a fresh basis.

The ordinary mode of preservation of the fossil has generally impaired the original organic texture of the skeleton, which became almost totally destroyed, and the space occupied by tissue mass filled with transparent crystalline carbonate of lime, while the former vesicular interlaminar interstices were replenished with turbid, milky dolomite. Sections through such specimens in vertical direction, show the transparent casts of the tissue pillars as tubular channels, and in horizontal sections the same appear to be circular orifices surrounded by a massive interstitial wall substance.

Silicified specimens occasionally occur in which the interlaminar spaces filled with silica are the only part preserved, while the actual skeleton has been removed by solvents, and the space once occupied by it remaining hollow, we then see the mass intersected by innumerable small circular channels.

I had the good fortune to find in the drift of Ann Arbor some calcareous specimens in which the original tissue mass is preserved, represented by a non-transparent, dull, calcareous matter, while the cellulose interlaminar interstices are replenished with clear, transparent carbonate of lime.

They consist of a succession of thick, concentrically superimposed, undulating and monticulose layers from two to six millimeters in thickness, which are generally demarkated from one another by darker colored division lines of greater density than the remainder of the lamina. Each such larger lamina represents a certain uninterrupted period of growth during which, beginning from a solid basal leaf, densely crowded with papillose prominences, delicate versiculous plates are formed at short intervals, connecting into a floor which bridges over the tops of these papilli, which are prolonged until another floor spreads over their apices, and until from six to twelve of these subordinate laminæ had formed, inclosing between them versicular cell-spaces. Then after an evident interruption in the uniform progress of growth, a new one of the larger layers composed of subordinate laminæ, commenced to form on top of the other. The pillars intersecting the laminæ subordinate to a larger bandlike layer form uninterrupted columelles which usually correspond with those of the next succeeding layers or bands. In other cases, however, the columellæ or pillars of each one of the thicker compound laminæ are independent in their position, and do not correspond. Some of these pillars are often much stouter than the others, and divide into several mammiform side branches. The majority of them are simple, rounded, or laterally compressed into vermicular crests, particularly so in the circumference of the monticulose prominences of the surface, where these crests radially converge towards the centre, resembling the horizontal radially converging channel expansions of an ordinary *Stromatopora*, but in this case it is the tissue-mass, and not the intervening furrows, which produces the vermicular radiating converging lines. The interstitial cell-spaces inclosed between the convex transverse leaflets bridging over the space from pillar to pillar, are very similar to the convex vesicules in a vertical section of a *Cystiphyllum*. As above stated in the majority of specimens occurring abundantly in the Trenton group of Escanaba River, and at Nashville, Tennessee, and also in the drift of Ann Arbor and in the upper part of the Cincinnati group at Madison, Indiana, the actual skeleton substance is almost completely destroyed, and its place filled with crystalline carbonate of lime. It often occurs that several of the thick bandlike layers are composed of a succession of vesiculose layers twice or three times the size of the vesicules composing other layers of the same specimens. In this case the vertical pillars become very obscure, so that the whole appears as an indiscriminate accumulation of vesicules as large as those of an ordinary *Cystiphyllum*.

The surface of *Stromatocerium* was not known to Messrs.

Nicholson and Murie. I have seen many specimens with a surface covered by rounded monticules similar to those of *Stromatopora monticulifera*, Winchell, and the tops of these monticules radiated by the convergence of the before-mentioned compressed vermiform crests representing the pillars of an ordinary *Stromatopora.* I had photographic representations of such natural surfaces on the plates pertaining to my old manuscript essay on *Stromatopora*, besides figures of vertical sections which exhibit the structure better than any description can do it.

As a second aberrant form of Stromatoporoids the authors pointed out a form to which they gave the name *Pachystroma.*

The type form occurs in the Niagara group and is described as consisting of subhemispherical masses formed of a concentric succession of very thick laminæ from one to two lines in diameter, which are in direct contrast, not separated by inter-laminar spaces except occasionally by narrow irregular intervals, consequently there are also no radial pillars. Under the microscope the great laminæ are formed of an indistinct porous calcareous tissue principally composed of irregular vertical fibres placed at some distance from one another, and only clearly brought to view by the use of polarized light. Numerous delicate but irregular, generally remote vertical vermicular tubules without distinct walls are said to perforate the mass, but such pores could not be discovered on fractured surfaces by the use of a simple lens. The surface of weathered specimens also shows radiating branched subdermal canals placed round numerous independent centres, precisely as in the so-called *Cœnostroma.*

Several figures of sections through *Pachystroma* are given, which, together with the above description, convince me that the authors had under observation imperfectly preserved specimens of *Stromatopora*, which occur abundantly in the Niagara group; those found in the vicinity of Lockport in calcified condition, particularly correspond with the given descriptions. They have generally lost the finer structure, but exhibit distinctly a composition of concentrically superimposed bands consisting of an almost structureless, compact, calcareous mass, cut into thin slices, showing under the microscope the above described fibrous texture.

On examination of a good many specimens exceptionally a spot may be found in which the structure is better preserved, and in those I can see that each one of the described large, thick laminæ consists of a number of delicate subordinate laminæ, separated as usual by minute interlaminar spaces, intersected with pillars. In my opinion, therefore, the so-called *Pachystroma* merely represents a certain imperfect state of preservation of several of the ordinary species of *Stromatopora* found in the Niagara group. The grouping of the smaller structural elements into broader bands is almost universally the rule in *Stromatopora.* Any vertical section almost, in which the delicate laminæ and interstitial spaces alternate through the whole thickness of the mass with great uniformity, will, if we direct our attention to it, show a grouping of a number of such laminæ into one broader, occasionally narrower bands, discernible by a darker shade of color on the junction line of two of such bands. It indicates temporary short interruptions in the regularity of the progressing growth, as I have intimated previously, while giving a description of the structure of *Stromatocerium.*

Prof. Nicholson considers also *Stromatopora densa* of the Helderberg group as a representative of his *Pachystroma*, but of this form I can most positively assert that its structure does not differ in any respect from the typical forms of *Stromatopora.*

The specimens before me allow the recognition of the regular superposition of laminæ, supported by galleries of short, stout pillars with greatest distinctness; the orifices of the horizontal channel expansions are in vertical sections, rather large, and the ordinary interlaminar cell-spaces unusually small, which causes the compactness and apparent density of the mass, as compared with the open porous appearance of sections of other associated forms of *Stromatopora*, the commonest of which is *Stromatopora ponderosa*, Nicholson. This latter form I had years ago distributed among my scientific friends under the name of *Stromatopora tentilis*, on account of its most elegant reticulated appearance in vertical sections. In this respect it exceeds in distinctness any other form of *Stromatopora* known to me.

A third group of Stromatoporoids, aberrant from the ordinary type, Mr. Nicholson named *Clathrodictyon.* It is distinguished from the type form by the flexuose course of the lamellæ composing the laminated section. They are continually turned up and downward, the upturned portions representing the vertical pillars of ordinary forms of *Stromatopora.* The interlaminar spaces, therefore, appear as layers of rounded or elongated vesicules somewhat resembling the tissue of *Cystiphyllum* on a minute scale. Forms of this structure occur abundantly in the Niagara group and some in the Devonian strata.

A generic distinction of these forms, represented in many different modifications, can, in my opinion, be made with propriety, but as intermediate forms occur, in which the lamellæ are only little disturbed in their straight course by the inflexions representing the interstitial pillars, it is difficult to draw a line separating *Clathrodictyon* from *Stromatopora*.

Prof. Nicholson's type form of *Clathrodictyon*, occurring in the Niagara group, is described as forming large cake-like expansions from one to two inches in thickness centrally, but thinning out near the margins. Upper face irregularly undulating and exfoliating concentrically round elevated points. Surface smooth. Internal structure exceedingly delicate, formed of fine close-set, horizontal or slightly undulating laminæ, of which about twenty to twenty-five occupy the space of one line. Interlaminar spaces divided into minute lenticular cells formed by curved inflexions of the horizontal laminæ.

Specimens to which, in a general way, this description is applicable, are common in the Niagara group of Michigan, Kentucky and Iowa, but although a good many hundreds came under my observation I could never find one whose structure was so minute as to exhibit from twenty to twenty-five laminæ on the space of one line. The most delicately built among my specimens had not over sixteen within the space of a line.

The form having this delicate structure I had, in my abovementioned essay on *Stromatopora*, described and figured under the name *Stromatopora minuta*. Its structure does not represent the character of *Clathrodictyon* in its most perfect development, as the lamellæ, which by their inflexion form the pillars, are not much twisted out of their rectilinear general direction, and as a number of pillars are observable in such sections which are papillose prominences of the surface of the lamellæ, not showing any inflexion of the latter at their base.

Associated with this form are several other forms of much coarser structure with from six to eight lamellæ within the space of one line, which exhibit the clathrodictyon character in much more ideal perfection than the type form does. These had been described in my before-mentioned essay under the name of *Stromatopora vesiculosa*, as their vertical sections appear as an accumulation of layers of cystose cells, rather than as a succession of continuous laminæ, separated by interstitial spaces. The demarkating walls of the cells appear in vertical sections as the meshes of a net-work bounded by lines diagonally intersecting the direction which the laminæ should have if they formed continuous leaves. In some of these specimens a banded structure is observable, whereby from five to eight layers of vesicules are grouped together to form a broader band, which then is sharply defined by a straight continuous division line from the adjoining similar bands above and below it.

Other specimens of this vesiculose species of *Stromatopora* are found intergrown with stems of *Syringopora filiformis*, sometimes also with stems of *Diphyphyllum multicaule*, exactly in the same manner as in the previously mentioned Devonian forms, which have been subordinated by the authors to *Caunopora*, supposing the enveloped stems to be part of the skeleton of *Stromatopora*.

Among the Devonian representatives of his genus *Clathrodictyon*, Mr. Nicholson describes, under the name *C. cellulosum*, a form which I had in my paper named *Stromat. cellulifera*. It occurs in the corniferous limestone of Port Colborne and elsewhere, in association with another form which I called *Str. invaginata*, but which, it seems, did not come under his observation. *C. cellulosum* is described as growing in irregular expansions of considerable size, formed of a succession of horizontal lamellæ, about four occupying the space of one line, and so inflected as to form complete or incomplete partitions, which divide the interlaminar spaces into a number of irregularly oval vesicules, about three occupying one line. Surface tuberculated or granulated; the tubercules occasionally perforated. In the specimens found in the same locality the surface, instead of being tuberculated or granulated, as above described, is covered with roof-like, elongated, laterally uniting crests, forming in this way a network, enclosing shallow subpolygonal cell-pits, somewhat similar to the shallow pits of a minute compound star-coral, as the margins of these crests on weathered silicified specimens, being of porous texture, appear sometimes crenulated, which crenulation increases the resemblance. The other form allied to

Clathrodictyon which is not described by Prof. Nicholson, presents the weathered surfaces of the silicified specimens, covered with very stout rounded conical papilli of almost uniform size, about half a millimetre in diameter and twice that distance apart. Apices of the not cross-fractured papilli imperforate. In a vertical section four or five well-demarkated stout lamellæ occupy the space of two millimetres, which is approximately the same as one line. The interlamellar pillars are formed by upward flexions of the lamellæ, and therefore we see the base of each one excavated by an inverted funnel-shaped sinuosity; and as the pillars of the successive laminæ correspond, the apices of the pillars of the inferior laminæ become invaginated into the basal funnel-shaped excavation of the next ones above, which being the case through the whole thickness of the laminated mass, makes it appear as if so many vertical columns intersected it transversely. This structure was observed by Mr. Nicholson in another species of *Stromatopora*, and induced him to propose for it the generic name *Stylodictyon.*

The space between these pseudo-columns is bridged over by a gently downward curved portion of the lamellæ, leaving correspondingly large elongated interlaminar spaces between them, which often are subdivided by arched vesicular plates obliquely and irregularly traversing them. The mode of growth of this form is the same as that of the former species; it occurs in thick undulating expansions, covered by an epithecal crust on the under side.

An associate of these two forms, which I had named *Stromatopora explanata*, has been described by Prof. Nicholson under the name of *Stromatopora tuberculata.* Its surface is crowded with rather close-set, rounded papilli, somewhat differing in size. Occasionally an arrangement of somewhat compressed, elongated papilli, in radial order towards certain centres, is faintly indicated, but rarely becomes obviously developed. The lamellæ are stout, formed of a compact tissue-mass, in which distant perforations are observable, maintaining communication between the superimposed interlaminar spaces. Five or six lamellæ occupy the space of one line, interstitial cell-spaces comparatively large, oval or elongated to twice the amount of their height. The course of the laminæ is generally in straight parallel lines, but we can often observe their upward inflection at the base of some of the pillars. This produces in vertical sections of this form a considerable resemblance to sections of *Clathrodictyon cellulosum*, whose structure is somewhat coarser, having only four or five lamellæ within the space of a line, and more conspicuously inflected in order to form pillars.

As a fourth aberrant form of Stromatoporoids, a single specimen found in the upper Cincinnati group of Ohio is described by the authors, about which I am unable to give an opinion of my own, as from the rather vague description I cannot say that anything similar ever was under my observation.

After these expositions, a classification of the different types of Stromatoporoids is attempted, and seven generic *cadres* are proposed, most of which had been sketched already in the previous chapters.

These proposed genera are: (1) *Stromatopora* Goldfuss, comprising all those forms consisting of concentrically superimposed laminæ, each lamina separated from the other by a distinct interlaminar space, which is crossed by numerous vertical pillars. In some of these forms are radial, subhorizontal canals or surface grooves placed round minor centres, which, according to my own experience, are present in almost every form of *Stromatopora*—at least, in rudimentary development. In addition to these characters, large vertical canals intersecting the laminated masses are described by the authors, which they believe to be analogous to the oscula of sponges. I have to reject this opinion as erroneous.

(2). *Caunopora* Phillips. Type, *Caunopora placenta*. Representative form of the authors' *Stromatophora perforata*. I need not enter again into a discussion of the value of this generic distinction, as I have previously proved that these forms do not represent one organism, but are coral stems, parasitically invested with various kinds of *Stromatopora*, which in the same localities grew perfectly free of such enclosed stems, erroneously believed to be parts of the organism.

(3). *Clathrodictyon* Nicholson, likewise, has been sufficiently taken into consideration.

(4). *Stylodictyon* Nicholson, is represented by two species, *St. columnare* and *St. retiforme*. Besides the general structure of *Stromatopora*, as special character of this genus, it is asserted that a system of vertical columns of dense calcareous tissue pervades the laminated skeleton. The concentric arrangement of the successive laminæ and their interstices round these vertical columns, is also brought forward as a noteworthy circumstance. It is likewise stated that radiating channel expansions may be present or not. I had described and figured these two forms in my paper, under the name *Stromatopora Wortheni*, thinking a division into two species superfluous, as insensible gradations from one form into the other exist.

The columellar streaks, seen to intersect the mass of this otherwise typical form of *Stromatopora* in vertical sections, are produced by the repeated abrupt flexions of the lamellæ into papillose prominences which cover the surface, similar to those we observe in many other forms of *Stromatopora*, as for instance, in *Str. pustulifera* Winchell.

As in this latter form, the prominences are somewhat larger and consequently the flexions are not so abrupt, and as the tissue of this form is throughout more compact, we do not observe an obvious contrast between the density of the parts corresponding with the papillose prominences and the broader downward-curved intermediate portions of the skeleton, while in the so-called *Stylodictyon*, the abrupt flexions of the lamellæ in the papilli into an almost vertical direction, cause the closer approximation, and consequently greater density, of these parts than of the intermediate gently downward-curved portions of the laminated skeleton which have comparatively open, well-defined interlaminar cell-spaces contrasting with the denser portions, so as to let them appear under the form of vertical columns. Examining transparent vertical sections of such specimens, we see that the lamellæ are not interrupted in their continuity while passing across these columellar streaks, and that no additional tissue element comes into play, which could be claimed as constituting the substance of the columelles. On the contrary, every portion of these columellar streaks is identifiable either as a normal part of the lamellæ or of the intermediate system of pillars. To mention among the generic characters the concentric arrangement of the lamellæ and their interstices round these columellar centres, appears to me rather superfluous, as it is a necessary consequence of the monticulose prominences into which the surface is raised. I could invariably observe in all specimens of this tribe which came under my observation, radial horizontal ducts, which, by the authors, are said to be sometimes developed and sometimes not.

The structure of the form called *Stylodictyon columnare*, found in the Helderberg limestones of Kelley's Island, etc., is somewhat more compact than we find it in the specimens of the Hamilton group named *retiforme*, but there occur numerous transition forms from the compact to a more open, porous structure. In the size of the papillose prominences, also, a great variation of forms exists. I think, therefore, we could well spare one specific name and retain the one I had selected for both varieties jointly, *Stromatopora Wortheni.*

In the Helderberg limestones of Vernon, Indiana, and at the Falls of Ohio, occurs a form of *Stromatopora* very similar in structure with the former, but with columellar streaks much smaller than in these, measuring only half a millimetre in diameter, or little over. Its tissue mass is also more bulky, of open reticulated spongious texture plainly recognizable with a common hand magnifier. I had given in my manuscript description and figures of it, under the name *Stromatopora granulifera*, as the papilli on its surface give it rather a granulated than papillose aspect, on account of their smallness. Horizontal radial ducts are well developed in this form. In it and in the former species these ducts unite in more or less distant centres, which are totally independent of the papillose prominences of the surface, while in many other forms of *Stromatopora*, as for instance, in *monticulifera* and *pustulifera* Winchell, the apex of each of these monticulose elevations is also the centre of convergence for such channels.

Under Nos. 5 and 6, generic descriptions of *Stromatocerium* and of *Pachystroma* are given, which require no further critical comment, as I have on a previous page sufficiently expressed my views on the correctness of the emended characteristic of *Stromatocerium* and of the merits of the distinction of *Pachystroma.*

As a seventh generic form of Stromatoporoids a certain concentrically laminated fossil found in the Niagara limestone of Louisville, Ky., has been described by Mr. Nicholson under the name *Dictyostroma*, which has nothing in common with the Stromatoporoid tribe, excepting an external resemblance, being composed of a succession of laminæ separated by large interstices. The upper surface of these laminæ is covered with spiniform prominences, part of which are long enough to reach the bottom of the superincumbent lamella; others are shorter.

These numerous processes vertically intersecting the interlamellar spaces increase the resemblance of these fossils to *Stromatopora.* Each of the undulating superimposed laminæ, of not quite one millimetre in thickness, and about from one to three millimetres distant from one another, is composed of a layer of horizontally prostrate tubules with solid intimately united walls, which after some extent in the horizontal position, abruptly bend upward and open on the surface of the laminæ with oblique compressed orifices bordered on the outside either by a sharp lip, or by a vertically rising strong proboscidal prolongation, similar to the pillars on the surface of the lamellæ of a *Stromatopora.* The underside of each one of these lamellæ in the concentric succession, is covered by a wrinkled epithecal crust, through which the outlines of the single tubules composing the lamella are plainly visible, just as we see it on the underside of foliaceous expansions of *Alveolites*, and indeed, the structure of this fossil in every respect corresponds with the structure of *Alveolites* or *Limaria*, and has no analogy whatever with *Stromatopora.*

As the numerous specimens I possess of this fossil were not only found in the same locality from which Prof. Nicholson's type specimen comes, but were collected at the same time when Rev. Mr. Herzer picked up the specimen now in possession of Prof. Orton, of Ohio, I am positive that the objects I have under consideration are identical with Prof. Nicholson's type specimen.

A very similar concentrically laminated fossil, but on the whole of coarser structure, with interlaminar spaces from three to five millimetres in width and with very stout intervening pillars is not rare in the drift deposits of Ann Arbor. The specimens are silicified and the structure of the laminæ, as being composed of a layer of prostrate tubules, is no longer recognizable. The wrinkled epithecal crust on the underside of each lamina is, however, still well preserved. The pillars, if broken through, exhibit sometimes a central channel; the shorter ones, not injured, are imperforate at the apex; some of the larger pillars divide into mammiform side branches. There remains no doubt in my mind that this and the former *Dictyostroma* of Nicholson belong to the tribe of *Alveolites*, *Limaria*, etc. I propose, therefore, for them the name of *Alveolites stromatoporoides.*

A genuine Stromatoporoid which in its external aspect has some resemblance to Mr. Nicholson's *Dictyostroma*, is found at the same locality at Louisville, but the descriptions given by Nicholson, and his figures, sufficiently prove that it was not this form which served him as a type for *Dictyostroma.* The rather closely approximated laminæ are inflected upwards to form stout conical pillars with a funnel-shaped excavation at their base, as in *Clathrodictyon* and in *Stylodictyon* of Nicholson. The pillars of the superimposed laminæ correspond, and the apices of the lower pillars become invaginated into the basal cavities of those above, whereby a sort of pseudo-columns are formed which vertically intersect the entire thickness of the masses, growing in flat expansions and covered with an epithecal crust on the underside. A number of other interesting forms of *Stromatopora* occur in the Niagara group, but as my present intention is only a review of Messrs. Nicholson and Murie's work, I abstain from their description on this occasion.

NOTES ON THE TERTIARY GEOLOGY AND PALEONTOLOGY OF THE SOUTHERN UNITED STATES.

BY PROF. ANGELO HEILPRIN.

Eocene of Texas.—In a limited collection of fossils from near the northern border of San Augustine Co., Texas, transmitted to me for examination by the Texas State Geological and Scientific Association, I have been able to determine the following species :—

Ostrea Alabamiensis.	*Cardita Blandingi* (*alticosta*).
Ostrea sellæformis.	*Crassatella antestriata.*
Ostrea divaricata.	*Corbula Texana.*
Pecten Deshayesii.	*Buccitriton altile?* (*Texana*).
Anomia?	*Scalaria* sp. indet.

The horizon represented is evidently the "Clabornian," the deposits probably occupying a position in the "Jacksonian" area.

The Nummulitic of Florida.—Prof. G. A. Wetherby, of Cincinnati, has furnished me with a number of rock fragments obtained at a locality some six miles southwest of Gainesville, Fla. They are interesting as containing, in addition to one or more species of *Orbitoides*, several nearly perfect individuals of *Nummulites Floridanus* Heilprin, which, therefore, represent the most northern locality in the State where the members of this group of Foraminifera have thus far been found. They lend further confirmation to the views already advanced by the writer as to the broad extent of the southern Nummulitic formation, and to the relative antiquity of the Floridan peninsula. One considerable fragment of a *Heterostegina* is also represented in the rock.

Since the receipt of Prof. Wetherby's specimens I have been favored, through Mr. Joseph Willcox, of this city, with other fragments from approximately the same locality, Arredonda, Alachua Co., which also contain *Nummulites Floridanus*, *Orbitoides*, and *Operculina rotella* (*O. complanata?*).

Eocene of Kentucky.—Mr. R. H. Loughridge has kindly forwarded to me for determination a number of fossils collected by the Geological Survey of Kentucky, from the immediate neighborhood of Paducah. They are mainly in the form of casts in a highly ferruginous and fairly micaceous yellow-white sandstone, and in the most part recognizable only in so far as the determination of genera is concerned.

The species are referable to the following genera :—

Mysia— species probably *M. ungulina.*
Leda— species probably *L. protexta.*
Leda— species indet.
Nucula— species probably *N. ovula.*
Turritella— species *Turritella Mortoni.*

This is, as far as I am aware, the first notification of the discovery of marine fossils in the Tertiary deposits of the State. The presence of the strongly carinate form of *Turritella Mortoni* fixes pretty definitely the horizon, the Lower Eocene, or that of the older Tertiaries of Maryland and Virginia. This is what we should have expected to find from the position of the strata.

March 2.

The President, Dr. Leidy, in the chair.

Twenty-four persons present.

March 9.

Mr. Edw. Potts in the chair.

Seventeen persons present.

The deaths of Jesse W. Starr, and of Ward B. Haseltine, members, were announced.

Botanical Notes:—*Secretion of Nectar in Libonia.*—At the meeting of the Botanical Section, on the 8th instant, Mr. Thomas Meehan remarked that the Brazilian Acanthaceous plant, *Libonia*, secreted an enormous amount of nectar at the base of the flowers. As the corollas faded, and dropped from the receptacle, the nectar would be drawn over the still fresh pistil, and leave it with a succession of small globules, the whole shining like a necklace of diamonds in the sun. In a state of nature, honey-collecting insects would doubtless not permit it to accumulate to this extent.

Production of Nectar in Ornithogalum coarctatum.—This pretty species is distinguished by the development of broad sheathing stipular appendages at the base of the inner series of three stamens, stipular appendages as, following Mr. Worthington G. Smith, in a paper contributed to the Horticultural Congress in London in 1865, we must feel bound to term them. These appendages were closely appressed against the ovarium. Noticing little brownish globules projecting above the edges of these appendages he was led to examine, and found that nectar was secreted only at the base of the stipulate stamens. It was produced in such quantity as to press upwards and above the edges, as already noted. It was of thick consistence, and with the exact odor of honey. Above or near the apex of the ovarium—at the base of the short style—nectar exuded in limited quantity, and this suggested an analogy between the morphology of the carpellary leaves and the stipular filaments.

Mr. Meehan further remarked on the production of stipular appendages by the petals of flowers as accounted for by Mr. Worthington Smith. In one of his earliest contributions to the *Proceedings of the Academy* he had shown that in *Magnolia* the petals were formed by the suppression of the laminal portions and the development of the stipules. The petals were indeed modified stipules, not true leaves. The petals of roses were certainly modified stipules, and this process of development could be traced in many plants. In this species of *Ornithogalum* there is but a slight dilation at the base of the outer whorl of stamens. A great advance is made in the stipular development in the inner whorl of stamens, where the appendages extend half-way up the filament. The three carpellary leaves formed the next whorl, and we might reasonably imagine a greater development of the stipular energy in a succeeding whorl, and therefore that these carpels were also enlarged stipules. An absolute proof of this was afforded by one plant, which had the habit of producing some flowers with an union evident from the phyllotaxy, of an outer petal (or sepal) with a stamen of the inner verticil. In this case the staminoid petal took the shape of the stipule, that is to say, it was emarginate, or inversely saggitate at the apex, the filament being wholly wanting, and with the anther in the sinus.

An additional fact of interest connected with this species is, that a large number of plants among seedlings, though with stamens apparently perfectly formed, have wholly sterile anthers.

Seeds on Depauperite Plants.—A specimen of a grass, *Setaria viride*, was exhibited, not over half an inch high, but which had a large number of perfect seeds nearly mature. It was exhibited to show that such minute plants might grow and produce seed annually for many successive years, the plants each year reproducing themselves among other vegetation, without any one being aware of their existence. When such tracts were ploughed up, and plants like this grass get a good chance to develop themselves fully, it would appear that there had not been any plant of the species growing for years, and the fact used to illustrate the long vitality of seeds in the earth. It might be that there was good evidence that cases of long vitality were undoubted ; but it served a good purpose to point out where error may creep in.

Of Bracts in Cruciferæ.—It was an axiom that no true cruciferæ had bracts to the flowers. The double Sweet Alyssum of gardens, *Koniga maritima*, seemed an exception to this rule. The lower flowers were always solitary in the axils of the leaves, and the leaves were often reduced to mere bracts for a long distance up among the flowers. Branches but not flowers in cruciferæ would spring from the axils of the leaves. An examination of these double flowers showed that many had not followed the rule in double flowers, by transforming stamens to petals. Some, in fact, showed they were arrested branches, with depauperite leaves, a solitary petal being produced in the axil of each little leaf. The sepals seemed united, and formed a sort of sheath-like bract, above which the petal emerged. In this form they appeared as arrested spikes.

The Coronal Disk in Spiræa.—Exhibiting some flowers of *Spiræa Reevesiana*, Mr. Meehan called attention to the elevated disc which rose on the inner face of the line of filaments, and pointed out the correspondence in outline of each division with the form of the two-celled anther. The inner line of stamens were alternate with these divisions, and the whole study led to the conclusion that this little crown was composed of the immature anthers of abortive stamens. He referred to *Acer rubrum*, and other plants, where, in the abortion of stamens the anthers were generally almost fully formed before the development of the filament, and remarked that in truly female flowers of this maple there was a course of sterile anthers as in this *Spiræa*.

MARCH 16.

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

Sixteen persons present.

MARCH 23.

The President, Dr. LEIDY, in the chair.

Twenty-eight persons present.

Fermentation in Perenji's Fluid.—Dr. BENJAMIN SHARP remarked that in a bottle of Perenji's fluid (nitric acid 10 per cent. sol. 4 pts., Chromic acid $\frac{1}{2}$ per cent. sol. 3 pts., 95 per cent. Alcohol 3 pts.) effervescence was noticed. On shaking the bottle and removing the cork the fluid frothed violently, resembling very active beer; when the frothing had to a certain extent subsided, another shaking produced another violent frothing. The fluid had been used for hardening chick embryoes, and the portion used had been turned back so that a slight sediment was in the bottom of the bottle, and from this sediment the frothing seemed to originate. The sediment was examined with a high power lens, and Bacteria were found in great numbers. They were probably introduced with the sediment caused by the hardening of the organic tissues upon which they lived.

On the Eye of Pecten.—Prof. SHARP further called the attention of the members to the eye of *Pecten*. In one of his articles (On the Visual Organs of the Lamellebranchiata, Mitth. Zool. Stat. Neapel, 1884, p. 457), he makes the following assertion: "The question as to the function of this organ (the so-called eye of *Pecten*) is one of considerable interest. Hickson states that a few experiments have been made on this subject, concerning the visual power of this animal; he says 'It is very doubtful whether they (the so-called eyes) are of much value to the animal in avoiding its enemies. The most reasonable theory of their function seems to be that when in the ebbing tide, a probability arises that they will be left high and dry on the shore, they can appreciate the fact by the growing intensity of the light, and by that peculiar flapping motion of the valves the Pectens are so remarkable for, move away into deeper water.' This theory may at once be set aside when we consider that the Pectens of the Mediterranean, where we have practically no tide at all, a state of affairs that has existed for an exceedingly long period of time, have as well developed eyes as those found on shores where tides do exist; and further, it seems hardly probable that such a complicated organ would have developed to determine for the animal whether it be out of water or not. . . . As regards the complicated organ known as the eye, I might suggest that, if this be an eye, it is one where we have no true pigmented layer in any direct relation to either the nerve or the retina. The mass of red pigment and the metallic-like tapetum would hardly answer the place of the black choroid coat so essential to the eye."

Dr. Sharp stated that at the time the above was written, he was under the impression that the organ was probably a phosphorescent organ, but he had no proof of it. At Nantucket he obtained many specimens of the animal and found that the edge of the mantle was phosphorent, and on questioning Dr. Kite, formerly of the "Fish-Hawk," who had often seen *Pecten* dredged at night, he was informed that the phosphorent condition of Pectens had often been observed. He thought it was not unreasonable to suppose that organs for the emission of light should be formed upon the same general principles as organs for the admission of light, hence the similarity of these organs to eyes. He further stated that this function (phosphorescence) would be of great use to the animal in obtaining its food.

On Amia and its probable Tænia.—Prof. Leidy stated that in our market on Saturday last, three Mud-fishes, *Amia calva*, had been given to him. They came in a barrel of shad from North Carolina. One was a female about two feet long, the others male, of which the smallest was eight inches. Protruding from the vent of the latter was a little tape-worm, which, on disturbance, retreated into the rectum. Three other worms of the same kind were found in the mouth, but none were in the intestine of this or the other fishes. The worms accord with the description of the *Tænia filicolis*, infesting Sticklebacks, *Gasterosteus*, and is probably the same species. They range from $1\frac{1}{2}$ to 3 inches long, gradually widening from the delicate thread-like neck to the posterior rounded extremity where they measure from 1· to 1·5 mm. wide. The head is spheroidal, variably broader or longer, and about 0·625 mm.; with the summit slightly prominent and unarmed, and with four hemispherical, lateral bothria 0·25 mm. in diameter. Neck variable; when extended, long and narrow and usually about half the width of the head. Anterior segments, transversely linear, about an eighth the length of the breadth; gradually becoming inverted saucer-shaped or scutellate, and about one-fourth the length of the breadth. Posterior segments more quadrate, slightly widening behind, about 0·75 mm. long and from 1· to 1·5 mm. broad. Last segment longest and rounded. Genital apertures marginal.

MARCH 30.

Mr. CHARLES MORRIS in the chair.

Twelve persons present.

Prof. J. C. Arthur was elected a correspondent.

The following was ordered to be printed:—

REVISION OF THE PALÆOCRINOIDEA.

BY CHARLES WACHSMUTH AND FRANK SPRINGER.

PART III—SECTION II.

SUBORDER ARTICULATA.

The Articulata include the group formerly defined by us under the family name Ichthyocrinidæ, with the addition of *Crotalocrinus* and *Enallocrinus*, which possess in a remarkable degree some of the most characteristic features of the group. We have elsewhere shown that our former definition of the structure of the ventral surface in the Ichthyocrinidæ was faulty in the use of the word "soft," in which we did not have in mind the idea of membranous as opposed to calcareous, or of disk as opposed to vault, but simply employed the word to express more strongly the notion that the vault was not rigid. We maintain, however, that the outer test of the ventral side in this group was a continuous integument, composed of calcareous plates, united, by ligament and not by a close suture, and that by reason of this structure and the articulation among the plates of the dorsal side it must have been pliant or flexible. The exact nature of this integument we do not know. The plates may have been arranged in various ways; they may even have been imbricated in some types—like the interambulacral plates in some Periechocrinidæ, and even in some of the true Echini—these are points we may perhaps never be able to settle. That there was an inner integument roofed in and covered by the flexible vault we have mentioned, and that it contained the summit plates and "covering pieces" we know to be true in the Crotalocrinidæ, and we think it altogether probable that the general plan of the ventral structure for the Articulata generally is expressed in that of *Crotalocrinus*.

The effect of the patelloid plates, observed in *Forbesiocrinus*, in permitting mobility in the whole skeleton, has been heretofore mentioned. The suggestions we then made are confirmed by the discovery of the remarkable articulation not only among the radials themselves, but also between the radials and interradials (Pl. 6, figs. 3–5). This articulate structure, and the consequent mobility in the test, and flexibility of the vault, we consider characteristic of the whole group, though it may vary in degree, and is probably far less perfect in some genera than in *Forbesiocrinus* and *Onychocrinus*.

Zittel (Handb. d. Palæont., i, p. 353–5–6), has separated the genera which belong to this suborder into three families, viz.: = Taxocrinidæ, including: (A), *Taxocrinus*, *Forbesiocrinus*, *Onychocrinus*, *Gissocrinus*, *Myelodactylus;* (B), *Lecythocrinus* (?), *Dactylocrinus* (*Dimerocrinus* Pictet); Ichthyocrinidæ, including: *Homalocrinus*, *Lecanocrinus*, *Clidochirus*, *Mespilocrinus*, *Ichthyocrinus*, *Anisocrinus* and *Pycnosaccus;* Crotalocrinidæ, including *Crotalocrinus*, *Enallocrinus*, *Cleiocrinus*. Angelin refers *Taxocrinus*, *Forbesiocrinus*, *Gissocrinus* and *Myelodactylus* to the Taxocrinidæ; *Ichthyocrinus* and *Pycnosaccus* to the Ichthyocrinidæ; *Crotalocrinus* to the Crotalocrinidæ and *Enallocrinus* to the Enallocrinidæ.

The so-called genus *Myelodactylus* may be left out of consideration. It was founded upon columns only, and, if correctly identified by Angelin, which is improbable, it would not belong to the Articulata at all. A separation of the genera included by us in the Ichthyocrinidæ into two families is desirable, but all attempts to define satisfactory characters for such families have so far failed. We have tried to arrange them according to Zittel's definition as well as various plans of our own, but without success, and we have come to the conclusion that the separation must be based upon characters as yet undetected. It is a remarkable and perplexing fact that in this whole group such characters as the presence or absence of interradials dorsally, the number of primary radials, or the position of the anal or azygous plate, whether resting on the basals or not, seem to be of little value.

Until some new light shall be obtained we see no other course than to leave the family Ichthyocrinidæ as we have already defined it.

Gissocrinus, which is placed by Angelin and Zittel among the Taxocrinidæ on account of having three underbasals, belongs to the Fistulata, and has been referred by us to the Cyathocrinidæ, as have also *Lecythocrinus* and *Dactylocrinus*. In addition to the genera formerly included by us, we refer *Cyrtidocrinus* to the Ichthyocrinidæ.

Cleiocrinus was independently referred by Zittel to the Crotalocrinidæ, and by us to the Ichthyocrinidæ. It differs from all other Articulata in the position of the interradials and may prove to be the type of a distinct family.

F. Roemer established the family Anthocrinidæ to receive *Anthocrinus* and *Crotalocrinus*, and Pictet, as Dujardin and Hupé, recognized the family Anthocrinidæ, but referred to it only *Anthocrinus*. As *Anthocrinus* proves to be a synonym, the family name will fall with it, and we shall distinguish the family as Crotalocrinidæ, and follow Zittel in referring to it *Crotalocrinus*, *Enallocrinus*, but not *Cleiocrinus*.

The Crotalocrinidæ are distinguished by the possession of a ventral tube or anal appendage, located ventrally near the periphery. In *Crotalocrinus* it consists of a tube composed of eight vertical rows of heavy quadrangular pieces. In *Enallocrinus* its form is unknown. The family differs from the Ichthyocrinidæ in a similar way as Platycrinidæ from Actinocrinidæ in that the higher radials are imperfectly developed.

The Articulata, therefore, fall into two families, which are defined as follows:

A. Ichthyocrinidæ. Base dicyclic. Underbasals unequal, proportionally very small, rarely visible externally. Basals generally small. Dorsal cup chiefly built up of radial plates of different orders, abutting laterally against each other or separated by interradials. Number of radials variable in genera, species and individuals. Radial and arm plates decreasing in size in the successive orders, each division being about half as wide as the preceding one, and of uniform size in corresponding divisions of the ray, but the plates of adjacent rays generally alternate with each other. The line of articulation between radials and arm plates is frequently undulating, and there are sometimes additional patelloid pieces. Arms uniserial, bifurcating, generally touching laterally so as to form a wall continuous with the calyx. Arm plates with straight sides and very deep ambulacral grooves. Pinnules apparently wanting.

Interradial system chiefly developed on the ventral side. Special anal plate sometimes resting on the basals, sometimes upon the radials, and sometimes wanting dorsally. Anus unknown in most of the genera. The radials are united longitudinally by articulation, laterally by ligament, the interradials among each other and with the radials by a loose suture, admitting of motion and producting flexibility in the calyx and vault.

B. Crotalocrinidæ. Base dicyclic. Underbasals unequal, small. Basals generally large. Radials so far as known, 2×5. Arms uniserial, with numerous branches, spreading broadly. The branches of each ray partly or completely connected by lateral projections or direct union. When completely connected, they form reticulated leaves overlapping when folded. Pinnules wanting. Ambulacral furrow deep, ramifying with the arm branches, covered by alternating plates and bordered by side pieces. The first anal plate rests on the basals; it is followed by others which form the base of a ventral tube. Interradials numerous, covering the entire ventral surface, but not more than one or two—sometimes none—are exposed dorsally. Calyx roofed over by a pliant integument of irregular plates, extending over the arm bases, and enclosing the summit plates and covering pieces of the disk. Ventral tube lateral.

Family XI.—ICHTHYOCRINIDÆ W. and Spr.

We are of the opinion that some of the genera described by Angelin are founded upon characters of specific value only, but as the original specimens are unique and inaccessible to us, we cannot, at present, undertake to review them.

ICHTHYOCRINUS Conrad, Rev. i, p. 33.

No new species of *Ichthyocrinus* have been described since our first list, in which, however, we omitted to notice *Ichthyocrinus arthriticus* (d'Orbigny), mentioned in Prodr. i, p. 46, which is a *Gissocrinus*, and also *Ichthyocrinus capillaris* and *I. goniodactylus* (d'Orbigny), which Phillips had correctly referred to *Cyathocrinus*.

HOMALOCRINUS Angl., Rev. i, p. 35.

ANISOCRINUS Angl., Rev. i, p. 37.

CALPIOCRINUS Angl., Rev. i, p. 38.

LECANOCRINUS Hall, Rev. i, p. 39.

1882. **L. Soyei** Oehlert. Bull. Soc. Géol. de France (ser. 3), vol. x, p. 354, Pl. 8, fig. 2. —Lower Devonian. Near Sabré, France.

Lecanocrinus elegans Billings, see **Taxocrinus elegans** Billings; **Lecanocrinus lævis, Taxocrinus lævis.**

CYRTIDOCRINUS Angl., Rev. i, p. 145.

Cyrtidocrinus was placed by us among the "imperfectly known genera," but should be referred to the Ichthyocrinidæ, as it is closely allied to *Lecanocrinus*, from which it differs only in having four in place of three underbasals. Like that genus it has a small, quadrangular azygous piece, placed obtusely against the posterior basal, and between it and the right postero-lateral radial. The upper radials are extremely narrow.

The only known species is *Cyrtidocrinus fascietatus* Angelin.

PYCNOSACCUS Angl., Rev. i, p. 41.

MESPILOCRINUS De Kon and Leh., Rev. i, p. 41.

TAXOCRINUS Phill., Rev. i, p. 43.

Additional species:—

*1884. **Taxocrinus Beyrichi** (Dewalque MS.) Fraipont, **Zeacrinus Beyrichi**; Extr. des Ann. de la Soc. Géol. de Belg., Tome xi, p. 112, Pl. 1, fig. 5.—Dev. superieur. Senzeille, France.

1882. **T. curtus** Williams, Proc. Acad. Nat. Sci. Phila., p. 30.—Portage group. Ithaca, N. Y.

*1856. **T. elegans** (Billings), **Lecanocrinus elegans** Rep. géol. Surv. Canada, p. 278; also 1859, Decade iv, p. 47, pl. 4, fig. 4 *a b*.—Trenton limest. City of Ottawa, Can. We consider this species, and also **Lecanocrinus lævis** E. Billings, to be **Taxocrinus.** They evidently possess no azygous plate, as they should have if they belonged to **Lecanocrinus.**

Taxocrinus Egertoni (**Poteriocrinus Egertoni** Phill. = **Cladocrinus Egertoni** Aust.), Rev. i, p. 48, is probably an **Onychocrinus** having 6–7 radials.

1882. **Taxocr. Fletcheri**, Bull. i, Illinois St. Mus. Nat. Hist., p. 31; also Geol. Rep. Illinois vii, p. 308, Pl. 30, fig. 2.—Kinderhook gr. Marshall Co., Iowa.

1882. **T. ithacensis** Williams, Proc. Acad. Nat. Sci. Phila., p. 29, Pl. 1, fig. 10.—Portage gr. Ithaca, N. Y.

*1856. **T. lævis** (E. Billings), **Lecanocrinus lævis**, Rep. Geol. Surv. Canada, p. 278; also 1859, Decade iv, p. 47, Pl. 4, fig. 3 *a*.—Trenton limestone. City of Ottawa, Can.

*1836. **T. nobilis** (Phill.), **Poteriocrinus nobilis** Geol. Yorkshire, p. 205, Pl. 3, fig. 40.—This species has been regarded by some authorities as identical with **Forbesiocrinus nobilis** De Kon. and Lehon; but is in our opinion not only specifically distinct, but in all probability a **Taxocrinus.**—Mountain limest. Bolland, Engl.

1852. **T. oligoptylus** (Pacht.).—**Dimerocrinus oligoptylus** Beitr., z. Kenntniss der Gattung **Dimerocrinus**, St. Petersburg, p. 8, with 3 plates.—Devonian. Costijitsi, Russia.

Syn. **Dimerocrinus aptilis** Pacht.

N. B.—*Taxocrinus priscus* (Schnur.) Steinninger, 1853, Geogr. Beschr. d. Eifel, p. 37, is not sufficiently defined for identification.

GNORIMOCRINUS W. and Sp., Rev. i, p. 50.

FORBESIOCRINUS De Koninck, Rev. i, p. 51.

Additional species :—

1859. **Forbesiocrinus Saffordi** Hall, Suppl. Geol. Rep. Iowa, p. 87.—Keokuk limestone. White's Creek, Tenn.

1879. **F. parvus** Wetherby, Jour. Cincin. Soc. Nat. Hist. (October number), p. 5, Pl. 11, figs. 4 *a b*.—Kaskaskia gr. Pulaski county, Ky.

N. B.—*Forbesiocrinus Whitfieldi* Hall, which has been referred to the genus *Taxocrinus*, according to Meek and Worthen (Geol. Rep. Illinois, vol. v, p. 553), came from the Kaskaskia group, of Randolph Co., Ill., and not from the Keokuk limestone, as stated by Hall. It also occurs at that horizon in Pulaski Co., Ky.

LITHOCRINUS W. and Sp., Rev. i, p. 52.

ONYCHOCRINUS W. and Sp., Rev. i, p. 53.

1882. **Onychocrinus distensus** Worthen, Bull. Ill. St. Mus. Nat. Hist, p. 31, also Geol. Rep. Ill., vii, p. 307, Pl. 29, fig. 5.—Kaskaski gr. Monroe Co., Ill. (We are unable to distinguish this specimen from *O. exsculptus* Lyon and Cass.)

NIPTEROCRINUS Wachsm., Rev. i, p. 55.

Zittel (Handb. der Pal., p. 352) refers this genus to the *Cyathocrinidæ*, probably on account of its three small underbasals. The presence of interradials clearly removes it from that family, and its waving sutures leave no doubt that it was properly placed by us among the *Ichthyocrinidæ*.

Family XII.—CROTALOCRINIDÆ.

CROTALOCRINUS Austin.

1843. Austin, Ann. and Mag. Nat. Hist., Ser. I, vol. xi, p. 198.
1848. Morris, Cat. Brit. Foss., Ed. 1, p. 50.
1854. Salter, apud Murchison, Siluria, Ed. 2, p. 219.
1855. McCoy, Brit. Pal. Foss., p. 55.
1873. Salter, Cat. Mus. Cambr., p. 123.
1878. Angelin, Icon. Crin. Suec., p.26.
1879. Zittel, Handb. d. Pal., i, p. 356.
1882. De Loriol, Pal. d. France, tome 11, Crin., p. 51.

Syn. *Anthocrinus*, 1853, Müller, Abhandl. Aka. Berlin, p. 192 ; 1857. Pictet Traite de Pal., iv, p. 312 ; 1862. Dujardin and Hupé, Hist. Nat. Zooph. Echin., p. 117 ; 1855. Quenstedt, Handb. d. Petref., iv, p. 943.

Crotalocrinus was established by Austin in 1843 (Ann. and Mag. Nat. Hist., p. 198), for the reception of a single species, which was described by J. S. Miller, in 1821, as *Cyathocrinus rugosus*, from a calyx without the arms. He had previously used the name *Crotalocrinites rugosus* (1842, Ann. and Mag., vol. x, p. 109), in his list of the class *Pinnastella*, and he referred it to the *Marsupiocrinoidea*. His original definition of the genus is as follows:

"Dorsocentral plates, 5; first series of perisomic plates, 5; second series, 5. On the latter are a series of wedge-shaped plates, which bear the rays; the exact number of these plates is unascertained. Column with a pentapetalous perforation."

"*C. rugosus.* The plates surrounding the body agree with the generic characters. Rays numerous, probably amounting to one hundred. Column composed of thin joints, articulating into each other by radiating striæ. The columnar canal is pentapetalous. The rays are remarkably small in proportion to the size of the animal."

McCoy, in 1854 (Brit. Pal. Foss., p. 54), redescribed the genus, but gave little additional information regarding it. He mentions the presence of an interradial plate in the "second perisomic row," and says that above, and alternating with the primary radials, are five large pentagonal secondary radials (scapulæ), completing the cup, on each of which rests a series of small pentagonal plates, supporting for the width of each plate a large number (? 15 or 16) of very slender long rays. According to McCoy, the genus "differs from *Cyathocrinus* in the vast number of its rays."

Hisinger (Leth. Suec. Supp., II, p. 6) described under the name *Cyathocrinus pulcher* a specimen without arms which afterwards proved to be of this genus.

Johannes Müller was the first to call attention to the remarkable characters of this type exhibited in the brachial parts. In 1853 (Abh. Ak. Wiss. Berlin, p. 187, *et seq.*), he described, under the head of "Crinoiden mit netzförmigen Händen," some specimens from Gothland in which the arm structure was well shown. He says he could not identify Hisinger's species because his figure was too imperfect, although he thinks it may have belonged to the same group. He also says that a specimen with arms and branches somewhat resembling the net-form had been obtained from Dudley, which he acknowledges to be *Cyathocrinus rugosus* Miller, but he expresses the opinion that the arms in the English form are not laterally connected and that it must have had more than five arms. Regarding, therefore, the English form as described by Miller, Austin and McCoy as distinct from the Gothland form with reticulated arms, Müller proposed for the latter the genus *Anthocrinus*, of which there was but a single species, *A. Lovéni.*

Angelin (Icon. Crin. Suec., p. 26), with the whole of the excellent material from Gothland before him, finds that *Anthocrinus Lovéni* is a synonym of Hisinger's *Cyathocrinus pulcher*, and that it belongs, along with *C. rugosus*, to Austin's genus *Crotalocrinus*, of which he also describes and figures a third species, *C. superbus.* According to his definition of the genus, there are five arms, connected at their bases by branches and pinnules, and the pinnules, reticulately connected by narrow transverse joints, form a broad plicated net. This reticulate structure, by which all the ramifications of each ray throughout their entire length are united into a net-work, seems to be the principal distinction between this genus and the closely allied *Enallocrinus*, in which the arm branches are transversely connected for a short distance near the base, but are free for the greater part of their length. Angelin uses the word "pinnules" carelessly, and it is evident that in this case it means simply the ultimate divisions of the arms. The character intended to be described by Angelin is much better stated by Zittel (Handb. d. Pal., i, p. 356), and Johannes Müller (1853, Berl. Akad., pp. 187–192).

Generic Diagnosis.—The calyx is constructed very similar to that of the Cyathocrinidæ. Its form is subglobose; its symmetry bilateral. With arms closed, the Crinoid resembles an elongated bud with folded leaves. With outspread arms its figure is that of a flattened disk with five deep, narrow, lanceolate areas, which separate the rays.

Base dicyclic. Underbasals 5, small, pentangular. Basals 5, large, hexagonal and octagonal. Primary radials 2×5; the first wider than high, excavated in the middle of the distal face for the reception of a very small trigonal, bifurcating second radial, upon which the arms originate and bifurcate in much the same manner as in *Marsupiocrinus.* The lateral margins of the first radials are very deeply incurved, extending between the arm bases until they meet the tegminal plates on the ventral side. The arms divide into numerous branches, which are connected throughout their entire length, in such a way that the brachial apparatus of the whole animal is included in five broad, net-like leaves with inrolled edges, which when closed overlap each other. These leaf-like arms are separated by very prominent, deep petaloid areas, whose margins are formed by the deeply incurved lateral faces of the peripheral arm joints, and the radials which are enormously thickened. When spread out, these connected rays would be free from contact with one another. and would resemble the outstretched leaves of a pentapetaloid flower, but folded together they overlap just as the closed leaves of a bud or flower. The arm joints are disposed in regular dichotomizing longitudinal rows, and also in regularly concentric transverse rows, the alternate arrangement of joints of adjacent branches being absent here. The arm branches are transversely compressed and flattened, very deep in proportion to their width, meeting throughout their entire length by their lateral surfaces.

Upon the dorsal side, the branches are laterally connected by points of attachment projecting from the middle of each point, or by direct contact of the sides of the joint, in such a way as to produce a reticulated structure composed of numerous small meshes. The projection of the points of attachment from the middle of the joints gives them the appearance, when seen from the dorsal side, of a cross with short arms, and the network appears to have regular cross-shaped meshes. At the lower part of the arms the joints are not cross-shaped, but meet directly by their sides, and the reticulate appearance is not so marked as higher up. The whole structure of these leaf-like rays is adapted to the greatest flexibility in all directions, and we think it probable that the meshes of the network were occupied by elastic connective substance of some kind. The joints are flat on the dorsal side; near the calyx they are extremely thick from the dorsal to the ventral side, the thickest being those which rest upon the radials, and they decrease rapidly toward the extremities of the rays. The articular faces at the ends of the joints are provided with an axial canal. Along the ventral side the joints are deeply excavated for the ambulacral furrow, which ramifies with the arm branches throughout their length. The furrow is lined at each side by a row of small side pieces, three to four to each arm joint, which inclose in the middle two rows of covering plates, alternately arranged, of equal number with the side pieces.

The dorsal cup is roofed over and covered by an integument of comparatively heavy interradial plates of irregular arrangement, which extend out some distance over the rays and enclose the bases of the arms, but in no sense constitute or include covering plates of the arms, as Angelin's figure (Pl. xxv, fig. 15) clearly shows. The plates at the margin of this integument meet and connect with the incurved edges of the radials and peripheral row of arm joints, which are proportionally much thicker than those of other parts of the ray. The arms, with their covering plates, which are laterally connected without the interposition of interradials or interaxillaries, emerge from underneath this integument, which must have been pliant to admit of the varieties of positions assumed. Also the summit plates—oral and proximals—must have been located beneath this integument, or we could not understand their position and relation to the covering pieces which are represented by Angelin's figure on Pl. xvii, fig. 3 *a*. Only occasionally the first interradial is visible dorsally; the dorsal cup, however, includes always a comparatively large subquadrangular anal plate, which rests between the radials and upon a hexagonal basal. This supports a very long, tapering, lateral ventral tube, which rises between the arms. It is composed of vertical rows of short, transverse pieces, and its walls are pierced by numerous pores.

The calyx plates appear to be united by syzygy, in part at least, and the lines of junction are marked by pits and clefts which penetrate deeply into the walls, as shown in fig. 4, Pl. viii, of Angelin.

Column heavy, round, composed of thin joints, whose articular faces are traversed by small radiating canals, which form pores on the external surface. Axial canal large, pentangular.

Geological Position, etc.—Upper Silurian of Gothland and England.

These species have been described:

1821. **Crotalocrinus rugosus** Miller, **Cyathocrinus rugosus** Nat. Hist. Crin., p. 89, pts. 1 A—4 B.—1808. Parkinson, **Turban** or **Shropshire Encrinite,** Org. Rem., Vol. ii, p. 193, Pl. 15, figs. 4, 5.—1837. Hisinger, **Cyathocrinus rugosus,** Leth. Suec., p. 89, Tab. xxv, fig. 3 *a*; also Antekni, Heft iv, p. 217, Tab. vii, fig. 3.—1839. Phillips, **Cyathocrinus rugosus** Phillips, apud Murchison's Sil. Syst., p. 672, Tab. 18, fig. 1.—1843. Austin, Ann. and Mag.

Nat. Hist., Ser. 1, Vol. xi, p. 198.—1843. Morris, Cat. Brit. Foss., Ed. 1, p. 50.—1850. D'Orbigny, **Cyathocrinus rugosus**, Prodr. d. Pal., Vol. i, p. 46. —1854. Salter, apud Murchison, Siluria, Ed. 2, p. 219, figs. 4–7, Tab. 13, fig. 3.—1855. McCoy, Br. Pal. Foss., p. 55.—1873. Salter, Cat. Mus. Cambr., p. 123.—1878. Angelin, Icon. Crin. Suec., p. 26, Tab. vii, fig. 4; Tab. xvii, figs. 3, 3 *a-b*, 8, 8 *a*.—1879. Zittel, Handb. d. Pal., i, p. 357, fig. 244.—1885. Quenstedt, Handb. d. Petref., iv, 942, Tab. 75, figs. 2, 3.—Upper Silurian. Gothland, Sweden, and Dudley, England.

1840. **C. pulcher** Hisinger, **Cyathocrinus pulcher**, Leth. Suec. Supp. ii, p. 6, Tab. xxxix, figs. 5 *a*, *b*.—1878. Angelin, Icon. Crin. Suec., p. 26, Tab. vii, figs. 5–7, 7 *a–b*; Tab. viii, figs. 1–9 *a*; Tab. xvii, figs. 1, 1 *a–d*; Tab. xxv, figs. 8–20.—1879. Zittel, Handb. d. Pal., i, p. 357, figs. 2, 4, 4 *a–d*. Syn., **Anthocrinus Loveni** Joh. Müller, 1853, Abh. d. Berl. Akad., p. 192, Tab. viii, figs. 1–11.—Pictet, 1857, Tr. d. Pal., iv, p. 312, Pl. c, fig. 8.—Dujardin & Hupé, Hist. Nat. Zooph. Echin., p. 117.—Quenstedt, 1885, Handb. d. Petref., iv, p. 943, Tab. 75, figs. 4, 5; Petref. Deutschl., iv, p. 508, Tab. 108, fig. 13.—Upper Silurian. Gothland, Sweden.

1878. **C. superbus** Angelin, Icon. Crin. Suec., p. 26, Tab. xvii, figs. 2, 2 *a–b*.—Upper Silurian. Gothland, Sweden.

ENALLOCRINUS d'Orbigny.

1850. D'Orbigny, Prodr. de Pal., Vol. i, p. 46; Cours Elem., ii, p. 142.
1854. Salter, apud Murchison, Siluria. Ed. 2, p. 218.
1857. Pictet, Traite de Pal., iv, p. 320.
1862. Dujardin and Hupé, Hist. Nat. Zooph. Echin., p. 134.
1878. Angelin, Icon. Crin. Suec., p. 25.
1879. Zittel, Handb. d. Pal., i, p. 356.

Syn., *Apiocrinites* (Hisinger) in part; *Millericrinus* (d'Orbigny) in part.

In 1850 d'Orbigny established this genus to receive two species, which had been noticed and figured by Hisinger as *Apiocrinus scriptus* and *A. punctatus*. Only the calyx was then known, and the generic definition simply stated that this was composed of five depressed basals, five large "subradials" and five "brachials." He placed the genus in the family Melocrinidæ, while Pictet, and also Dujardin and Hupé, referred it to the Cyathocrinidæ. Angelin makes it a distinct family, and Zittel considers it as belonging to the Crotalocrinidæ. It is clearly separated from the Inadunata by the fact that its radial divisions are connected either by direct union or by interradial plates between the secondary radials. Although Angelin, in his definition of the genus (Icon. Crin. Suec., p. 25), states "interradialia nulla," his figures demonstrate their undoubted presence both on the dorsal and ventral side (Pl. xv, figs. 1*a*, 3*a*; Pl. xxv, figs. 4, 4*a*). It appears from these illustrations that in some cases the corresponding radials of adjacent rays meet again above the interradials, just as in some species of *Ichthyocrinus* and *Batocrinus*.

The genus differs from *Crotalocrinus*, its nearest ally, in the absence of the reticulate arm structure, although there is a lateral connection between the arm branches for some distance above their bases; also in the alternate arrangement of adjacent rows of arm joints. The construction of the ventral covering is apparently the same in both forms. There is, however, a difference in the mode of union of the calyx plates, the lines of junction in *Enallocrinus*, showing strong indications of an articulation, as we judge from Angelin's figs. 1, 4, and 4 *a*, of Pl. xxv. Angelin united the two types of Hisinger under his first species *E. scriptus*, and described one new species.

Generic Diagnosis.—The calyx differs but little from that of *Crotalocrinus*, and when the arms are spread this produces a similar discoid figure, and lanceolate areas similar to those of that genus. The calyx is depressed, broadly expanding, composed of thick plates with deeply beveled sutures, indicating a union by articulation. Base dicyclic; symmetry bilateral; underbasals 5, depressed, linear; basals 5, large, hexagonal, angular above, except on the anal side; radials 2×5, the first one wide, with its distal face occupied by a deep lunate excavation, which is filled by the second radial and the two first arm joints. Lateral faces of first radials deeply incurved between the arm bases, and meeting tegminal plates on the ventral side. Second radial trigonal or pentagonal, and on its superior sloping margins the arms bifurcate as in *Marsupiocrinus*. The first arm-joint small, linear, sometimes coalesced with the second; the second small, axillary; arms broad, thick, composed of short uniserial joints, dichotomizing frequently. The branches are laterally connected near their bases, but throughout the greater portion of their length are free. Arm joints alternating with those of adjacent rows. As in *Crotalocrinus*, the outer sides of the peripheral rows of the rays are the thickest, and the deep inward curvature of their exterior lateral faces leaves similar large petaloid or lanceolate areas. The exterior ventral margins of the incurved radials of the first and higher orders, and some of the lower arm joints, connect with the plates of the ventral covering, which is of a similar nature as that of *Crotalocrinus*. Ambulacral furrow deep, dichotomizing with the arm branches, bordered by two rows of small alternating side pieces, and covered along the median line by two rows of saumplättchen.

Anal plate one, in line with first radials. Of the numerous interradials only one or two are exposed dorsally, and these are succeeded ventrally by an indefinite number of other vault plates. Ventral tube lateral, its construction unknown. Column strong, round, with short joints; axial canal large, round or obtusely pentangular.

Geological Position, etc.—Upper Silurian; known only from Gothland, Sweden.

Two species have been recognized:

1828. **Enallocrinus scriptus** Hisinger (**Cyathocrinites?**), Anteckn iv, p. 217; Tab. v, fig. 9; Tab. vii, fig. 1.—1831. (**Apiocrinites** (?) **scriptus**), Anteckn v, p. 123, Esquisse d. tab. petrif. d. Swede, p. 23.—1837. Leth. Suec., p. 89, Tab. xxv, figs. 1 and 2.—D'Orbigny, 1840 (**Millericrinus scriptus**), Hist. Nat. Crin., p. 94, Pl. xvi, fig. 29.—1850. Prodr. d. Pal. i, p. 46.—Angelin, 1878, Icon. Crin. Suec,, p. 25, Tab. vii, figs. 1–3 a; Tab. ix, figs. 18 and 19; Tab. xxv, figs. 1–7; Tab. xxvii, figs. 17–20 a.—Upper Silurian. Gothland, Sweden.

Syn.—**Enallocrinus punctatus** Hisinger, Leth. Suec., p. 89.—**Millericrinus punctatus** d'Orbigny, Hist. Nat. Crin., p. 94, Pl. xvi, fig. 30.—**Enallocrinus punctatus** Salter, apud Murchison, Siluria, Ed. 2, p. 218.—**Anthocrinus scriptus** and **A. punctatus**, Quenstedt, Handb. d. Petref. iv, p. 944, Tab. 75, figs. 6, 7.

1878. **E. assulosus** Angelin, Icon. Crin. Suec., p. 26, Tab. xv, figs. 1–4.—Upper Silurian. Gothland, Sweden.

CLEIOCRINUS Billings.

1856. Geol. Surv. Canada, p. 276.
1859. Ibid, Decade IV, p. 52.
1879. Wachsm. and Spr., Rev. i, p. 35.
1879. Zittel, Handb. d. Pal., i. 357.

Cleiocrinus in its general habitus has close affinities with the *Ichthyocrinidæ* and *Crotalocrinidæ*, and this has induced us to place it provisionally with the Articulata, without assigning it to any special family, although it differs in two important points. *Cleiocrinus*, contrary to all other Articulata, has an interradial in lateral contact with the first radials, forming a ring with them, and the plates of the calyx apparently were not articulated in a strict sense. Zittel has referred the genus to the *Crotalocrinidæ*, while we placed it in Part I with the *Ichthyocrinidæ*. If certain parts were better known, we should make it the type of a new family, but at present, having no positive knowledge of the basal regions, nor even of the arms, we are not in a position to give a satisfactory definition of the group.

In order to obtain some additional information, we applied to our friend, Walter R. Billings, who, with his usual kindness, has furnished us the diagrammatic sketch of the type-specimen, which is reproduced on Plate 9, fig. 5. The suture lines of all plates above the primary radials, vertically and horizontally, are provided with a kind of minute pores; which, it seems to us, indicates a union by syzygy, and not by articulation, and that the arm structure was altogether different from that of the other Articulata. Mr. Billings informs us that "the plates are all joined together, but where the strain in crushing has acted upon the specimen, the cracks or gaping sutures are preferably on the lines of the grand divisions, *i. e.*, the lines dividing the arms from one another and from the anal series." This parting of the plates, however, does not indicate necessarily a leaf-like structure of the rays, as in the case of *Crotalocrinus*, for all plates united by syzygy, as a rule, come easily apart.

Mr. Billings informs us that the ridges of the column are interradial in position, which confirms the supposition made by us (Part I, p. 36), that *Cleiocrinus* possesses underbasals, and that the so-called basals of E. Billings are interradials. He also states that the lowest visible circlet of plates "apparently overlaps the column, instead of passing under it," which shows that the base must have been concave, with ample space for the basals and underbasals to lie concealed from view. We have indicated the basals and underbasals in the diagram by dotted lines.

It will be useful to give an amended—

General Diagnosis.—General form obconical; with bilateral symmetry. Base dicyclic. Underbasals probably 3, minute or rudimentary. Basals probably 5, small and hidden by the column. Primary radials 3×5, increasing in width upwards, supporting several superior orders of radials, dichotomizing frequently and uniformly, and interlocking with those of adjoining rows.

The rays and their divisions are laterally connected, without the intervention of interradial plates, except at the anal side and along the first primary radials. The first radials are much smaller than the succeeding ones, and separated from one another by a comparatively large pentangular interradial. The interradial of the posterior side is quadrangular, and supports a longitudinal row of anal plates, which extend to the full length of the calyx, and in their form closely resemble the radials. Arms apparently recumbent. Column more or less obtusely pentagonal ; axial canal large.

Geological Position, etc.—Lower Silurian, Canada. No additional species have been described.

Suborder INADUNATA.

a. Branch, Larviformia.

The Larviformia comprise the families: *Haplocrinidæ*, *Symbathocrinidæ*, *Cupressocrinidæ* and *Gasterocomidæ*.

The Haplocrinidæ are the simplest brachiate Crinoids and may be regarded as representing the larva, not only of the Inadunata but of the Palæocrinoidea generally. Even the most complicated Platycrinoid or Actinocrinoid must have passed in its early life a stage in which radials and interradials consisted of but a single ring of plates when we think the interradials covered the entire ventral surface. This stage is probably represented by the young *Allagecrinus.* In *Haplocrinus* the conditions are essentially the same, but here the interradials already began partly to open out, and the oral plate made its appearance upon the surface. It is very possible that also the growing *Allagecrinus* before reaching maturity attained this condition, or perhaps even the condition of *Symbathocrinus,* but in default of any such evidence, we refer the genus for the present to the Haplocrinidæ.

The Haplocrinidæ are very closely allied to the Symbathocrinidæ, and it is a question with us, whether it would not be better to unite them under one family. Both are built essentially on the same plan, but the Symbathocrinidæ—at least their typical genus—had proximals, and, as a rule, a somewhat higher developed mode of articulation. The articular facet in the Symbathocrinidæ forms a straight horizontal line, it is extended into a large muscle-plate, and this covers the greater part of the ventral cavity, leaving only a small median space, which is covered either by the interradials and an oral plate as probably in *Pisocrinus*, or by interradials and a full set of summit plates as in the case of *Symbathocrinus.* In the Haplocrinidæ the interradials[1] are comparatively large, and rest upon the upper face of the main part of the radials; in *Symbathocrinus* small, placed against the distal ends of their limbs, and separated by radial dome plates. In the Haplocrinidæ the anal opening penetrates one of the interradials, and also probably in *Pisocrinus*, *Storthingocrinus* and *Stylocrinus;* in *Symbathocrinus* and *Phimocrinus* it is placed along the suture of two adjacent muscle-plates. This position of the anal opening between the muscle-plates is a peculiarity found exclusively among the Larviformia; we meet with it again in Cupressocrinidæ, and in a somewhat different form among Gasterocomidæ.

The Cupressocrinidæ and Gasterocomidæ are dicyclic Crinoids, containing within their basal ring an undivided plate in form of a disk. The disk is pierced by several large openings, a central one which represents the axial canal, and by four (exceptionally three or five) peripheral ones, which are continued to the whole length of the column. The other two families have only a central opening, which is small. Dr. P. H. Carpenter, whom we consulted as to the functions of these openings, thinks it "very probable that the peripheral ones represent downward extensions of the body cavity in which water circulated; while there was an exhalant or outgoing current through the interradial (so-called anal) opening with which the intestine was related, so that fæcal matter could be carried away from the creature, very much as it is by the circulation through the dorsal and ventral siphons of a *Solen* or *Mya*."

The specimens for which Hall (1862, 15th Rep. N. Y. St. Cab. Nat. Hist.) proposed the name *Ancyrocrinus* are evidently crinoidal stems with four peripheral canals, and as such may belong to *Myrthillocrinus* or some other genus of this family. There are at the lower end four lateral appendages, which in our

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[1] If the five ventral plates in *Haplocrinus* and the allied *Allagecrinus* were orals, as Dr. P. H. Carpenter suggests, it would follow that these two genera exceptionally had no interradials, and vary on this point from all other Palæocrinoidea. To this we had reference on p. 72, but in place of stating, as we intended, "Carpenter denies the interradials to be present *always* in Palæocrinoids," we made the erroneous statement: "C. denies that interradials are present *as a rule* in Palæozoic Crinoids." The correction was made throughout our own edition, but we discovered the error too late to rectify it in the Proceedings of the Philadelphia Academy.

opinion are a kind of radicular cirrhi. In a specimen from the Canada Survey Museum of Ottawa we found the lower face of the stem covered by a calcareous deposit closing the canals. This deposit appears to have been of a similar nature to that which closes the centro-dorsal of Comatula and the nodal stem joints of the Pentacrini, which, according to Wyville Thomson and Carpenter (Chall. Rep., pp. 18, 19), occasionally break their stems at a syzygy so as to become free. In the case of *Ancyrocrinus*, however, the stem may have become detached and the free state been the rule in the adult, as those stems with their anchor attached are found in great abundance.

The bottom plate in the calyx of the *Cupressocrinidæ* and *Gasterocomidæ*, which we take to be a coalesced underbasal disk, has been described heretofore as representing the upper joint of the column, because the plate, at least in the adult, is undivided. It is, however, well known that a fusion of one or more plates takes place not only among basals, but also among underbasals; while, on the other hand, the columnar joints, which in most of the *Crinoidea* are undivided, sometimes are tri- and quinquepartite. The plate of *Cupressocrinus* unquestionably has the position of the united underbasals; it forms, like them, a part of the calyx, as much so as the basals of *Dolatocrinus* and *Stereocrinus*, in which, as a general rule, the sutures are totally obliterated, and in which the basal disk resembles most remarkably the underbasal disk in this family. It is to be regretted that neither the central canal nor the angles of the column in *Cupressocrinus* give any light on this question, the former being circular, the column quadrangular; but it seems to us that the plate, if really representing a stem-joint, should be quadrangular, in accordance with the other stem-joints in this genus, and not pentangular, as we always find it.

The muscle-plates of the *Cupressocrinidæ* have a more horizontal position than in the *Symbathocrinidæ*, and those of different rays are laterally anchylosed, so as to form an annular plate with a central opening. There is, besides, an interradial lateral opening, and five pairs of radial ones. The central space was probably covered by interradial and summit plates, but these occupied a comparatively small space of the ventral surface, the larger portion being covered by the muscle-plates. The interradial opening represents the anus, the outer radial ones the axial canals, the inner and larger ones are probably ambulacral openings.

The arms of the *Gasterocomidæ* have similar axial canals as those of the *Cupressocrinidæ*, but these face outward, while the others are directed upward. This is readily explained by the condition of their articular facets, which are lateral, horseshoe-shaped, and do not extend over the whole width of the plates. The articular facets of the radials throughout this family, instead of bending over to the ventral side, stand erect as in *Platycrinus*, and their outer ends support the interradials in a similar manner as in that genus. In accordance with this structure, it is evident that, if the anal opening was to occupy a position corresponding to that of *Symbathocrinus* and *Cupressocrinus*, it had to be located, as it is throughout this group, dorsally between the upper portions of the radials, which resemble structurally, if not quite functionally, the extensions of the muscle-plates in the other groups. The radials of the *Gasterocomidæ* have limb-like extensions, they are simply notched for the ambulacral canal, and their axial opening penetrates the median portions of the plates.

The *Larviformia* agree with the Blastoids as to certain conditions of their arm structure (see our notes on *Cupressocrinus*), and probably possessed hydrospires and hydrospire pores to connect with the ambulacra; *Cupressocrinus* even had similar pinnules. The arms are simple throughout, but some of the radials, exceptionally, support two arms. The arms were united with the radials by strong muscles; but the arm-plates among each other, so far as known, were suturally connected and moved in a body.

We give the following definitions of the four families:—

A. Haplocrinidæ. Dorsal cup small, composed of basals and radials; covered ventrally by five large single interradial plates, which form a pyramid. These plates are supported upon the outer ends of two adjoining radials, and are united with one another, leaving only a small ambulacral opening. There is no anal plate; the anal aperture, so far as known, penetrates the upper part of one of the interradials. Column with small central canal.

B. Symbathocrinidæ. Dorsal cup small; composed of basals and radials only. The latter are provided with large muscle-plates, which are connected by suture, except at their inner ends, where they leave generally a slit-shaped opening. The muscle-plates extend over the greater part of the ventral surface, and constitute a more or less elevated pyramid, with an open space in the centre. The central space is closed by comparatively small interradials and the summit plates; the latter, as a rule, are more extensively developed than in the *Haplocrinidæ*. The arms are extremely long, closely folded together. They are composed of quadrangular joints, suturally connected, and moved upon the radials by means of strong muscles. The anal opening, where it has been observed, is intermediate between two muscle-plates. Column round, with a small central canal.

C. CUPRESSOCRINIDÆ. Calyx large. Base dicyclic. The underbasals are anchylosed, and form a solid disk, which is succeeded by five basals. The radials are provided with large muscle-plates, which are laterally anchylosed, and form a continuous plate covering a large portion of the body. It stands on a level with the upper faces of the radials, and is pierced by the anus and the ambulacral openings. The arms are simple, closely folded together, and composed of massive, wide, quadrangular pieces, which, being connected by suture, moved in a body upon the radials. Column strong, containing a large central canal surrounded by peripheral ones.

D. GASTEROCOMIDÆ. Base dicyclic; basals and underbasals as in the Cupressocrinidæ. Radials large; their articular facet lateral, horseshoe-shaped, covering almost the whole outer face of the plates. They are provided with large axial openings, which occupy the median portions of the facets, and are notched at their upper end to pass in the ambulacral canal. The anal opening is dorsal, placed between two radials, and either succeeds the anal plate, or this succeeds the opening. The interradial plates are small occupying the equatorial zone. The oral plate is very large, excentric, and surrounded by four large proximals, its posterior side resting against the radials. Arms recumbent or widely divergent.

FAMILY XIII.—HAPLOCRINIDÆ.

Under this family we place only the two genera *Haplocrinus* and *Allagecrinus*. Roemer referred to it *Haplocrinus* and *Coccocrinus*, in which he was followed by Zittel and S. A. Miller. Schultze, like us, referred *Coccocrinus* to the Platycrinidæ, but added *Triacrinus*, which Zittel, Angelin and Miller made the type of a distinct family. We admit there are close affinities between *Haplocrinus*, *Triacrinus* and *Pisocrinus*, but we believe the last two are closer allied to *Symbathocrinus* (see our notes on the Symbathocrinidæ). Pictet refers to the Haplocrinidæ: *Haplocrinus*, *Coccocrinus*, *Myrtillocrinus*, *Ceramocrinus*, *Epactocrinus* and *Gasterocoma;* Dujardin and Hupé: *Haplocrinus*, *Coccocrinus*, *Myrtillocrinus* and *Stephanocrinus.* D'Orbigny arranged his "Aplocrinidæ" between the Pentremitidæ and Cupressocrinidæ.

In Troost's catalogue of 1850 we find the following names: *Haplocrinus granulatus*, *H. hemisphericus*, *H. maximus* and *H. ovalis*, which have not been defined, and are species of *Pisocrinus* and *Triacrinus. Haplocrinus annularis* and *H. monile* were defined by Eichwald from pieces of the column.

HAPLOCRINUS Steininger.

(Pl. 5, figs. 1, 2.)

1834. Steininger, Bull. Soc. géol. de France (Ser. i), vol. viii, p. 231.
1844. F. Roemer, Rhein. Uebergangsgebirge, p. 63.
1849. Steininger, Versteinerungen der Eifel, p. 20.
1853. Steininger, Geognostische Beschr. d. Eifel, p. 36.
1852. Quenstedt, Handb. d. Petrefactenkunde, p. 624.
1855. J. Müller, Verh. naturh. Verein, Jahrg. xii, p. 21.
1855. F. Roemer, Lethaea Geogn. 1855 (Ausg. 3), p. 260.
1857. Pictet, Traité de Paleont., iv, p. 308.
1862. Dujardin & Hupé, Hist. natur. des Zoophytes Echin., p. 105.
1862. Hall, 15th Rep. N. Y. St. Cab. Nat. Hist., p. 143.
1866. Schultze, Echin. Eifel Kalk., p. 103.
1868. De Koninck, Bull. d. l'Acad. Roy. d. Belg. (Ser. 2), Tome iii (Extr. p. 63).
1879. Zittel, Handb. d. Palæont., i, p. 347.
1882. Quenstedt, Handb. d. Petrefactenkunde (Ausg. 3), p. 964.
1885. P. H. Carpenter, Chall. Rep. Crinoidea, p. 158, etc.

Syn. *Eugeniacrinites* Goldfuss (in part), 1826, Petref. Germ. i, p. 213.
Syn. *Aplocrinus* d'Orbigny, Prodr. i, p. 102.
Syn. (?) *Dimorphocrinus* d'Orbigny (Zittel).

The first species of this genus was described by Goldfuss under *Eugeniacrinites mespiliformis.* Goldfuss did not know the construction of the plates, nor did Steininger who described the same species under *Haplocrinus spaeroideus.* F. Roemer, in 1844, gave a good description of the plates, but his way of interpreting them was rather peculiar. According to his diagnosis, the calyx of *Haplocrinus* is composed of five basals. These, as he states, alternate with five "para-basals," of which three are separated from the basals by intervening plates (Costalglieder). He states further that, placed upon the sutures of two adjoining "para-basals," there are five simple arms, which in their closed condition form a pentamerous "Scheitelpyramide." If it were true that the latter plates, which at their lateral union form conspicuous grooves, were arms, this Crinoid would have no radials, and the basals would be radially disposed, contrary to the fundamental rules of the class. The ventral pyramid had been erroneously described by Goldfuss as composed of five series of eight to ten pieces longitudinally arranged, and it was this, likely, which misled Roemer. The fact, however, is that the ventral surface is covered by five single trigonal pieces, arranged alternately with the upper ring of plates in the dorsal cup, and that the latter plates, as Goldfuss correctly stated, are provided with an articular facet upon which the arms moved. This was confirmed by Müller's observation, who, in 1855, discovered in one of his specimens, resting upon the facet, a small brachial.

Allman was the first writer who undertook to homologize the five ventral plates of *Haplocrinus*, *Coccocrinus* and *Stephanocrinus* with the orals of recent Crinoids. It seems, however, that he was not aware of Müller's discovery of arm joints, for he supposed that all those genera possessed recumbent ambulacra. A similar view was held by d'Orbigny. Schultze calls the ventral plates "interradiale Pyramidenstücke." Zittel describes the "Kelchdecke" to be composed of "fünf grossen, im Centrum zusammenstossenden, dreieckigen Oral-platten, welche eine Pyramide bilden, und zwischen sich fünf breite, gerade, durch die abgeschrägten Seitenflächen begrenzte, nach unten geschlossene, nach oben offene Ambulacralfurchen bilden." There is nothing to confirm this view, and, in fact, we do not know how this could have been possible. It is difficult to see what office the so-called "open ambulacral groove" could have had, especially if *Haplocrinus* possessed arms, as Prof. Zittel admits. The grooves, evidently, are mere compartments for the reception of the arms, and served for their protection. Carpenter agrees with Zittel that the ventral plates are orals, but opposes his open ambulacra. He regards the genus to be "permanently in the condition of a Pentacrinoid larva with a closed tentacular vestibule." We fully agree with him that *Haplocrinus* is a persistent larval form, but do not understand how the five large plates, which occupy almost the entire ventral surface, and as much as one-half of the whole test, possibly can represent the orals in a Palæocrinoid, as all other genera of this group in which the ventral covering has been observed, have largely developed interradials, and these, whether composed of one or a series of plates, extend up invariably to a comparatively small area surrounding the peristome. We, therefore, regard the small central piece as the homologue of the orals, and not the five large plates which we take to be interradials.

The basals of *Haplocrinus* were described by Dujardin and Hupé to be composed of three pieces in place of five. The three small plates alternating with the basals, the "Costalglieder" of Roemer, which are radial in position and support three of the arm-bearing plates, were called by Schultze "parabasalia," by De Koninck "subradials," while Müller, Pictet and Zittel called them "first radial plates." The term parabasals was used by Schultze for basals in dicyclic Crinoids, and, therefore, cannot be applied to radial plates, neither can the name "subradials," as also this term has been used in the same sense. We regard the three plates as representing mere sections of the radials, which, jointly with the arm-bearing part above, are equivalent to one of the undivided radials of the other two rays.

Generic Diagnosis.—Of very small size. Form of calyx subglobose, sometimes biturbinate, extending almost over the whole ventral surface. The summit pieces are represented only by a small oral plate.

Basals five, small, pentagonal, forming a shallow cup with slightly acute angles. Radials very irregular, two of them consisting of single pieces, the other three of two plates each, connected by suture. The two single plates, which agree in size—but not in form—with the compound ones, belong to the anterior ray and left postero-lateral one; they are heptagonal and almost of the same form and size. The three compound ones differ from one another; two of the lower segments are pentagonal, that of the right anterior ray hexagonal, its left lateral face being angular. The upper segments are quadrangular, except the one of the right postero-lateral ray, of which the lower corner is slightly truncated. The articular faces form a straight line, and occupy about one-third the width of the radials. They enter deeply the upper surface of the plates, and form at each side of them a rather conspicuous upright projection, which is truncated at the upper face. These projections are laterally connected in pairs, and each pair supports a large interradial plate, which almost covers the whole ventral surface. The five interradials join with one another; they are subtrigonal, their angles truncated; the upper angle so as to admit a small oral plate, the other two to make space for the articular facet. The sides of the plates along their suture line are beveled, thereby producing along the suture line, in a radial direction, a deep groove, which, evidently, was occupied by the arms in their closed condition. Beneath these grooves there is an opening in the test, at which the ambulacra enter the calyx. The openings contain along their median line the ambulacral passage, which is oval in form. At each side of it there is apparently another opening, which Schultze described as "kleine grubenartige Vertiefungen," whose functions we cannot understand unless they are in connection with the respiratory apparatus. There is no anal plate; the anal opening is small, and penetrates the upper part of the interradials close to the oral plate.

The arms are imperfectly known, but they probably were long, simple, and composed of long joints, like those of the Larviformia generally. The articulation upon the radials was by muscles, the axial canals being plainly visible. Column cylindrical.

Geological Position, etc.—Haplocrinus seems to have had a wide vertical range, three species being from the Devonian, the fourth one, according to De Koninck, from the Carboniferous (?).

The following species have been described :—

1862. **Haplocrinus clio** Hall, 15th Rep. N. York State Cab. Nat. Hist., p. 143, Pl. 1, figs. 5–9.—Marcellus Shale. Onondago Co., N. Y.

1868. **H. granatum** De Koninck, Bull. d. l'Acad. Roy. de Belg. (Ser. 2), Tome iii, No. 4, Pl. 5, figs. 6–10.—(?) Mountain limest. Bolland, Yorksh., England.

1826. **H. mespiliformis** (Goldfuss), **Eugeniacrinites mespiliformis**, Petref. Germ., i, p. 213, Pl. 64, fig. 6.—**Haplocrinus spæroideus**, 1834, Steininger, Bull. Soc. Geol. de France, Tome viii, p. 232.—**Haplocrinus mespiliformis** F. Roemer, 1844, Rhein. Uebergangsgeb., p. 16; also Leth. Geogn., 1855 (Ausg. 3), p. 261.—Pictet, 1857, Traité de Paléont., iv, Pl. e, fig. 2.—Bronn, 1860, Klassen d. Thierreichs (Actinozoa), Pl. 28, fig. 4 A–C.—Dujardin and Hupé, 1862, Hist. Nat. des Zoophytes Echinod., p. 105, Pl. 5, fig. 9.—Schultze, 1866, Echin. Eifl. Kalk., p. 104, Pl. 12, figs. 10, 11.—Devonian. Eifel, Germany.

1844. **H. stellaris** Roemer, Rhein. Uebergangsgeb., p. 63, Pl. 3, fig. 5; also Sandberger, Jahrbuch, 1845, p. 777.—Roemer, 1855, Lethæa Geogn. (Ausg. 3), p. 261.—Devonian. Nassau, Germany.

ALLAGECRINUS Ether. & Carp.

1881. Ann. and Mag. Nat. Hist. (April), pp. 281–298.
1884. De Loriol, Paléont. Francaise (Serie i), Tome xi, p. 46.

Allagecrinus was made by Etheridge and Carpenter the type of a distinct family, and this was accepted by De Loriol. In our opinion it is either a Haplocrinoid or no Palæocrinoid at all If the five ventral plates, as E. and C. assert, are orals, which in the younger specimens extended to the radials, closing in the tentacular vestibule, but in their subsequent stages were "relatively carried inwards, away from the radials, and separated from them by perisome," we should regard *Allagecrinus* a Neocrinoid. If, however, it is a Palæocrinoid, we think the five ventral plates are interradials, which in the young Crinoid were closed, and gradually opened out so as to expose the summit plates. In this case, *Allagecrinus* was in its earlier life morphologically in a similar condition as *Haplocrinus*, but may have attained in the adult a somewhat higher degree of development.

Messrs. Etheridge and Carpenter state on p. 284 of their paper on *Allagecrinus*, that the mouth in the larger specimens could not have been " roofed over or closed by a dome or vault of any kind," for " if such a structure had existed within the circle of radial plates, it would assuredly have been preserved." To this we reply, that the summit structure of *Symbathocrinus* which is comparatively solid was discovered after hundreds of the most perfect specimens had been examined, and until then it was regarded as membranous; the same was the case in *Cyathocrinus*. *Allagecrinus* in its more advanced stages, may have attained the conditions of *Haplocrinus* or *Symbathocrinus*, or even of *Cyathocrinus*, and passed perhaps through all those phases successively; but there is not the least evidence that the Scheitelplatten in any Palæocrinoid were carried inward by perisome as in the Neocrinoidea.

The same writers remark on p. 286, that " in none of the smaller specimens is there any trace of an anal opening, either directly piercing an oral plate, or at the margin of the dome between the orals and radials." And they state further, that " the central end of one or more of the former may be marked by tubercles, but we cannot suggest any explanation of these." If E. and C. had regarded these tubercles as mere ornamentations, they certainly would have stated so. We judge from their figs.

5 and 7 *b*, on Pl. xvi, that one of the tubercles was larger than the others. The larger one may have been pierced by the anal opening, for it occupies relatively the same position as the anal opening in *Haplocrinus*.

We cannot agree with Etheridge and Carpenter that *Poteriocrinus isacobus* Austin, which we referred (Rev. I, p. 113) to *Scaphiocrinus*, is an *Allagecrinus*. The little cup, which Austin figured on Pl. 8, fig. 4, of his Monograph, is evidently a ring of underbasals, with a few stem-joints attached to it, and not basals. To judge from the figures, there is in our mind scarcely a doubt that, in some way or another, the calyx in the type-specimen became detached, that the basals and radials were lost, and the underbasals temporarily fastened to the arms for safe-keeping. Similar detached cups are frequently found in the Burlington limestone, and we doubt if there will ever be found a species of *Allagecrinus* with branching arms.

Generic Diagnosis.—Crinoid minute. Calyx pyriform or cylindro-conical. The dorsal cup composed of two rings of five plates each; the ventral surface, so far as known, of five single pieces. There are no anal plates, neither dorsally nor ventrally.

Basals five; suture-lines rarely visible. Radials five, elongate, variable in form and size; they are either axillaries and support two simple arms, or truncate above and bear a single arm, but neither one of them is branching; when axillaries, they are considerably wider. The articular facets for the attachment of the arms are large and distinct, and nearly horizontal in position, so as to give a projecting lip-like appearance to the upper and outer edges of the radials. There is a transverse articular ridge around the opening of the central canal, which is large. The arms are strong, cylindrical, and probably without pinnules. The first arm-joint is much shorter than the others, cuboidal, with a nearly circular distal face, the succeeding ones elongate, three and four times as wide as high.

The construction of the ventral surface is only known in the younger specimens, in which it consists of five interradial plates, which form a closed pyramid, the relative size of which is greater the smaller the specimen. The plates are trigonal, but the lower angles slightly truncate to form the arm-opening. In the smaller specimens, the plates are so closely united, that there is no trace of sutures between them; but the sutures gradually become more marked, and turn in the larger ones into rather distinct grooves. No central plate has been observed as in *Haplocrinus*, and nothing is known of the ventral surface in any of the larger specimens. Column short, of vermiform appearance; composed of small, low, rounded joints, with a circular central canal.

Geological Position, etc.—Restricted, so far as known, to the top of the Carboniferous limestone of Scotland and America.

1881. **Allagecrinus Austini** Ether. and Carp. Type of the genus. Ann. and Mag., vol. vii, p. 289, Pts. 15 and 16.—Upper Carboniferous limestone of Scotland.

1882. **A. Carpenteri** Wachsm., Bull. I, State Mus. Nat. Hist., p. 40; also Geol. Rep. Illinois, vol. vii, p. 341, Pl. 29, fig. 14.—Kaskaskia group. Monroe Co., Ill.

Family XIV.—**SYMBATHOCRINIDÆ,** W. and Sp.

We refer to this family the genera: *Symbathocrinus*, *Phimocrinus*, *Stylocrinus*, *Stortingocrinus*, *Pisocrinus*, *Triacrinus* and *Lageniocrinus*. Zittel made of these genera two families; he placed *Symbathocrinus*, *Phimocrinus* and *Lageniocrinus*, to which he added *Cupressocrinus*, under the "*Cupressocrinidæ*," and *Pisocrinus*, *Triacrinus*, with *Catillocrinus*, under the "*Pisocrinidæ*." These groups were adopted by De Loriol and S. A. Miller. We willingly admit that *Cupressocrinus* agrees with *Symbathocrinus* and *Phimocrinus* very closely in the mode of articulation and in the arm structure; but they differ essentially in other points. *Cupressocrinus* has a large dorsal cup, basals and underbasals, and three or four large peripheral canals, which follow the column. Nothing of this has been found either in *Symbathocrinus* or *Phimocrinus*, which both have a very small dorsal cup, and a small central opening along the column. After separating *Cupressocrinus*, and making *Symbathocrinus* the type of the group, it is extremely difficult to establish family distinctions between *Symbathocrinus* and Zittel's *Pisocrinidæ*. Not even the irregularity in the construction of the calyx will hold good, as also in *Symbathocrinus* the symmetry is disturbed by the presence of an anal plate. *Catillocrinus*, which also had been identified with these groups, has a ventral sac, and has been referred by us to the *Fistulata*.

SYMBATHOCRINUS Phillips.

(Pl. 4, figs. 8 to 11, and Pl. 5, figs. 12 to 14.)

1836. Phillips, Geol. Yorksh., Pt. ii, p. 206.
1843. Austin (in part), Monogr. Rec. and Foss. Crin., p. 93.
1850. D'Orbigny, Prodrome de Paléont., i, p. 156.
1852. Owen and Shumard, Geol. Surv. Ia., Wisc. and Minns., p. 597.
1854. McCoy, Syn. Brit. Palæoz. Foss.
1858. Hall, Geol. Rep. Iowa, Vol. i, Pt. ii, p. 559.
1868. Meek and Worthen, Proc. Acad. Nat. Sci. Phila., p. 324.
1873. Meek and Worthen, Geol. Rep. Ill., Vol. v, pp. 324 and 437.
1875. Meek and Worthen, Geol. Rep. Ill., Vol. vi, p. 514.
1879. Zittel, Handb. d. Palæontologie, i, p. 349.
1880. Wetherby, Journ. Cincin. Soc. Nat. Hist. (Extr., p. 7).

Not *Symbathocrinus* Roemer 1855, Müller 1855, Schultze 1866 = *Stylocrinus* Sandberger.

The genus *Symbathocrinus*, as it is now recognized, contains two distinct generic types. The one which occurs in the Carboniferous and *upper* Devonian has a large anal plate, and this supports a long tube which extends to nearly the whole length of the arms. The other form, which is restricted to the *lower* Devonian, has no anal plate, nor does it show an anal opening. The Carboniferous form will be recognized by us as *Symbathocrinus*, the other as *Stylocrinus*.

When Phillips proposed the name *Symbathocrinus* he gave no description, he only stated that the "pelvis" was "anchylosed." The two Austins described Phillips' species, but they also took the base to be undivided, and nothing was said by them about an anal plate, although they indicated it in one of their figures (Monograph, Pl. 12, fig. 4 *b*). Their fig. 4 *a* is a totally different thing, and represents either a *Graphiocrinus* or *Scytalocrinus*. Owen and Shumard discovered the base of *Symbathocrinus* to be tripartite, and Prof. Hall was the first to describe the anal plate. The muscle-plate was taken by Zittel, and formerly by us, for a so-called consolidating apparatus, like the similar structure in *Cupressocrinus*, and homologous with the oral plates. It was also the general belief that the central space was not closed, and represented the mouth.

Symbathocrinus granulatus and *S. Tennesseæ* Troost are catalogue names, *S. tabulatus* (Goldfuss) a *Scytalocrinus*, and *S. tennesseensis* Roemer a *Pisocrinus*.

Generic Diagnosis.—Calyx small. Dorsal cup obconical or basin-shaped. Basals three, forming a shallow cup, which is slightly excavated for the reception of the column. They are composed of two larger equal pieces which are pentangular, and a smaller quadrangular one; the latter placed to the left of the anterior interradius as in *Platycrinus*.

Radials nearly equal, subquadrangular; the basi-radial suture slightly angular; width much wider above than below. Their upper side forms a straight, horizontal line, except at the right postero-lateral radial, of which the left upper end is sloped off for the reception of an anal piece. The anal plate rests completely upon this one radial, occupying about one-fourth of its upper width. The radials are provided with large articular facets, which, extending inwards and upwards, form jointly at the ventral side of the calyx a sharply angular pyramid with re-entering angles. The upper end of this pyramid is truncated, and contains a good-sized opening in the centre, which in perfect specimens is completely covered by the interradial and summit plates. The lateral margins of the facets meet at their lower ends, except at the azygous side, where they are separated by the anal plate; along their upper ends, however, they stand apart, and form rather conspicuous clefts. Each facet is divided vertically by a narrow sinus,[1] and the two halves of the plates or the limbs, as they might be called, at their upper end form an ambulacral opening.

The interradials are unusually small, wider than high; those at the four regular sides resting against the upper face of two limbs of adjoining radials. The number of interradials at the azygous side cannot be ascertained in our specimens, as the parts connecting the anal plate with the ventral surface of the calyx were not preserved. The anal plate stands in line with the first brachial, it has the same height but not its width, and is succeeded by a slender tube which follows the whole length of the arms. Hall has figured a second anal plate, triangular in form; this, however, constitutes the lower portion of the first plate of the tube, which always takes a sharp inward turn, leaving only a small triangular space exposed externally between the arms. The tube is composed of five rows of quadrangular, rather

[1] These sinuses, which look somewhat like suture lines, give to the muscle plates the appearance of representing separate pieces, interradially disposed, and this led us at first to regard them as oral plates.

delicate plates, which are bent longitudinally so as to form an angle, and each plate extends to, and forms a part of, two of its sides. The interradials alternate with radial dome plates, which are even smaller, angular above.

The summit is closed by the proximals and oral plate, all of which are much larger than the interradials. The proximals consist of four comparatively large, nodose plates, which enclose toward the azygous side three scarcely convex, smaller ones. The oral plate is the largest piece of the ventral side, it forms an inverted cup, containing radiating grooves along the inner floor, which lodged the ambulacra.

Arms five, long, simple; closely folded together and forming a narrow, cylindrical body. They are composed of a large number of quadrangular joints, with parallel sutures, and are provided with a deep ventral furrow, but apparently have no pinnules. The first brachial differs somewhat in form from the others; it is always higher, extending to the level of the oral plate; also wider, but not quite as deep. Its proximal face is provided with a muscular appendage, which corresponds with that of the radials; its distal end, however, shows neither ridge nor fossæ. The higher brachials in all probability were united by suture, and the arms moved as a body upon the radials. The articular faces of the latter are provided near their outer margin with a transverse ridge (Pl. 5, figs. 12, 13), extending to the whole width of the plate, with a transverse axial canal. The ventral furrow is deep, has a longitudinal groove along the inner floor, and rib-like projections alternating with grooves along the inner walls. The sides of the furrow are lined by two rows of short transverse side-pieces—about eight to each side of the arm joint—alternately arranged, which leave a zigzag median opening along the whole length of the arms. There are also lateral pores, one to every side-piece, and these connect with, and form the upper end of, the lateral furrows at the inner walls of the arm grooves to which we alluded. The lateral faces of the arm joints are provided along their outer side with shallow slanting grooves (Pl. 5, figs. 12, 13), and these agree in number with the pores. It seems to us very probable that, by means of these grooves, the ventral furrow was brought in contact with the surrounding element, as the arms in this genus are so closely folded together, that without them no communication was possible.

Column long, cylindrical; with small central canal.

Geological Position, etc.—Symbathocrinus, commenced in the Hamilton group, attained its greatest abundance in the two Burlington formations, and disappeared at the termination of the Keokuk period.

1869. **Symbathocrinus brevis** Meek & Worthen, Proceed. Acad. Nat. Sci. Phila., p. 68; also Geol. Rep. Illinois, vol. v, p. 439, Pl. ii, fig. 6.—Lower Burlington limestone, Burlington, Iowa.

1836. **S. conicus** Phillips, Geol. Yorkshire, p. 206, Pl. 4, figs. 12, 13; Austin, Ann. and Mag. Nat. Hist., x, p. 108; also Monog. Rec. and Foss. Crin., p. 93, Pl. 11, figs. 5 *b*, *c* (not 5 *a*, which is a Poteriocrinoid); d'Orbigny, 1850, Prodr. i, p. 156; McCoy, 1854, Syn. Brit. Palæoz. Foss., p. 118.—Mountain limest., Ireland and England.

1852. **S. dentatus** Owen & Shum., Jour. Acad. Nat. Sci. Phila. (new ser.), vol. ii, p. 93, Pl. 11, fig. 7; also 1852, Geol. Rep. Iowa, Wisc. and Minnesota, p. 597, Pl. 5 *B*, figs. 7 *a b*.—Upper Burlington limest., Burlington, Iowa.

1880. **S. granuliferus** Wetherby, Journ. Cincin. Soc. Nat. Hist., Pl. 16, figs. 3, 3 *a*. —Kinderhook gr., Kentucky.

1858. **S. matutinus** Hall, Geol. Rep. Iowa, vol. i, p. 483, Pl. i, fig. 2.—Hamilton gr., New Buffalo, Iowa.

1860. **S. Oweni** Hall, 13th Rep. N. York St. Cab. Nat. Hist., p. 111.—Kinderhook gr., Rockford, Indiana.

1861. **S. papillatus** Hall, Descr. New Crin. (Prelim. Notice), p. 18.—Upper Burlington limestone, Burlington (a mere variety of **S. dentatus**).

1865. **S. robustus** Shumard, Trans. Acad. Nat. Sci. Phila., vol. ii (Palæozoic Foss. America), p. 397.—Meek and Worthen, 1885, Geol. Rep. Illinois, vii, p. 514, Pl. 29, fig. 4.—Keokuk limestone. Button-Mould Knob, Ky., and Sulphur Springs, near Nashville, Tenn.

1858. **S. Swallovi** Hall, Geol. Rep. Iowa, vol. i, Pt. II, p. 672, Pl. 17, figs. 8 and 9.—(?) St. Louis limestone. Missouri.

1869. **S. Wachsmuthi** Meek and Worthen (not 1866 = **Catillocrinus Wachsmuthi**), Proc. Acad. Nat. Sci. Phila., p. 67; also Geol. Rep. Illinois, v, p. 437, Pl. 2, fig. 5.—Lower Burlington limestone. Burlington, Iowa.

1859. **S. Wortheni** Hall, Geol. Rep. Iowa, vol. i, Pt. ii, p. 560, Pl. 9, fig. 9.—Upper Burlington limestone. Burlington, Iowa.

PHIMOCRINUS Schultze.

1866. Schultze, Monogr. Echin. Eifl. Kalk., p. 29.
1879. Zittel, Handb. d. Palæontologie, i, p. 350.
1882. Oehlert, Bull. Soc. Géol. de France, Ser. 3, x, p. 353.

Phimocrinus agrees almost completely with *Symbathocrinus*, but it has *five* basals in place of three. It also has similar articular facets, which, in a like manner, form a stelliform pyramid, of which, however, the summit plates have not been observed. The anal opening is situated between two muscle-plates, and evidently was extended into a tube, as in *Symbathocrinus*. The form of the arms is not known. Column pentagonal, with a small pentalobate central canal.

Geological Position, etc.—*Phimocrinus* is restricted to the lower part of the Devonian.

1882. **Phimocrinus Jouberti** Oehlert, Bull. de la Soc. Géol. de France, Ser. 3, tome x, p. 352, Pl. 8, fig. 1.—Devonian. Sabré, France.

1866. **Ph. lævis**, Schultze (Type of the genus), Monogr. Echin. Eifl. Kalk., p. 29, Pl. 3, fig. 6.—Devonian. Eifel, Germany.

1866. **Ph. quinquangularis** Schultze, Monogr. Echin. Eifl. Kalk., p. 30, Pl. 3, fig. 7. —Devonian. Eifel, Germany.

STYLOCRINUS Sandberger.

(Re-defined by W. and Sp.)

1850. Versteinerungen Nassau's, p. 400.

Syn. *Platycrinus* (partim) Goldfuss, 1838. Nova Acta Leop. XIX, i, p. 345; also Quenstedt, 1852, Handb. d. Petrefactenk., Ed. 1, p. 618.

Syn. *Symbathocrinus* (partim) Müller, 1855, Verh. naturh. Verein für Rheinlande, xii, p. 19; also Neue Echin. Eifl. Kalk., p. 257; Schultze, 1866, Monogr. Eifl. Kalk., p. 26; Zittel, 1879, Handb. d. Palæont., i, p. 349.

Stylocrinus has been generally regarded as identical with *Symbathocrinus*, and Sandberger, when he proposed the name, failed to point out the generic differences. He applied the name to a species from Vilmar, which afterwards was found to be specifically identical with "*Symbathocrinus*" *tabulatus*, from the Eifel. The absence of an anal plate, and even of an anal opening in the Eifel species, was overlooked or disregarded by all European writers. Zittel described the ventral side of *Symbathocrinus* as plated, and containing an anal tube reaching to the tips of the arms; he also spoke of oral plates, which were said to form beneath the vault a concealed consolidating apparatus. This description, incorrect as it is, was evidently made from the Carboniferous form, as in the Eifel species nothing is known of the calyx beyond the radials. In *Symbathocrinus* the anal opening is located between two of the muscle-plates; but in the Eifel species, which we make the type of *Stylocrinus*, the muscular appendages of all the radials are suturally united. This suggests that the opening probably penetrated the interradials, as in *Haplocrinus*, and it may have had, like that genus, only an oral plate and no proximals.

In the construction of the dorsal cup, *Stylocrinus* agrees with *Symbathocrinus*. The two genera, however, differ in the articular extensions of their radials, which extend only inward, not upward, and form a level with the outer edges of the radials. The arms are composed of quadrangular joints, with parallel sutures, and they possess a deep ventral furrow. The column is circular, and consists of thick joints, those at the upper end being comparatively strong, but they are reduced very soon to less than one half of their greatest width.

The only known species is :—

*1838. **Stylocrinus tabulatus** (Goldf.), **Platycrinus tabulatus,** Nova Acta. Leopold. xix, i, p. 345. Quenstedt, Handb. d. Petrefactenk. (Ed. 1), p. 618, Pl. 54, fig. 25.—**Symbathocrinus tabulatus**, Müller, 1855, Verh. naturh. Verein f. Rheinl. xii, p. 19, Pl. 4, figs. 4, 5; Schultze, 1866, Monogr. Eifl. Kalk., p. 27, Pl. 3, figs. 4, 5.—Devonian. Eifel, Germany.

Var. alta Müller, Verein f. Rheinl. xii, Pl. 4, fig. 5; Schultze Monogr., Pl. 3, fig. 4.

Var. depressa Müller, ibid., Pl. 4, fig. 4; Schultze, ibid., Pl. 3, fig. 5.

Syn. **Platycrinus lævigatus** Goldf.; **P. alutaceus, P. scrobiculatus, P. nodulosus.**—These names were applied by Goldfuss to specimens in the Museum of Bonn to mere variations of **Stylocrinus tabulatus,** but have never been published (Schultze).

Syn. **Stylocrinus scaber** Sandberger, Versteinerungen Nassau's, p. 400, Pl. 35, fig. 12.

Syn. **Platycrinus gerolsteiniensis** Steininger, Geogn. Beschreib. d. Eifel, p. 37.

STORTINGOCRINUS Schultze.

1866. Monogr. Echin. Eifl. Kalk., p. 69.
Syn. *Platycrinus* (partim), Goldfuss and Wirthgen and Zeiler.

Stortingocrinus agrees in the lower portions of its calyx with *Platycrinus*, to which it was referred by Goldfuss and Müller. That it does not belong to the Camarata, and hence is no Platycrinoid, is shown by the mode of articulation, which is like that of *Haplocrinus*, and by the form of the radials, which, in the place of being notched, are extended upward, and support upon their limbs a single interradial as those of the Blastoids.

Generic Diagnosis.—Basals three, unequal; two of them twice the size of the third one, which is rhomboidal. Radials large, subquadrangular; their articular facets deeply inserted, forming a depression with a slightly concave upper face. Their lateral margins of adjoining radials are connected by suture, they extend upwards and inwards, forming partitions between the arm bases, leaving but a small space for the reception of the arms.

Column round, with a stellate central canal, its angles directed radially.

Geological Position, etc. *Stortingocrinus* is restricted, so far as known, to the lower beds of the Devonian of Europe.

*1838. **Stortingocrinus decagonus** (Goldfuss) **Platycrinus decagonus**, Nova Acta Ac. Leopold. xix, i, p. 345.—Schultze, **Platycrinus (Stortingocrinus) decagonus**; Monogr. Echin. Eifl. Kalk., p. 70, Pl. 10.—Devonian. Eifel, Germany.

*1855. **St. fritillus**, (Wirthgen and Zeiler), Type of the genus. **Platycrinus fritillus**, Verh. naturh. Verein f. Rheinl., Jahrg. xii (n. ser.), p. 80, Pl. 10, figs. 4 and 5.—Schultze, **Platycrinus (Stortingocrinus) fritillus**, Mon. Echin. Eifl. Kalk., p. 69, Pl. 10, figs. 8–8 f.—Devonian. Eifel, Germany.

Syn. **Platycrinus asper**, **P. pusillus**, **P. rugosus**, **P. scobiculatus** and **P. scaber** Goldfuss, and **P. minutus** Schurr.

*1866. **St. trifidus** (Schultze), **Platycr. (Stortingocr.) trifidus**, Monogr. Echin. Eifl. Kalk., p. 70, Pl. 10, figs. 8 a–g.—Devonian. Eifel, Germany.

PISOCRINUS De Koninck.

1858. De Koninck. Bull. de l'Acad. Roy. de Belgique (Ser. 2), iv, p. 104.
1873. Salter, Cat. Cambr. Museum, p. 128.
1879. Handb. d. Palæontologie i, p. 348.
1878. Angelin, Iconogr. Crin. Suec., p. 20.
1879. S. A. Miller, Journ. Cincin. Soc. Nat. Hist. (July).

Syn. *Symbathocrinus* (in part), F. Roemer, Silur. Fauna, West Tenn., p. 55.

Syn. (?) *Triacrinus*, Münster, 1839 (in part), Beiträge zur Petrefactenkunde, p. 4.

Syn. *Symbathocrinus* (in part), Roemer, 1860, Silur., Fauna West. Tennessee, p. 55.

Pisocrinus is closely allied to *Triacrinus*, but the latter is said to have three basals; *Pisocrinus* has five. The arrangement of the other calyx plates is identical, and also the arm structure. Schultze, who observed in the Eifel species only three basals, postulated from this that the Silurian species from Sweden, for which De Koninck had established the genus *Pisocrinus*, also consisted of but three plates. Angelin, who succeeded Schultze, and who had at his command the extensive collections of the Stockholm Museum, describes the genus with five basals, and all his figures show five plates. We also examined from the same horizon in America several hundred specimens of at least three species from Western Tennessee, all of which have five basals and not three; but in one of those species the basals are so small that they were almost completely covered by the column, and it appears as if the sutures between the plates of the second ring, of which only three touch the basals, were the sutures between the plates of the first ring. A similar structure is found in *Pisocrinus pilula* (Iconogr., Pl. 4, fig. 4 *b*), a species which in its general aspect is closely allied to *Triacrinus depressus* Müller. We do not pretend to say, however, that this species had five basals; it is very possible that two of these plates became anchylosed, and that the genus made its reappearance in the Devonian with only three basals.

Generic Diagnosis.—Calyx in its general aspect clove-shaped, its form subconical, sometimes pyriform.

Basals five, unequal; three of them larger and trapezoidal, the two smaller ones trigonal, which combined form an irregularly triangular cup.

The radials are extremely irregular, only the two antero-lateral ones touching the basals. These two are more than twice as large as the other three plates; they are hexagonal, and have the same form and size. The anterior radial is triangular, with convex sides, and rests with its lower angle half way between the two larger ones. At the posterior side, the basals do not support a radial, but are succeeded by a pentangular azygous plate, which shares with the two large radials an equal part. The plate has the form of an axillary, is broadly truncate below, with short lateral faces, and is sharply angular above. The two postero-lateral radials meet above the azygous plate, resting upon its sloping upper sides, and against the upper half of the two larger radials. Their width is identical with that of the larger ones, and in a ventral aspect the radials appear to be perfectly symmetrical.

Pisocrinus has similar articular appendages as *Symbathocrinus*, which cover a good part of the ventral surface. The articulation, however, does not occupy the whole width of the radials; there is at each side of the plates an upright extension, which together with that of adjoining radials produces interradially, between the arms, a conspicuous projection, similar to that of *Haplocrinus*, but more prominent. The construction of the ventral side is not known, the space beyond the articular faces is open in all our specimens, but probably was covered in a similar manner as in *Symbathocrinus.*

The arms are long, simple, rounded along the outer face, and less closely folded than in *Symbathocrinus.* They are composed of extremely long, single joints with parallel upper and lower faces. The column is circular and has a stellate central canal.

Geological Position, etc.—*Pisocrinus* is restricted to the Upper Silurian, and occurs in Europe and America.

Pisocrinus Dixoni Troost is a catalogue name.

1878. **Pisocrinus flagellifer** Angelin, Iconogr. Crin. Suec., p. 21, Pl. 4, figs. 1 *a–e.* —Upper Silur., Gothland, Sweden.

1879. **P. gemmiformis** S. A. Miller, Journ. Cincin. Soc. Nat. Hist. (July); Pl. 9, figs. 6 *a–c.*—Niagara gr., Riply Co., Indiana.

1878. **P. ollula** Angelin, Iconogr. Crin. Suec., p. 21, Pl. 4, figs. 4 *a–d.*—Upper Silurian, Gothland, Sweden.

1858. **P. ornatus** De Koninck, Bull. de l'Acad. Roy. de Belg. (Ser. 2), Tome 4 (Extr. p. 27), Pl. 2, figs. 12, 13.—Upper Silurian, Dudley, England.

1858. **P. pilula** De Koninck (Type of the genus), Bull. de l'Acad. Roy. de Belg. (Ser. 2), Tome 4 (Extr. p. 26), p. 106, figs. 8–11; Angelin, 1878, Iconogr. Crin. Suec., p. 21, Pl. 4, figs. 4 *a, b.*—Upper Silurian, Dudley, England, and Gothland, Sweden.

1878. **P. pocillum** Angelin, Iconogr. Crin. Suec., p, 21, Pl. 4, figs. 3, 3 *a.*—Upper Silurian, Gothland, Sweden.

*1860. **P. tennesseensis** (Roemer), **Symbathocrinus tennesseensis,** Silur. Fauna, West. Tenn., p. 55, Pl. 4, figs. 6 *a, b.*—Niagara gr. Decatur Co., Tenn.

TRIACRINUS Münster.

1839. Münster, Beiträge z. Petrefactenk., p. 3.
1850. D'Orbigny, Prodr. de Paleont., i, p. 104.
1866. Schultze, Monogr. Echin. Eifel Kalk., p. 106.
1879. Zittel, Handb. d. Palæont., i, p. 348.
Syn. *Trichocrinus* Müller, Monatsber. 1856, p. 354., and Neue Echin. d. Eifl. Kalk., p. 248.

Triacrinus differs from *Pisocrinus* in having three basals in place of five, in all other characters the two forms are identical. We have some doubt whether the few species which have been referred to *Triacrinus* have not really five basals instead of three. In this case the genus would take the name *Pisocrinus* and not *Triacrinus*, although the latter has priority. Münster described the base as tripartite, making this the name-giving character, and De Koninck, who found five basals in his species, was in our opinion perfectly justified in establishing for it a new genus.

1857. **Triacrinus altus** (Müller), **Trichocrinus altus**, Neue Echin. Eifl. Kalk., p. 249, Pl. 2, figs. 8–11.—Schultze, 1866, **Triacrinus altus**, Echinod. Eifl. Kalk., p. 109, Pl. 12, fig. 9.—Devonian. Eifel, Germany.

1857. **T. depressus** (Müller), **Trichocrinus depressus**, Neue Echin. Eifl. Kalk., p. 249, Pl. 2, figs. 12–17.—Schultze, 1866, **Triacrinus depressus**, Echin. Eifl. Kalk., p. 108, Pl. 12, fig. 8.—Devonian. Eifel.

1839. **T. granulatus** Münster, Beitr. z. Petrefactenk., p. 4.—Upper Silur. (?). Schübekammer, Germany.

1839. **T. granulatus** Münster, type of the genus, Beitr. z. Petref., p. 3, Pl. 1, figs. 4 *a*, *b*, *c*.—Devonian. Benitzlosau, near Hof, Germany.

LAGENIOCRINUS De Kon. & Lehon.

1853. De Kon. and Lehon., Recherch. sur les Crin. Carbon. de la Belg., p. 187.

1879. Zittel, Handb. d. Palæontologie, i, p. 350.

Zittel has placed *Lageniocrinus* along with *Symbathocrinus* and *Phimocrinus*, and we think for good reasons. We also agree with him that the five plates, which in the specimens cover the ventral surface, represent the arms and not radials as was supposed by De Koninck. These plates evidently could be opened, and there were plates underneath covering the calyx. *Lageniocrinus* represents in our opinion an embryonic form, and may possibly be the young stage of *Symbathocrinus*. Of this genus we found a very minute specimen, in which the arms consisted of but three successive joints, forming jointly a pyramid; while adult specimens sometimes have as many as a hundred.

Generic Diagnosis.—General form flagon-shaped; that of the dorsal cup funnel-shaped. Basals three, elongate, two of them larger and pentangular, the smaller one rhomboidal, which together form a tubular body which is slightly wider above. The radials are quadrangular, wider above than below. Two of them rest upon the truncate upper faces of the two larger basals, the three others against their sloping sides and against the upper sides of the smaller basal. There is no anal plate. The arms consist of single joints, which, folded together, form a pyramid. The ventral surface of the calyx is not known.

1853. **Lageniocrinus seminulum** De Kon. and Lehon, Recherch. sur les Crin. Carbon. de la Belg., p. 189, Pl. 4, fig. 1 *a–c*.—Mountain limest. Visé, Belgium.

(?) **RHOPALOCRINUS** W. & Sp., Rev. i, p. 57.

This genus was referred by us provisionally to the Ichthyocrinidæ, where it cannot remain, as it has not the articulate structure so characteristic of that group. We now place it with the Inadunata, as the arms were evidently free from the first radials; but we are yet in doubt if it should go with the Symbathocrinidæ, Cupressocrinidæ, Gasterocomidæ, or be made a distinct group.

Family XV.—CUPRESSOCRINIDÆ Roemer.

The Cupressocrinidæ in our classification consist only of the genus *Cupressocrinus.* Schultze, Zittel and De Loriol, however, added *Symbathocrinus* and *Phimocrinus*, which unquestionably differ from *Cupressocrinus* more than *Pisocrinus* and *Triacrinus*, for which they proposed a separate group.

CUPRESSOCRINUS Goldfuss.

(Pl. 4, fig. 1.)

1826. Goldfuss, Petref. Germaniæ, i, p. 330.
1835. Agassiz, Mémoir Soc. des Sci. natur. d. Neuchatel, i, p. 198.
1838. Goldfuss, Nova Acta. Ac. Leopold. XIX, i, p. 330.
1839. Münster, Beitrage z. Petref., p. 3.
1845. F. Roemer, Leonh. and Bronn's Jahrbuch, p. 291.
1850. D'Orbigny, Prodrome de Paleont., i, p. 102.
1852. Quenstedt, Handb. d. Petref. (Ed. 1), p. 623.
1855. Sandberger, Versteinerungen Nassan's, p. 401.
1855. F. Roemer, Lethæa Geognostica (Ausg. 3), p. 230.
1857. Pictet, Traité de Paléont., vol. iv, p. 306.
1862. Dujardin and Hupé, Hist. natur. des Zooph. Echin., p. 110.
1866. Schultze, Monogr. Echin. Eifl. Kalk., p. 14.
1879. Zittel, Handb. d. Palæontologie, i, p. 348.
1880. Quenstedt, Handb. d. Petref., Ed. 3, p. 962.
1882. De Loriol, Paleontologie Franc., tome xi, p. 47, not Ad. Roemer, Harzegebirge, p. 8; nor McCoy, Syn. Brit. Palæoz. Foss., p. 117.

Syn. *Halocrinites* Steininger, 1831, Mem. Soc. Géol. de France, i, p. 349.

Syn. *Cypressocrinites* Steininger, 1849, Verstein. Uebergangsgeb. d. Eifel, p. 20.

Syn. *Cypellocrinites* Steininger, 1853, Geogn. Beschr. d. Eifel, p. 36.

Goldfuss, in 1826 (Petrefacta Germania), gave a good description of this genus, to which he made additions in 1838 (Beiträge zur Petrefactenkunde, p. 334). At both times he expressed the conviction that the ventral covering was probably membranous.

The arms he described as bearing "säbelförmige Tentakeln" (pinnules), and in the description of *Cupressocrinus gracilis* he gave a graphic account of the articular facets of the radials. These, according to his statement, extend deeply inward, so as to diminish largely the width of the visceral cavity, which at the upper end is reduced to one half the depth of the facet. Behind the "Nahrungscanal" (axial canal), he says, there extend out two diverging muscular extensions, which connect by a cross-piece, abut against their fellows of adjacent radials, and form together a star-shaped figure, composed of five pairs of leaves. The ventral surface, therefore, according to Goldfuss, consists of five coalesced muscle-plates, and not, as was supposed by Roemer, Schultze and Zittel, and heretofore by ourselves, of an independent plate or apparatus, peculiar to this genus. F. Roemer described it as a cribriform calcareous plate, in form of a five-leaved flower. Schultze speaks of it as five delicate plates, which join radially, four of them equal, the fifth one different and containing the anal opening. He calls it a consolidating apparatus, constituting a part of the inner body, and not portions of the outer test; pierced by various openings, through which the blood-vessels, axial canals and genital organs passed into the arms. A similar view was held by Zittel, who stated: "There is in the interior of the calyx, at the base of the arms, a peculiar annular, so-called consolidating apparatus, composed of five large interradial (oral) plates, with a round (mouth) opening at the centre." Also, De Loriol mentions a peculiar "Consolidations-apparat, qui a été rapproché des hydrospires."

The views expressed by us, Rev. I, p. 12, to which De Loriol alludes, differ from those of our co-laborers. We held that the so-called "consolidating apparatus" was composed of five oral plates, which we thought stood in connection with five pairs of hydrospires. To this interpretation we were partly led by a certain superficial resemblance, but principally by the fact that Roemer, Schultze and Zittel, who had access to the splendid collections from the Eifel, all agreed that the plates in question were interradial in position. If this had been true, nothing could have been more natural but that these plates should be structurally identical with the deltoids of the *Blastoidea*, and the interradials of the *Cyathocrinidæ*, which were then held by us to be oral plates.

A very different interpretation of the so-called consolidating apparatus has been given to us by Dr. P. H. Carpenter, who regards it as representing the united muscle-plates of the radials. He wrote to us as follows: "I look upon the consolidating apparatus as offering a surface for the attachment of muscles by which the arms were moved on the calyx. The successive arm-pieces—I will not call them 'joints'—were suturally united and not movable upon one another, so that the arms were moved *en masse* upon the calyx, and this must have required very strong muscles between the calyx and first brachials. All that is ordinarily supposed to represent the articular face of the radials is shown in Schultze's Taf. II, fig. 5 *a*, while that of the arm-base appears on fig. 7 *b*. Now, it appears to me improbable that the heavy, massive arms of *Cupressocrinus* were moved by muscles which had no further surface of attachment—at their proximal end, at any rate—than is shown in Fig. 5 *a*. *Symbathocrinus* has large muscle-plates, but there is nothing of this kind in *Cupressocrinus*, without the consolidating plates. The calyx of *Phimocrinus lævis* (Schultze, Taf. III, fig. 6 *a*), corresponds to that of *Cupressocrinus*, with the consolidating plates *in situ*. There is the same arrangement round the anal opening, of which there is absolutely no trace in *Cupressocrinus*, *without* the consolidating plates, and yet it is clear from Schultze's description that he regards (rightly as I believe) the top of the calyx to be formed of the 'Gelenkflächen der Radialia,' with the anus between two of them. I cannot, therefore, help regarding the consolidating apparatus of *Cupressocrinus* as consisting of the united muscles-plates of the radials, from the lower portions of which they are apt to separate." This seems to us a very reasonable solution of the question, and we fully agree with Carpenter. We have since found that the plates are not interradially disposed, nor do they form separate pieces; the sutures which we thought we observed are evidently radial sinuses, similar to those which we described in *Symbathocrinus*.

The arm structure of *Cupressocrinus* was also pointed out more accurately by Goldfuss than by most of the succeeding writers. The outer and inner "Querbalken" of Schultze (Mon., Pl. 1, figs. 1 *h*, α, β), are obviously the basal portions of incurved pinnules, and as such they were described and figured by Zittel. These pinnules, however, in the opinion of Carpenter, are not homologous with those of other Crinoids, there being six or more of them to each arm plate, given off from each side, in place of one alternately arranged, a structure similar to that of the so-called pinnules of the Blastoids. Also their ambulacra, aside from not being recumbent and forming no part of the calyx, resemble closely those of the latter group. By removing the lancet piece and side pieces in *Pentremites*, and exposing the sinus, it will be found that the inner sides of the limbs are constructed almost exactly as the inner walls of the arm-grooves in *Cupressocrinus*, as seen by a comparison with Schultze's figure in his Monograph, Pl. ii, figs. 7 and 11. There are in both structures deep, rounded transverse grooves, alternating with ridges which are truncate above, and each one of them is provided lengthways with a small furrow at the top. These furrows do not extend to the full length of the ridge, but are provided at their outer end with an articular facet for the attachment of a pinnule. The pinnules at their base do not touch laterally, but leave a small open space in the direction of the lateral grooves. These grooves form the outer half of a pore, similar to the hydrospire pores of the Blastoids, and like the latter probably are communicating in a similar manner with hydrospires, lodged, however, within the arm grooves and not within the calyx. Schultze's figures 1 *h* and 1 *i*, in our opinion, are incorrect. *Cupressocrinus* certainly had no such "Tentakel-Furche" as here represented, and we doubt if the genus possessed such minute irregular covering plates, either along the perisome or within the arms.

Generic Diagnosis.—Dorsal side of the calyx basin-, cup- or bell-shaped, composed of rather large, heavy plates; when the arms are attached and closed, the form is ovoid or pyramidal.

The basals consist of five equal, pentagonal pieces, which enclose an equilateral, undivided disk, formed by a coalescence of the underbasals, or, according to others, by the upper stem joint which became enlarged and as such took the place of the underbasals in other genera.

Radials five, of similar form, wider than high, pentangular; the upper margins truncate, and forming a horizontal line. They are succeeded by five very short pieces, of the same width, which Schultze designated as "articularia" and as parts of the calyx. The arms are wide, simple, closely folded together, and composed of a single row of from 2 to 20 heavy, transverse pieces, of which the upper and lower sides are parallel. The arm plates grow narrower and shorter at their upper ends, they are suturally connected, and sometimes so closely anchylosed that no suture lines can be distinguished along the lateral margins of the arms.

The radials are connected with large muscle-plates (Pl. 4, fig. 1), which are laterally anchylosed, and together form one continuous plate. This covers the greater part of the ventral surface, leaving in the centre but a comparatively small, irregularly pentagonal open space, which, as we suppose from analogy with allied forms, was covered in the animal by interradial and summit plates. The median portions of each radial is pierced by two successive, rather large openings, of which the outer ones penetrate the upper margin of the plate, and serve as passages for the axial cords; the inner ones, which pass through the muscle-plate, probably are ambulacral openings. The muscle plate in its outer form is stellate, having five pairs of leaf-like extensions, two to each radial. They contain upon their outer faces indistinct striæ, which from both sides concentrate toward the axial opening. The leaves become more delicate toward the periphery, especially interradially, where they are frequently broken, and the spaces, thus formed, appear in the specimens as if constituting natural openings.

The articulation of the arms with the calyx was facilitated by the axillaria, which, like the radials, have an axial canal, and, according to Schultze, similar muscular processes. The articular face of the arms is truncate, sloping toward the inner side, and corrugated for the reception of ligament. The arm furrow is deep and wide, and contains along the inner floor an unusually large axial canal, which, to the extent of the proximal arm piece, is partitioned off from the ambulacral groove. The exact construction of the ambulacra is not known, but we judge they were plated in a similar manner as those of *Symbathocrinus*, and not membranous as described by Schultze. They probably also were provided with lateral pores, and these were alternately arranged with incurved, articulated pinnules, resembling in form those of the recent genus *Holopus*, but arranged like those of the Blastoids, there being four or more to each arm joint.

Cupressocrinus has been described to possess no anal plate, only an anal opening, located between two of the muscle plates.

It has been overlooked, however, that in the two radials adjoining the anal opening the passages of the axial cords are placed considerably to one side, leaving sufficient space for an anal plate such as we find in *Symbathocrinus*, and whose presence we postulated in *Phimocrinus.* That such a plate really existed, is more probable since we find in *C. gracilis* the margin which forms the anal opening at one side considerably raised, and there are irregular upper edges as if these had formed the base of an anal tube.

The column is circular, triangular or quadrangular, composed of short joints. It contains four large peripheral canals, rarely three or five, and a central one, which is either confluent with the others or isolated. It is frequently provided with cirrhi, which have two canals, vertically arranged, and these also are frequently confluent.

Geological Position, etc.—*Cupressocrinus* is only known from the lower portions of the Devonian of Europe.

N. B.—*Cupressocrinus dubius* and *C. teres* A. Roemer, and *C. pentaporus* Eichwald, were described from pieces of column; *C. calyx* McCoy = *Hydreionocrinus calyx* (Rev. ii, p. 131); *C. impressus* McCoy probably is *Eupachycrinus.*

1838. **Cupressocrinus abbreviatus** Goldf., Nova Acta Ac. Leopold. xix, Pt. i, p. 333, Pl. 30, fig. 4.—D'Orbigny, Prodr. i, p. 102.—Roemer, 1855, Leth. Geogn. (Ed. 3), i, p. 232.—Schultze, 1866, Echin. Eifl. Kalk., p. 19, Pl. ii, fig. 1, and Pl. iii, fig. 3.—Dujardin and Hupé, 1862, Hist. nat. Zooph. Echin., p. 112.—Devonian. Eifel, Germany.

Schultze recognized the following varieties: **C. alta, C. granulosa, C. hybida** and **C. minor.**

Syn. **Halocrinites Schlotheimii** Steininger, Mem. Soc. géol. de France i, p. 349, Pl. 21, fig. 1.

Syn. **Cupressocrinus Schlotheimii** Steininger, Geogn. Beschreib. d. Eifel, p. 36, and Verstein. der Eifel, 1849, p. 21.

Syn. **C. pyrimidalis** Stein., Bull. Soc. géol de France (Ser. i), ix, p. 295, Pl. 4.

Syn. **C. nodosus** Sandberger, Versteiner. Nassau's, p. 401, Pl. 35, fig. 5.

Syn. **C. Urogalli** Roemer, Palæontgr. iii, p. 9, Pl. 2, fig. 7.

1826. **C. crassus** Goldfuss (Type of the genus), Petref. Germaniæ i, p. 212, Pl. 64, fig. 4; also 1838, Nova Acta Ac. Leopold. xix, Pt. i, p. 331, Pl. 30, fig. 1.—Agassiz, 1835, Soc. de Neuchat. i, p. 198.—D'Orbigny, 1850, Prodr. i, p. 102.—Bronn., Lethæa Geogn. 1 and 2.—F. Roemer, Leth. Geogn. i, 1855 (Ausg. 3), p. 232, Pl. 4, figs 9 a, b, c.—Bronn, 1860, Classen des Thierreichs ii, Pl. 28, fig. 1.—Dujardin and Hupé, 1862, Hist. nat. Zooph. Echin., p. 112, Pl. 5, fig. 12.—Schultze, 1866, Mon. Echin. Eifl. Kalk, p. 23, Pl. 3, fig. 1.—Devonian. Eifel, Germany.

Syn. **Cypressocrinus crassus** Steininger, Geogn. Beschreib. d. Eifel, p. 36 and Versteiner. d. Eifel, p. 20.

Syn. **Cupressocrinus tetragonus** Goldfuss, Nova Acta Ac. Leopold. xix, Pt. i, p. 332, Pl. 30, fig. 3.

1838. **C. elongatus** Goldfuss, Nova Acta Ac. Leopold. xix, Pt. 1, p. 331, Pl. 30, fig. 2. —Münster, 1839, Beitr. d. Petrefactenk., p. 3, Pl. i, figs. 1 a, b.—D'Orbigny, 1850, Prodr. i, p. 102.—Schultze, 1866, Mon. Echin. Eifl. Kalk., p. 23, Pl. 3, fig. 1.—Dujardin and Hupé, Hist. natur. Zooph. Echin., p. 112.—Devonian. Eifel, Germany.

Syn. **C. gerolsteinensis** Stein, 1849, Verst. d. Eifel, 1849, p. 20.

Syn. **C. prismaticus** Stein, 1849, *ibid.*, p. 20.

Syn. **C. elongatus** Stein, Geogn. Beschreib. d. Eifel, p. 36.

1826. **C. gracilis** Goldfuss, Petref. Germaniæ, i, p. 213, Pl. 64, fig. 5: also Nova Acta Ac. Leopold. xix. Pt. I, p. 334, Pl. 30, figs. 5 *a*, *b*, *c* (not 5 *d*).—Steininger, 1849, Versteiner. d. Eifel, p. 20.—D'Orbigny, 1850, Prodr. i, p. 102.—Dujardin, and Hupé, 1862, Hist. nat. Zooph. Echin., p. 113.—Schultze, 1866, Mon. Echin. Eifl. Kalk., p. 23, Pl. 3, fig. 2.—Devonian. Eifel, Germany.

1866. **C. hieroglyphicus** Schultze, Mon. Echin. Eifl. Kalk., p. 25, Pl. 1, fig. 3.—Devonian. Eifel, Germany.

1866. **C. inflatus** Schultze, Mon. Echin. Eifl. Kalk., p. 24, Pl. 1, fig. 2.—Devonian. Eifel, Germany.

1866. **C. scaber** Schultze, Mon. Echin. Eifl. Kalk., p. 25, Pl. 1, fig. 4.—Devonian. Eifel, Germany.

Family XVI.—GASTEROCOMIDÆ.

The Gasterocomidæ embrace the following genera: *Gasterocoma*, *Nanocrinus* and *Myrtillocrinus*. They were united by Pictet and by Dujardin and Hupé, with the Haplocrinidæ; Roemer, Schultze, Zittel and De Loriol, however, treated them as a separate family.

GASTEROCOMA Goldfuss.

1838. Goldfuss, Nova Acta Ac. Leopold. xix, i, p. 350.
1853. Steininger, Geogn. Beschreib. d. Eifel, p. 38.
1857. Müller, Neue Echin. Eifl. Kalk., p. 257.
1857. Pictet, Traité de Paléont., iv, p. 314.
1862. Dujardin and Hupé, Hist. natur. des Zooph. Echin., p. 109.
1866. Schultze, Mon. Echin. Eifl. Kalk., p. 95.
1879. Zittel, Handb. d. Palæont., i, p. 363.

Syn. *Ceramocrinus* Müller, 1855, Verh. naturh. Verein f. Rheinlande, xii (n. ser.), p. 83.

Syn. *Epactocrinus* Müller, 1855, *ibid.*, p. 84.

Gasterocoma was described by Goldfuss to be composed of five basals and five radials, the latter as enclosing laterally an anal plate, and the anal opening as being located next to the posterior basal. This definition, although substantially correct, was afterwards modified by Schultze. He found that among species, and even among individuals of the same species, the construction of the azygous side undergoes most remarkable variations; such as in other groups would be sufficient for generic separation. The anal opening in this genus, as a rule, is located between the radials. It either lies directly above the posterior basal, and is followed by a quadrangular or triangular anal plate, or the opening is situated above the anal plate. In the former case the two posterior radials may close above the opening, or be separated from one another by additional plates; the opening may even penetrate exceptionally the posterior basal. Müller's genus *Ceramocrinus*, according to Schultze, was founded upon a specimen in which the anal plate was placed above the opening, contrary to the typical form of Goldfuss, in which it was below. The name *Epactocrinus* was proposed for a specimen with very irregular basals, portions of which evidently had been destroyed or fractured, and were restored by the animal, and this may have produced the irregular form. The construction of the ventral side cannot be satisfactorily ascertained from Schultze's figures. His figs. 1 *f*, and 1 *i*, on Pl. xii, which are said to represent the ventral surface of *Gasterocoma antiqua*, are so different from one another, that we believe there is a mistake in the figures. These figures differ again essentially from fig. 5 *b*, which is said to represent the same parts in *Gasterocoma gibbosa.*

Generic Diagnosis.— The lower disk has the form of a pentagon, and extends somewhat beyond the column. It is surrounded by five basals, four of them equal, pentagonal; the fifth larger, hexagonal, truncate above.

Radials five, pentangular; three of them are equal, the two next to the azygous side irregular. The two latter enclose laterally not only the anal plate, but also the anal opening, which is surrounded by a single ring of small plates, and either rests upon the truncated upper face of the larger basal, or is separated from the latter by an anal plate. In either case the anus, as a general rule, is succeeded by one or more anal pieces, which, however, in some specimens do not extend to the upper end of the radials, and in this case the radials meet above the anal plates. The radials have a lateral articular facet of the horseshoe form, which extends deeply into the plate. It is notched above for the arm furrow, and pierced by a large axial canal, which is removed far off from the outer edge of the plate. The arms evidently were heavy, and, to judge from the facets, were probably pendent.

The mouth of *Gasterocoma*, according to the position of the central piece, was excentric. This central—or, as we call it, oral—

plate abuts against the two posterior radials; it is large, heavy, somewhat elongate, and surrounded anteriorly and laterally by what may prove to be four proximals (?). The interradial plates appear to be small, but may be partly hidden from view by the large covering plates.

The form of the column is not known, but it was, like in *Cupressocrinus*, perforated with a central canal and four peripheral ones, which were confluent at the centre.

Geological Position, etc.—Confined to the Devonian of the Eifel.

The following species have been described:—

1838. **Gasterocoma antiqua** Goldf. (Type of the genus), Nova Acta Ac. Leopold. XIX, i, p. 96.—Pictet, 1857, Traité de Paléont., iv, Pl. C, fig. 7.—Schultze, 1866, Echin. Eifl. Kalk., p. 96, Pl. 12, fig. 1.—Devonian. Eifel, Germany.

Syn. **Epactocrinus irregularis** Müller (Wirtgen and Zeiler), 1855, Verh. naturh. Verein. f. Rheinl., xii, p. 85, Pl. 12, figs. 5–8.

1866. **G. gibbosa** Schultze, Echin. Eifl. Kalk., p. 98, Pl. 12, fig. 5.—Devonian. Eifel, Germany.

1866. **G. Mülleri** Schultze, Echin. Eifl. Kalk., p. 99, Pl. 12, fig. 2.—Devonian. Eifel, Germany.

Syn. **Ceramocrinus eifliensis** Müller (Wirtgen and Zeiler), Verh. naturh. Verein f. Rheinlande, xii, p. 83, Pl. 12, fig. 2.

1866. **G. reticularis** Schultze, Echinod. Eifl. Kalk., p. 99, Pl. 12, fig. 3.—Devonian. Eifel, Germany.

1866. **G. stellaris** Schultze, Echin. Eifl. Kalk., p. 100, Pl. 12, fig. 4.—Devonian. Eifel, Germany.

NANOCRINUS Müller.

1856. Müller, Monatsber. d. Berl. Acad., p. 355.
1857. Müller, Neue Echinod. Eifl. Kalk., p. 249.
1866. Schultze, Monog. Echin. Eifl. Kalk., p. 102.
1879. Zittel, Handb. d. Palæontologie, i, 364.

Nanocrinus is very closely allied to *Gasterocoma*, and had not Schultze found six specimens which all have the same irregular structure, we should feel inclined to regard it an abnormal form of that genus. According to Schultze, the genus has five basals, but only four radials; the place of the fifth one is said to be occupied by an interradial. The latter is strictly radial in position, and as such should be designated as a non-arm-bearing radial.

Generic Diagnosis.—Basal cup as in *Gasterocoma*, but the plates less regular; four of them pentagonal, the posterior one considerably higher, hexagonal, truncate above.

Radials five, large, irregular in size, four of them arm-bearing, the fifth one not. The articular facet is lateral, horseshoe-shaped, and occupies almost the whole outer face of the radials. Three of the plates have a single facet, but the fourth, which is an axillary, has two, somewhat smaller than those of the others. The non-arm-bearing radial is smaller by more than one-half than any of the rest; it is hexagonal or trapezoidal, and sometimes altogether absent. The anal plate is placed between the lateral faces of two radials, and rests upon the truncate upper face of the larger basal. It is subquadrangular, somewhat excavated for the anal opening, which generally occupies the upper portion of the anal plate, occasionally, however, as in *Gasterocoma*, the lower side of it. The form of the arms is unknown.

The interradials appear to be small, but probably are partly hidden from view by the unusually large covering pieces, which occupy the greater part of the ventral surface, and rest against the oral plate, which is extremely large, there being no proximals. The column, like that of *Gasterocoma*, is provided with a central canal and four peripheral ones.

The only known species is :—

1856. **Nanocrinus paradoxus** Müller, Monatsber. d. Berl. Acad., p. 355; also Neue Echin. d. Eifl. Kalk., 1857, p. 249, Pl. 2, figs. 18–21.—Schultze, 1866, Echin. Eifl. Kalk., p. 102, Pl. 12, fig. 7.—Devonian. Eifel, Germany.

MYRTILLOCRINUS Sandberger.

1855. Sandberger, Versteiner. Nassau's, p. 388.
1857. Pictet, Traité de Paléont., iv, p. 311.
1862. Dujardin and Hupé, Hist. natur. des Zooph. Echinod., p. 108.
1862. Hall, 15th Rep. N. York St. Cab. Nat. Hist., p. 142.
1866. Schultze, Mon. Echin. Eifl. Kalk., p. 96.

We have not seen the original description of this genus, but we infer from the notes of Pictét, Schultze and Hall, that Sandberger described it to possess a quinque-partite, quadri-canaliculate base. In his figure it seems the central part was represented as undivided, and, curiously enough, the same is the case with Hall's figure of the American species, although he mentions in the description "five basals and five subradials." We cannot understand how a base like this could have been divided into five parts—not four—aud, therefore, prefer, in default of further evidence, to regard it as undivided, although we are well aware that, if any such division did exist, it would prove most satisfactorily that also the lower plate in the allied genera is underbasal. *Myrtillocrinus*, in our opinion, is closely allied to *Gasterocoma*, if not identical with it, but it is possible that the anal opening which has not been observed was subcentral, in place of lateral. It also appears from Hall's figure, as if it had two arms from each ray, although there is but one axial canal, which occupies the central space of the facet. The facet in Hall's species is oval and strictly lateral, thus indicating that the arms were pendent.

Geological Position, etc.—Only two species are known, the one from Europe, the other from America, both coming from lower Devonian beds.

1862. **Myrtillocrinus americanus** Hall, 15th Rep. N. York St. Cab. Nat. Hist., p. 142, Pl. 1, figs. 2–4.—Upper Helderberg group. Livingston Co., N. Y.

1855. **M. elongatus** Sandberger (type of the genus), Verstein. Nassau's, p. 388, Pl. 35, fig. 6.—Pictet, Traité de Paléont., iv, p. 311, Pl. c, fig. 4.—Dujardin and Hupé, 1862, Hist. natur. d. Zooph. Echinod., p. 108.—Müller, 1857, Neue Echin. Eifl. Kalk., p. 257.—Devonian. Nassau, Germany.

b. Branch, FISTULATA, W. and Sp.

The Fistulata embrace the Cyathocrinidæ as they were defined by us heretofore, but which we now subdivide into Hybocrinidæ, Heterocrinidæ, Anomalocrinidæ, Cyathocrinidæ and Poteriocrinidæ. To these we add the Belemnocrinidæ, Astylocrinidæ and Encrinidæ.

Zittel defined his Hybocrinidæ as follows: Calyx irregular; basis monocyclic; basals 5; radials 5; arms slender, single-jointed; pinnules wanting; and he placed in the family: *Hybocrinus* and *Anomalocrinus*. His definition is deficient and not quite correct. It would admit *Pisocrinus* and *Rhopalocrinus*, which we recognize as members of very different groups; and it actually excludes *Anomalocrinus*, which has seven plates in the radial series and not five, and strong pinnules, which are wanting in *Hybocrinus*.

Hybocrinus represents a very peculiar form. No other palæozoic Crinoid deserves in so high a degree the designation *embryonic type* as this genus, *Hybocystites* and the allied genera *Hoplocrinus* and *Bærocrinus*, which Zittel took to be synonymous with *Hybocrinus*. These four genera, which are easily recognized by their monocyclic base, large body, imperfectly developed radial plates, small ventral sac, the embryonic state of their arms, and the absence of pinnules, will be recognized by us as Hybocrinidæ.

Among the Heterocrinidæ Zittel placed *Heterocrinus*, *Graphiocrinus*, *Erisocrinus*, *Philocrinus* and *Stemmatocrinus*.

The family was defined as follows: Calyx regular; base monocyclic or dicyclic (five underbasals and five basals, or the latter only); five radials; arms long, simple, rarely bifurcating. The qualification "calyx regular" cannot be applied to *Heterocrinus*, which is one of the most asymmetrical forms of the Palæocrinoidea, and this want of symmetry extends not only to the interradial series but also to the radial plates, and forms its best generic distinction.

Neither does that term apply to *Graphiocrinus*, which is bilateral, nor *Philocrinus*, which we think is decidedly irregular. Only *Stemmatocrinus* and *Erisocrinus* have a pentamerous calyx, but these agree in other respects with the Poteriocrinidæ. *Heterocrinus*, in its general asymmetry, in arms and pinnules, and in its azygous side, closely resembles *Anomalocrinus*, which for other reasons we refer to a distinct family. We add to the Heterocrinidæ the two genera *Stenocrinus* and *Ohiocrinus*, which are founded upon species heretofore ranged under *Heterocrinus*, and unlike Zittel, place *Graphiocrinus*, *Philocrinus*, *Stemmatocrinus* and *Erisocrinus* under the Poteriocrinidæ.

Anomalocrinus, which we make the type of a distinct family, stands closer to the Heterocrinidæ than to the Hybocrinidæ, but differs from either of them very essentially in the relative size of the calyx, which is comparatively large, and low-cup or saucer-shaped in place of subcylindrical or narrowly turbinate. It further differs from all known Crinoids, recent or fossil, in the arrangement of its pinnules, which are not given off alternately from opposite sides, but from every successive joint on one side at a time from one bifurcation to the next, where they change on both rami to the opposite side. In the arrangement of the anal plates, and in having no underbasals, the Anomalocrinidæ agree with the Heterocrinidæ.

The Belemnocrinidæ, which only contain *Belemnocrinus* and the imperfectly known genus *Holocrinus*, differ from the preceding families in having no underbasals; they have, however, large basals, cylindrically arranged, but even these take little or no part in forming the visceral cavity. In this regard *Belemno-*

crinus resembles *Rhizocrinus*, but it differs from that in having a strong porous ventral sac.

Zittel's Cyathocrinidæ include *Cyathocrinus*, *Nipterocrinus*, *Barycrinus*, *Euspirocrinus*, *Ophiocrinus*, *Botryocrinus*, *Palæocrinus*, *Carabocrinus*, *Sphærocrinus* and *Pachyocrinus* (Billings, not Eichwald), with the following family diagnosis: Calyx globose; basis dicyclic, composed of five underbasals and five basals; anals 1–3; arms strongly developed, single-jointed, long, branching, without pinnules; ventral side covered by "oral plates." From his list must be excluded *Nipterocrinus*, which has interradials and only three underbasals, and *Pachyocrinus*, which is too imperfectly known to determine its position. There are besides *Sicyocrinus*, *Ophiocrinus*, *Botryocrinus* and *Barycrinus*, in which the arms, throughout their whole length, give off armlets at intervals, which evidently take the place of pinnules if they are not true pinnules themselves. We direct attention to this point, as both Zittel and De Loriol make the absence of pinnules in the Cyathocrinidæ the sole distinction between this family and the Poteriocrinidæ.

The presence or absence of pinnules has been considered by us heretofore as a doubtful character for distinguishing families. The pinnules are extensions of the arms, and in their organization, both morphologically and physiologically, almost identical with the arms. They are short branchlets given off along the sides of the arms, but ordinarily not extending to their tips. The pinnules differ from arms only by their containing the fertile portions of the genital glands, while the arms lodge the genital cord. The branches of the arms may be said to be modified pinnules, which differ from true pinnules in their greater length and thickness. They are usually called arms when attaining the form and length of the primary arms, but armlets when shorter, less robust, and given off at regular intervals. Frequently the branches are pinnule-bearing again, and this is the case in the Poteriocrinidæ, in which all arms, whether branching or simple, main arms or side arms, are fringed with true pinnules. The presence or absence of pinnules would prove to be a much better character for distinguishing the two groups, were it not that *Barycrinus* and allied genera represent a most perplexing transition form in having short side branchlets, given off at regular intervals, and these branching off once or twice again in a similar manner. In these genera it is exceedingly difficult to determine whether the branches are armlets or pinnules, a question which cannot be decided definitely until we know where the genital glands are located. It is probable that in the genus *Cyathocrinus*, at least in its Carboniferous form, all branches were arms. We found in *C. multibrachiatus*, along the three or four proximal arm joints, outside the adambulacral or side-pieces, small plates in rows of from four to six pieces (Pl. 4, fig. 7 *a*, *b*), succeeding each other longitudinally, which perhaps took the place of the genital pinnules. No such plates, however, were represented in *Barycrinus*, in which the ventral grooves are comparatively narrow. *Cyathocrinus longimanus* has no regular pinnules, but certain sabre-shaped appendages, composed of five segments, which from each side infold over the ventral furrow, covering it completely. These appendages which we (Rev., i, p. 25) erroneously took to be rudimentary pinnules,[1] perhaps correspond with the so-called "pinnules" of the Cupressocrinidæ and Blastoidea.

Another good distinction between the Cyathocrinidæ and Poteriocrinidæ is offered by their mode of articulation. The radials of the former have horseshoe-like facets for the brachials; in the Poteriocrinidæ they are more or less truncate along the upper margin, and united with the brachials by a transverse ridge, occupying a median line and frequently their entire width. The middle part of this ridge is pierced by an axial canal, and there is a kind of muscle plate with more or less conspicuous fossæ. The outer edge of the plate is dentated and evidently was occupied by ligamentous bundles. In the Cyathocrinidæ the arms are always bifurcating, and their branches are given off at close intervals; those of the Poteriocrinidæ are frequently simple from the brachial bifurcation upwards, but when bifurcating, the divisions are given off irregularly, and branches and main arms bear pinnules alternately from every joint; there being no syzygies. The arm joints of the former, with the exception of *Barycrinus*, are composed of long, slender joints with almost parallel sutures; those of the latter are shorter, heavier and strongly wedge-shaped, even interlocking. The same mode of articulation

[1] A similar interpretation at that time was given by us of the ambulacral plates covering the arm furrows of *Cyathocrinus iowensis*, a mistake which was rectified by Carpenter (Chall. Rep., pp. 63–66).

that unites radials and brachials, extends to all bifurcating plates of the Poteriocrinidæ. In *Erisocrinus*, *Eupachycrinus* and *Graphiocrinus*, species with ten arms, it is found also among the proximal arm plates, not, however, in the allied *Scytalocrinus* and *Decadocrinus*, in which all arm plates above the brachials are united by suture or elastic ligament. The same was probably the case in species with branching arms, in which all intermediate joints between the axillaries are without either ridges or fossæ. A sutural union also connects the brachials in cases where they consist of more than one plate, the apposed faces showing no traces of a syzygy or fossæ. In the arms of the Cyathocrinidæ there are, so far as observed, no articular ridges nor axial canals, and no ligamentous fossæ, not even between radials and brachials, nor upon the axillaries. The apposed faces of all their joints fit closely together, the distal end being slightly concave, the proximal to the same degree convex, so that we may assert that their mode of union has been either by suture or of a somewhat similar nature, and that the arms were either immovable or their motions limited, and probably of a mere passive character. This difference in the articulation of the two types was noticed by J. S. Miller when describing the typical genera, for he placed *Cyathocrinus* separately among Inarticulata, and *Poteriocrinus* among Semiarticulata. These names, as applied to the rays, are very characteristic of the two groups, for the Poteriocrinidæ are in their articulation much more highly differentiated, approaching in some cases the Neocrinoidea, Miller's Articulata.

In none of the Poteriocrinidæ has the ventral covering, with the exception of the so-called ventral sac, ever been observed, while that of the Cyathocrinidæ is comparatively well known. This, however, is partly explained by the condition of the radials, which in the Cyathocrinidæ had ample space for the reception of interradials, contrary to the Poteriocrinidæ, in which the articulation extends over the whole width of the radials, and the interradials, partly or wholly, had to rest against the muscle plates as in the Symbathocrinidæ. In the Cyathocrinidæ the interradials were persistent through life, but they may have become resorbed in the Poteriocrinidæ before reaching maturity. The condition of the ventral side among the Cyathocrinidæ varies considerably, and even among the species now referred to the genus Cyathocrinus there are several which range infinitely lower than others, and these should be placed under new genera.

The azygous side of the Cyathocrinidæ consists rarely of more than two plates in the calyx—the azygous plate and the anal piece; but the Poteriocrinidæ generally have three, owing to the fact that the first plate of the ventral tube extends often into the calyx. The ventral sac is perhaps more club- or balloon-shaped in the Poteriocrinidæ, more cylindrical in the Cyathocrinidæ.

We subdivide the Cyathocrinidæ into:

DENDROCRINITES, genera with a large azygous and well-developed anal plate, embracing: *Merocrinus*, *Carabocrinus*, *Dendrocrinus*, *Homocrinus*, *Ampheristocrinus* and *Parisocrinus*.

BOTRYOCRINITES, genera having no special azygous plate or occasionally a rudimentary one, and armlets in place of pinnules: *Atelestocrinus*, *Vasocrinus*, *Botryocrinus*, *Sicyocrinus*, *Streblocrinus* and (?) *Barycrinus*.

CYATHOCRINITES, genera without azygous plate, with branching arms without pinnules: *Cyathocrinus*, *Arachnocrinus*, *Gissocrinus*, *Sphærocrinus*, *Achradocrinus*, *Codiacrinus* and (?) *Lecythiocrinus*.

Zittel placed *Gissocrinus* among the Taxocrinidæ, the perfectly symmetrical *Codiacrinus* among the most unsymmetrical Gasterocomidæ, and *Ophiocrinus*, *Dendrocrinus* and *Homocrinus*, which are devoid of true pinnules, among the Poteriocrinidæ.[1]

We subdivide the Poteriocrinidæ as follows:

POTERIOCRINITES, genera having an azygous plate, a regular anal piece, and the first plate of the ventral sac enclosed in the calyx: *Poteriocrinus*, *Scaphiocrinus*, *Scytalocrinus*, *Decadocrinus*, *Woodocrinus*, *Zeacrinus*, *Hydreionocrinus*, *Cœliocrinus*, *Eupachycrinus*, *Cromyocrinus* and *Tribrachiocrinus*.

GRAPHIOCRINITES, genera without azygous or anal plate, but the first plate of the sac within the limits of the calyx: *Graphiocrinus*, *Bursacrinus*, *Phialocrinus* and *Ceriocrinus*.

ERISOCRINITES, genera without azygous or anal plate dorsally: *Erisocrinus* and *Stemmatocrinus*.

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[1] Prof. Zittel figures, Handb. d. Palæont., i, p. 359, as type of the Poteriocrinidæ a species devoid of pinnules. *Poteriocr. curtus* Müller, is evidently a *Homocrinus*.

Our Poteriocrinidæ contain essentially the same genera as those of Zittel, but we except from his list *Homocrinus*, *Dendrocrinus*, *Agassizocrinus* and *Belemnocrinus*. For the two latter we propose distinct families.

The Encrinidæ are closely allied to the Poterocrinidæ, and we think will ultimately be consolidated with them. Nothing, as yet, is known of their ventral structure, but neither of that of the Poterocrinidæ except their ventral tube. There is nothing which proves that the ventral surface of *Encrinus* was composed of soft parts, or that it was exclusively perisomic or differed from that of the Poteriocrinidæ which are universally regarded as Palæocrinoids. The only difference which we have discovered is that in the Encrinidæ the brachials are united by syzygy and also the proximal arm plates; contrary to the Poteriocrinidæ in which syzygies, so far as known, do not occur.

Among *Astylocrinidæ*, which represent the free floating Palæocrinoidea, we include *Agassizocrinus* and *Edriocrinus*, the former with underbasals, the latter with basals only. It is very possible that *Edriocrinus* will prove to be the type of a distinct family.

The *Catillocrinidæ* contain: *Catillocrinus* and *Mycocrinus*. The allied Calceocrinidæ only the genus *Calceocrinus*.

These ten families are defined by us as follows :—

A. Hybocrinidæ. Base monocyclic; calyx large compared with the arms. Basals 5, unusually large. Radials irregular, the postero-lateral one either unrepresented or very much smaller, and sometimes non-arm-bearing. Arms frequently undeveloped in one or more rays, or recurrent and appressed onto the outer surface of the calyx; simple, and without pinnules. Azygous side composed of a single, large azygous plate, and frequently an anal piece, which in form resembles the right posterior radial. Ventral sac very small, consisting of a mere tumor-like protuberance.

B. Heterocrinidæ. Base monocyclic. Calyx small; plates irregular. Basals 5, variable. Radials irregular, frequently compound in one or more rays; the right posterior radial smaller, resting upon the azygous plate. Brachials consisting of two or more pieces, united by syzygy. Of the succeeding arm joints only every second, third or fourth one pinnule-bearing. Azygous plate large; anal plate consolidated with the right posterior radial, which toward the left supports a series of anal plates; toward the right the brachials. Arms long; the pinnules sometimes take the form of arms, and attain the same general height. Column tri- or quinque-partite.

C. ANOMALOCRINIDÆ. Base monocyclic. Form irregular. Calyx capacious. Azygous plate large; supporting the right posterior radial, which toward the right is succeeded by a row of brachials, and toward the left by the ventral tube. Arms composed of large quadrangular joints, giving off pinnules from one side only, from one bifurcation to the next, when all pinnules change to the opposite side. Column strong, central canal wide, stelliform, its projecting angles directed interradially.

D. BELEMNOCRINIDÆ. Base monocyclic. Basals large; cylindrical; solid, only pierced by a narrow central canal with a shallow concavity at its upper end. Radials small, quadrangular, enclosing an anal plate of the same form. Ventral sac large, club-shaped. Arms long with numerous syzygies, only every second or third joint pinnule-bearing. Pinnules long, often bifurcating. Column round or pentangular, frequently with long cirrhi given off interradially.

E. CYATHOCRINIDÆ. Base dicyclic. Calyx globose, rarely turbinate. Radials with horseshoe-like lateral facets supporting at least two, but frequently several more brachials. Arms without true pinnules, but with branches in regular succession to their tips. Arm joints with a few exceptions long and narrow; quadrangular with almost parallel sides; united either by suture or ligament, apparently not by muscles. Ventral sac large, cylindrical. Column round or pentagonal; central canal rather above medium size, pentagonal, the projections directed radially.

F. POTERIOCRINIDÆ. Base dicyclic. Calyx deep and turbinate, or shallow and disk-like, owing to the form of the underbasals, which are either extended into a cup, or are turned inward and concave. Radials somewhat irregular, of variable size, the right posterior one generally smaller; all truncated at the upper face. Brachials one or two, connected by suture; the lower or proximal face truncate. Arms simple or branching, with pinnules alternately arranged from every joint; without syzygy. Arm joints cuneate or interlocking. Articulation between brachials and radials by muscles and ligament, and also between the upper faces of all axillaries and succeeding plates. Ventral sac large, frequently inflated. Column more or less pentagonal, its outer angles placed interradially, the cirrhi radially.

G. ENCRINIDÆ. Dicyclic. Closely allied to the Poteriocrinidæ, but, *as a rule*, without anal plates. Basals with well-developed axial canals proceeding to the radials. Their brachials composed of two pieces, united by syzygy, frequently with other syzygies in the higher portions of the arms. Arms biserial or uniserial.

H. ASTYLOCRINIDÆ. Pedunculate in earlier life, detached from the column and free-floating in the adult, but not cirrhus-bearing. Plates of the calyx massive, and hence the visceral cavity comparatively small. Underbasals present or absent, and also the azygous piece is sometimes wanting; while the anal plate is always well developed.

I. CATILLOCRINIDÆ. Base monocyclic. The pentamerous symmetry greatly disturbed by the unequal size of the radials. Those of the antero-lateral rays much larger and supporting many more arms. Arms simple; composed of single joints resting directly upon the radials, with a separate socket for each arm, and a furrow for each ambulacrum. Anterior ray, and both posterior rays rarely with more than one arm each. There is no azygous nor special anal plate, one of the posterior radials supports towards the left a large ventral tube, composed of a single row of heavy curved plates, longitudinally arranged, with an open furrow along their inner, *i. e.*, ventral side. Column circular.

J. CALCEOCRINIDÆ. Base monocyclic. Calyx laterally depressed; hanging downward from the column; composed of three unequal basals, three arm-bearing radials, and two azygous radials without arms. Basals and radials united by ligament, and toward the anterior side by muscles also. In the normal position of the crinoid, the basals are located posteriorly, and the three radials at the opposite side. Anterior radial smaller, compound; composed of two pieces, which frequently are separated by the overhanging sides of the two lateral radials. Arms of the lateral rays more numerous and branching; anterior ray with a single arm, which sometimes dichotomizes toward the upper end. Anal tube as in the *Catillocrinidæ*.

FAMILY XVII.—HYBOCRINIDÆ Zittel.

(Emend. W. and Sp.)

BAEROCRINUS Volborth.

1864. Volborth, Eine neue Crinoideen Gattung. (Author's copy, p. 35).
1865. Volborth, Bulletin St. Petersb. Acad., vol. viii, p. 178.
1866. Volborth, Bulletin Soc. Imp. de Nat. de Moscow, ii, p. 442.
1867. Grevingk, Archiv. f. Naturkunde Liv.-Ehst. und Kurlands, Ser. I, vol. iv, p. 110.
1867. Grevingk, Uber *Hybocrinus dipentas* and *Baerocr. Ungarni*, Dorpat, p. 14.
1882. P. Herb. Carpenter, Quart. Journ. Geol. Soc. London, August, pp. 298 312.
1883. W. and Sp., Amer. Jour. Sci., vol. xxvi, November, p 365.

Syn. *Homocrinus* Eichwald (in part), 1865–66; *Hybocrinus* Schmidt (in part), 1874; Zittel (in part), 1879.

The genus *Baerocrinus* has been a subject of much controversy ever since 1864, owing to doubts whether the genus should be admitted or rejected. It is unnecessary to give again a full history of these controversies, for which we refer to Dr. P. H. Carpenter's paper "On the Relations of *Hybocrinus*, *Baerocrinus* and *Hybocystites*," and to our notes "On *Hybocrinus*, *Hoplocrinus* and *Baerocrinus*," in the American Journal, of 1883. Carpenter agrees with us and with Volborth and Grevingk that *Baerocrinus* is a good genus, and not, as suggested by Eichwald and Schmidt, an abnormal specimen of *Hybocrinus dipentas*. There has been also much difference of opinion as to the meaning of certain plates. The type specimen has on its surface, along the basi-radial suture, and between two of the plates within the second or so-called radial ring, a peculiar structure, composed of numerous, irregular pieces, and upon this, principally, Volborth founded the genus. He took this structure to be a madreporic body; while Grevingk, Eichwald and Schmidt held it to be an accidental break in the test, due to mechanical agencies. Carpenter considered it to be the regular anal opening. He pointed out that it had the position of the anus in the Pentacrinoid larva at its earlier phases.

We stated in our paper that we did not agree with any of those views. We think it possible that this structure may have served as an anal opening, but as an abnormal one, which had opened out when the regular opening became functionally defective. We also differ from other authors in our interpretation of the plates. Those of the second circlet have been regarded all five as radials, and the calyx to the top of the radials as being perfectly symmetrical. It looks to us unreasonable, when we compare *Baerocrinus* with *Hoplocrinus* and *Hybocrinus*, and finding their structure in other essential points almost identical, that the one genus should be almost perfectly symmetrical, the other extremely irregular. And, therefore, it is probable that one of the non-armbearing so-called radials represents an azygous plate, such as we find in most of the *Fistulata*, that the right posterior radial and the anal plate were as yet undeveloped, and that *Baerocrinus* had but four radials. This interpretation of the plates, it seems to us, is corroborated by the gradual disappearance of the azygous plate among allied forms in palæontological times, and by the contemporary increase in the dimensions of the right posterior radial and the anal plate. The two latter pieces probably were absorbed from the azygous plate: at first the posterior radial, which in *Hoplocrinus* took the right upper corner, the left side remaining intact; afterwards in *Hybocrinus* the anal piece, which absorbed the left corner of the plate also.[1]

All this goes to prove that *Baerocrinus* represents a very low organization, or is, according to P. H. Carpenter, "a permanent larval form."

Revised Generic Diagnosis.—Form of the calyx cup- or goblet-shaped. Underbasals wanting. Basals five, subequal and comparatively large.

Radials large, irregular, only four of them developed, the right postero-lateral one absent. Three of the plates equal, the fourth one narrower. A large azygous plate occupies the same range with the radials and, like these, rests alternately upon the basals. It is undivided, and resembles the radials in form. In the type specimen only three of the radials are arm-bearing, the smaller one not having even an arm-facet. Arms five, simple throughout,

[1] In our paper on *Hybocrinus, Hoplocrinus* and *Baerocrinus*, we stated that probably the azygous plate of the latter was homologous with the anal plate as represented in the larva of *Antedon*. In making this statement we had overlooked the fact that the latter plate is simply an interradial with special function, while the azygous plate in *Baerocrinus* is as much radial as interradial. They both agree, however, in being absorbed by other plates; the azygous plate palæontologically by the right posterior radial and anal plate, the other in the growing animal over the whole surface.

composed of single quadrangular joints and destitute of pinnules; the ventral grooves lined by alternate plates. Form of the anus, ventral covering and length of arms unknown.

Remarks.—In our analysis, we have taken the absence of the right posterior radial to be a fixed character. It is, however, possible that this plate was exceptionally undeveloped in the type specimen, and in this case *Baerocrinus Ungerni*, the only known species of the genus, must be placed under *Hoplocrinus*.

1864. **Baerocrinus Ungerni** Volborth, Bull. de l'Acad. des Sci. de St. Petersburg of 1865, tome viii, p. 178, with plate (adv. sheet), November, 1864, p. 37.—Eichwald, 1859, described and figured under the name of **Homocr. dipentas** Lethæca Ross., v, p. 183; and 1865, Bull. de Moscou, iii, p. 160.—Volborth, 1865, **Baerocr. Ungerni,** Bull. de Moscou, iv, p. 442.—Eichwald, 1866, **Homocr. dipentas,** Bull. de Moscou, i, pp. 149–161, Pl. 8, fig. h.—Grevingk, 1867, **Baerocr. Ungerni,** Ueber **Hoplocr. dipentas** and **Baerocr. Ungerni,** with plate; also Arch. f. Naturk. Liv. Ehst. and Kurlands, Ser. I, vol. iv, p. 110.—Schmidt, 1874, **Hybocrinus dipentas,** Memoires de l'Acad. Imp. des Sci. de St. Petersb., Ser. vii, tome xxi, No. 11, p. 3, Pl. 1, Figs. 1–2.—P. Herb. Carpenter, 1882, **Baerocr. Ungerni,** Quart. Jour. Geol. Soc. London (August), pp. 298–312.—W. and Sp., 1883, **Baerocr. Ungerni,** Amer. Jour. Sci., vol. xxvi, November, p. 365.—Brandschiefer, Lower Silurian. Erras, Russia.

HOPLOCRINUS Grevingk.

1867. Grevingk, Ueber *Hoplocr. dipentas* and *Baerocr. Ungerni*, p. 9.
1867. Grevingk, Arch. f. Naturk. Liev.-Ehst. und Kurlands, Ser. I, vol. iv, p. 110.
1883. W. and Sp., Amer. Jour. Sci., vol. xxvi, November, p. 365.

Syn. *Apiocrinus*, 1843, Leuchtenberg; 1856, Eichwald.—*Homocrinus*, 1859, Eichwald.—*Hybocrinus*, 1864, Volborth; 1874, F. Schmidt; 1879, Zittel; 1882, Carpenter.

Volborth, F. Schmidt, Zittel and Carpenter have made *Hoplocrinus* a synonym of *Hybocrinus*, although they admit that the two forms differ in the construction of their azygous side. We have heretofore directed attention to the fact that the differences in the number and arrangement of the azygous and anal plates have been generally regarded as good characters for distinguishing genera, and especially among the *Cyathocrinidæ* and allied families in which those plates frequently form the only means for generic separation. That the one azygous plate in *Hoplocrinus* is equivalent to the two in *Hybocrinus*, which we have fully admitted, does not warrant an exception in this case, as the differences in the arrangement of the respective plates are evidently the result of modifications from one to another. We, therefore, accept Grevingk's genus, and give the following—

Generic Diagnosis.—General form pyriform, more protuberant upon the azygous side. Calyx composed of five basals, four large radials, and a large azygous plate. The latter with its left side extending to the upper margins of the four large radials, its sloping right side supporting the fifth radial, which is small and triangular, and, taken jointly with the azygous piece as one plate, the two resemble in form the four large radials, only that the arm-facet is pushed to one side.

Basals large, pentagonal, nearly equal in size. Four of the radials pentagonal, the smaller one subtriangular, resting upon the right sloping upper side of the azygous plate, which is irregularly pentagonal. Arm-facets occupying scarcely one-third of the width of the radials. Arms simple, without pinnules; composed of quadrangular joints, arranged parallel to each other. Column cylindrical.

The only known species is:

1843. **Hoplocrinus dipentas** Leuchtenberg (**Apiocrinus dipentas**), Beschreibung neuer Thierreste d. Urwelt von Zarskoje. Selo, p. 17, Tab. ii, figs. 9–10; also Eichwald, 1856, Bull. de Moscow, i, p. 115.—**Homocrinus dipentas,** 1859, Eichwald, Leth. Ross., v, p. 583, Tab. 31, figs. *a–c* (excl. specimen from Erras).—**Hybocrinus dipentas,** 1864, Volborth, Bull. d. l'Acad. de. St. Petersb., Tome viii, p. 178.—**Homocrinus dipentas,** 1865, Eichw., Bull. d. Moscow, No. iii, p. 159.—**Hybocrinus dipentas,** 1865, Volborth, Bull. de Mosc., No. iv, p. 443.—**Homocrinus dipentas,** 1866, Eichwald, Bull. de Moscow, No. 1, pp. 149–161, Tab. 8, figs. 2, 3, 4.—**Hoplocr. dipentas,** 1867, Grevingk, Uber, **Hoplocr. dipentas** and **Baerocr. Ungerni,** p. 10, figs. 1 *a–f*; also Arch. für Naturk. Liv. Ehst. und Kurlands (Ser. i), Vol. iv, p. 110.—**Hybocrinus dipentas,** 1884, Schmidt, Memoires de l'Acad. Imp. des Sci. de St. Petersb., Tome xxi, No. 11, p. 3, Pl. i, figs. 4, 5, 6; also Carpenter, 1882, Quart. Journ. Geol. Soc. London (August), pp. 298–312.—**Hoplocr. dipentas,** 1883, W. and Sp., Amer. Journ. Sci., Vol. xxvi (November), p. 365.—Vaginaten Kalk., Low. Silur. Pulkowa, Russia.

HYBOCRINUS Billings.

1857. E. Billings, Geol. Surv. Can. for 1853–56 (Rep. of Progr.), p. 275.
1859. E. Billings, Geol. Surv., Decade iv, p. 23.
1879. Zittel, Handb. d. Palæont., i, p. 350.
1879. W. and Sp., Rev. of the Palæocr., i, p. 74.
1880. Wetherby, Journ. Cincin. Soc. Nat. Hist. (July).
1882. Carpenter, Quart. Journ. Geol. Soc. London (Aug.), pp. 298–312.
1883. W. and Sp., Amer. Journ. Sci., Vol. xxvi, p. 365.

When we defined *Hybocrinus*, Rev., Pt. i, p. 74, we regarded it as synonymous with *Hoplocrinus* and *Baerocrinus*, which, we have since shown, are generically distinct. However, in our late paper in the Amer. Journal we made some remarks upon the azygous side, which must be modified. We asserted that the upper end of the anal plate possessed a peculiar crenulated surface, a structure which Wetherby had previously described, and which we thought we had observed also in some of his specimens. The fact that the so-called "crenulation" was visible, more or less, in every specimen which Wetherby had sent us for comparison, led us to believe that it was an organic structure, probably of a similar nature as the pectinated rhombs of the Cystidea. We are now satisfied that we had not sufficiently taken into consideration the peculiar state of preservation of Wetherby's specimens, which are not only highly silicified, but the surface of the plates is badly weathered, and more or less destroyed. Through the kindness and liberality of Mr. Walter Billings we are now enabled to give a more satisfactory interpretation of these parts. On receiving our paper he promptly informed us that in the Canadian species of *Hybocrinus* the azygous plate was not crenulated, but crowded by numerous, very small pieces, forming a short pyramid. He accompanied his description with good figures, and offered us his specimens for examination. In these we found, resting upon the upper side of the anal plates, several rows of minute subquadrangular pieces, about six to the width of the plate, which together form a tumular protuberance without any visible opening. There appear, however, minute pores along the sutures, and it is evident that the protuberance represents a ventral sac, reduced to its minimum size. The crenulated appearance in Wetherby's specimens is evidently the result of weathering, the apparent grooves representing the sutures between the small plates. A similar short protuberance has been observed in *Hybocystites*, and in all probability was present in the two other genera.

No new species of this genus have been described since our first discussion. We found several specimens in the Trenton limestone, near Knoxville, Tennessee, but none of them perfect enough for specific identification.

HYBOCYSTITES Wetherby.

(Revised by W. and Sp.)

1880. Wetherby, Cincin. Journ. Nat. Hist. (July).
1882. P. Herb. Carpenter, Quart. Journ. Geol. Soc. London, pp. 298–312.

Hybocystites combines, in a remarkable degree, some of the characters of Palæocrinoidea, Cystidea and Blastoidea. Wetherby describes it as a Cystid, Carpenter was more inclined to place it with the Blastoids; while we take it to be a Palæocrinoid of low organization.

There are several points in Wetherby's description with which we cannot agree. He describes the mouth or ambulacral orifice as situated nearly centrally upon the upper surface. We had several of Wetherby's best specimens for comparison, but were unable to observe in any of them an external oral orifice, and doubt if such an orifice existed in this Lower Silurian genus "upon the surface." Neither can it be ascertained from the specimens whether there were proximals surrounding the oral plate. Wetherby further speaks of "a valvular anal opening, placed between the upper azygous plate and the mouth," and he mentions "a proboscis or ventral sac" which was said to be "indicated by the presence of the upper azygous plate." If it is meant that the so-called "valvular opening" is separated from the ventral sac, and we infer it from fig. 1 on Plate 5, which shows an irregular break upon the ventral surface in the direction to which he alludes, he is certainly in error. Even if an opening did exist, we doubt if he could have observed small, valvular pieces in specimens in which even the larger ventral plates cannot be distinguished. If he means that the anal opening is connected with the ventral sac, placed along its inner or ventral side, we can partly agree with him.

Wetherby described the genus as having in three of its rays arms like those of the Crinoidea, in the other two rays appressed ambulacra, such as occur in the Cystidea. He does not say anything about the length of the three arms, leaving it in doubt, whether he took the three projections to be only the stumps of the arms, or as representing their full length. He only mentions that the arms are composed of a single row of plates, that they are very deeply excavated at the inner side by the ambulacral furrows, and that the latter are covered by a closely interlocking series of small plates, having the same arrangement as those of the two appressed ambulacra. He mentions further a more or less obscure furrow upon the outer surface, "of which nothing further is known."

Carpenter, in his paper on *Hybocrinus* and *Hybocystites*, called attention to the fact, that in Wetherby's figures, and in the specimens which he had examined himself, only one or two so-called arm joints were shown, that from appearances there had been no others, and that these formed, in all probability, "merely upward prolongations of the radials." He states further that the "more or less obscure furrow," seen by Wetherby upon the outer surface of each arm, was in reality a recurrent ambulacrum, and that in his opinion the relations of *Hybocystites* are rather with the Blastoids and "Crinoids than with the Cystids." Upon the latter point we cannot agree with him, although we admit that there are recurrent ambulacra in all five rays. We think, like Wetherby, that the ambulacra resemble decidedly those of the Cystids, and not those of the Blastoids. *Hybocystites* evidently had no hydrospires and no hydrospire pores, and the ambulacra, contrary to any of the Blastoids, extend beyond the radials down into the basals. Neither has it calicine pores, nor pectinated rhombs, and hence cannot be a Cystid, even if it has appressed ambulacra, which, we think, take the place of true arms.

Among the specimens from the Canada Survey Museum, which we had the good fortune to examine through the kindness of Prof. Whiteaves, we examined the type of *Lecanocrinus elegans* Billings (*Taxocrinus elegans* W. and Sp.), one of the earliest of all known Crinoids, and which seems to be destined to throw light upon the peculiar ambulacra of *Hybocystites.* This beautiful and well-preserved specimen has upon the outer or dorsal surface of its free arms, upon each one of them, from their tips as far down as the top of the secondary radials, in addition to their regular ventral furrows a recurrent dorsal furrow, such as is found in *Hybocystites* upon the calyx, and dorsally and ventrally upon the two arm joints. These dorsal furrows are indistinctly represented by Billings in Decade iv, Pl. 4, fig. 4 *a*, although in the specimen they are well defined, and it appears as if they had been lined by a double series of alternating plates. Such dorsal furrows have since been identified also in the type of *Taxocrinus lævis* by Walter R. Billings. That these furrows are continued from the ventral side, and as such form a part of the ambulacra, cannot be doubted, and is further proven by the fact that the furrows diminish in width as they descend the surface of the arms. In these species the regular furrows of the arms probably were not sufficient to supply the animal. This was certainly the case in *Hybocystites*, which in two of its rays has no brachial appendages whatever, and these consist in the three other rays of but a few joints, the ambulacra resting almost exclusively against the dorsal side of the calyx.

Hybocystites is one of the earliest and lowest forms of the Palæocrinoidea ; it may be regarded as a permanent larval form of *Hybocrinus*, which had no arms, but in their place food grooves upon the dorsal side of the calyx. It is interesting that in this case as in that of *Baerocrinus*, which has similar relations to *Hoplocrinus* as this has to *Hybocrinus*, three of the rays are somewhat higher developed than the two others.

We propose the following :—

Revised Generic Diagnosis.—*Hybocystites* agrees with *Hybocrinus* in its general form, the arrangement and proportions of the plates in the calyx, in the ventral covering, and in the form and size of the ventral sac, but differs from that genus essentially in the arm structure. It has no underbasals ; five large subequal basals, five radials, one of them much smaller and resting upon the right sloping upper side of the large azygous plate. The latter supporting at its left sloping side an anal plate, in form resembling the adjoining small radial. Arms rudimentary, of the most primitive kind, restricted to the two posterior rays and the anterior one. They consist, so far as known, of two quadrangular joints, which are united with the radials by close suture. The joints are provided with an ambulacral furrow, which enters the calyx apparently at the top of the radials as in *Hoplocrinus.* This furrow passes from the ventral side of the two arm joints, over the top of the upper one, and follows the dorsal side of the plates until reaching the calyx, whence it extends upon the surface of the radials to the basals, either entering them or terminating close to the basi-radial suture or along the face of the large azygous plate. The two antero-lateral rays have no arm plates whatever, but each is provided with an ambulacral furrow, passing out from near the top of the radials, traversing these plates, and entering the basals. There is considerable irregularity in their position and length, but as a rule these latter furrows enter deeper into the basals than those of the three other rays. The furrows are provided with two rows of side pieces which are arranged in the usual way.

Ventral sac short, as in *Hybocrinus*, provided along its ventral side with a small anal opening. Column circular, small.

The only known species is:—

1880. **Hybocystites problematicus** Wetherby, Cincin. Journ. Nat. Hist. (July). P. Herb. Carpenter, 1882, Quart. Journ. Geol. Soc. London (Aug.).—Trenton gr. Mercer Co., Ky.

Family XVIII.—HETEROCRINIDÆ Zittel.

(Emend. W. and Sp.)

Zittel and S. A. Miller included among the Heterocrinidæ the genera *Graphiocrinus* and *Erisocrinus*, which both have underbasals, and which differ essentially in the plates of the azygous side. We place in this family only *Heterocrinus*, *Iocrinus* and our new genera *Stenocrinus* and *Ohiocrinus*.

The Heterocrinidæ differ from the Cyathocrinidæ and Poteriocrinidæ in the absence of underbasals, in the arm structure, and the arrangement of their azygous plates.

In 1866, Hall thought he observed in *Heterocrinus* two rings of five pieces beneath the radials, and he adopted the term basals for those of the proximal ring, and that of subradials for those of the succeeding one. Afterwards, it was proved by Meek, Ohio Paleont., i, p. 2, that the so-called "basals"—proximal ring—were not plates of the calyx but parts of the column. He described the stem to be divided longitudinally, and the so-called "basals," which in their vertical range were said to correspond with the five segments of the column, as constituting the imperfectly developed uppermost stem joint. Meek proposed for these plates the name "subbasals," and called those of the next ring basals, while we used on Pt. I of the Revision the terms underbasals and basals, respectively, as we took all of them to be integral parts of the calyx.

We have lately given this subject careful consideration, and found by grinding the column in various species, that important differences exist among the species originally referred to this genus. We found that most of them have a pentapartite column, of which the five sections alternate with the basals without forming a part of the calyx, but that the column of *Heterocrinus simplex*, Hall's typical species, is tripartite, composed of three equal sections.

We have elsewhere shown that whenever the column is divided, its sections alternate with the proximal ring of plates in the calyx. They are placed interradially when those plates are underbasals, radially when they are basals, and as they have in *Heterocrinus* and allied genera a radial position, we may assert that these genera had no underbasals. The Heterocrinidæ occupy, owing to the absence of underbasals, relatively, the same position toward the Cyathocrinidæ and Poteriocrinidæ as the Actinocrinidæ and Platycrinidæ hold toward the Rhodocrinidæ. They agree with the Cyathocrinidæ and Poteriocrinidæ in having the azygous interradius extended into a porous ventral sac.

The arms consist of single joints, are comparatively strong, and either bifurcate or remain simple from above the brachials. The pinnules are given off not from alternate joints, but alternately from each second, third or fourth joint. They are heavy and long, and sometimes bifurcate near their tips. In the typical form of *Heterocrinus* always two joints are connected by syzygy, but we are unable to prove the syzygy in species referred by us to *Stenocrinus* and *Ohiocrinus*, unless by the pinnules which are given off regularly from every third or fourth joint. Most probably in *Iocrinus* and *Stenocrinus* the pinnules, and sometimes even their branches, were developed into regular arms, for the divisions follow each other alternately and at regular intervals, and the branches have no further pinnules.

The Heterocrinidæ agree with the Hybocrinidæ in the absence of underbasals, but differ essentially in the proportions of the calyx and ventral sac. In the former the calyx is extremely small, the ventral tube large; in the Hybocrinidæ, on the contrary, the calyx comparatively large and the sac small. They also differ in the structure of the arms, which in the Heterocrinidæ are more highly developed.

The structure of the ventral side has been observed only in "*Heterocrinus juvenis*," where it is composed of five comparatively large plates, which enclose a small oral plate. The ventral sac throughout the whole family is much stronger than in the Hybocrinidæ, reaching sometimes the tips of the arms, and it is profusely perforated.

Position, *Locality*, *etc.*—Confined to the Lower Silurian of America. The Heterocrinidæ, although forming a neat little group by themselves, may be considered as the forerunners of several types which afterwards became distinct families. *Heterocrinus* foreshadows the Belemnocrinidæ, *Iocrinus* the Poteriocrinidæ, while *Anomalocrinus* is a prophetic type for the Cyathocrinidæ.

1. HETEROCRINUS Hall (not Frass).

(Restricted and redefined by W. and Sp.)

1879. Revision Palæocr., Pt. i, p. 68.
1880. Wetherby, Cincin. Journ. Nat. Hist., July number.
1881. Wetherby, ibid., April number.

Heterocrinus, as defined by Hall and revised by Meek, contains so widely different species that a subdivision becomes necessary. This has been conceded by previous writers. Wetherby, in describing his *H. Milleri*, expressed the opinion that in the comparative size of the column, and in the plates of the calyx, that species differed sufficiently from *Heterocrinus simplex* to be separated at least subgenerically. And a year later, he directed attention to his *H. Vaupeli*, which he thought to be very distinct in the structure of its arms. *H. Vaupeli*, if it is a good species, which we doubt, agrees in its arms and pinnules closely with *H. constrictus* and *H. laxus*, with either of which it may be identical, but not with *H. simplex*, as suggested by S. A. Miller. The species heretofore referred to *Heterocrinus* vary in the composition of their radials, in the structure of arms and pinnules, and in the column. *Heterocrinus simplex*, Hall's type, has five basals of varying form, owing to irregularities in the radials. The radials in two of the rays consist of a large single plate, two others are divided into two sections, and the fifth one rests upon the azygous plate, which agrees in size with the lower half of the compound radials. The compound plates consist of two pieces each, which together, agree closely in form and size with the two single plates. The brachials are large; they consist of two nearly equal plates, united by syzygy, and support ten heavy, simple arms. The arms, to their full length, are composed of syzygial joints, which, as we think, were connected by suture and not by articulation. The epizygal or pinnule-bearing pieces are slightly wedge-shaped, and alternate with one another; the lower or hypozygal ones rhomboidal, and their upper and lower sides are parallel. Pinnules stout and comparatively long.

All other species heretofore referred to this genus, with the exception of *H. canadensis*, which may be identical with *H. simplex*, have a somewhat different arm structure. Not only are the pinnules given off at greater intervals, but they attain the size and form of arms or armlets, which sometimes branch again, and extend to the general height of the primary arms. The latter agree also in having a strictly pentagonal and pentapartite column, contrary to *H. simplex*, in which the column is stouter, almost circular, and regularly tripartite. The species with a quinque-partite column are divisible again into two groups, the one with a straight, comparatively small ventral tube, the other in which the tube is thread-like, convoluted, and even in its coiled state extending beyond the limits of the arms. We hold these differences important enough to make them the basis for another separation, proposing for the latter the genus *Ohiocrinus*, with *H. laxus* Hall = *Ohiocrinus laxus* as type, and for the other the genus *Stenocrinus* with *H. heterodactylus* Hall = *Stenocrinus heterodactylus* as type.

Heterocrinus inæqualis and *H. articulosus* Billings have been referred by us to *Calceocrinus; H. crassus* and *subcrassus* to *Iocrinus*.

The genus *Heterocrinus* thus restricted may be defined as follows:—

Revised Diagnosis.—Calyx small; subcylindrical; tapering but slightly from the column upwards.

Basals five, more or less unequal, without underbasals; the so-called subbasals of Meek representing the upper stem joint.

Radials very irregular, and varying among the rays in number as well as in size. There are two segments in the two antero-lateral rays, while the three remaining rays have but one, this, however, nearly as large as the two in the other rays. The two plates at the right postero-lateral side consist of the azygous piece—the lower one—and of the radial, which upon its upper side supports the brachials, giving off laterally a small ventral tube. Arms ten, composed of single joints, alternately united by syzygy, with strong pinnules from every second joint.

Column tripartite, almost circular; axial canal large, pentalobate, the lobes directed interradially.

Locality, Position, etc.—Trenton and Hudson River group of America.

1859. **Heterocrinus canadensis** Billings, Geol. Rep. Can., Decade iv, p. 48, Pl. 4, fig. 5.—Trenton limest. Ottawa and Montreal, Canada.

1843. **H. simplex** Hall, Geol. Repr. N. York, vol. i, p. 280, Pl. 76, figs. 2 a–d; also Geol. Surv. Ohio, Paleont. i, p. 7, Pl. 1, figs. 4 a–c, 5 a–b, 6 a–b.—Hudson River gr. Cincinnati, Ohio.

*1873. **H. grandis** Meek, described as **H. simplex** var. **grandis**, Geol. Surv. Ohio, Paleont. i, p. 9, Pl. 1, fig. 6, and figured by Hall as **H. simplex** in the 24th Rep. N. Y. State Mus. Nat. Hist.• Pl. 3, fig. 11.—Hudson River gr. Cincinnati, Ohio. **H. grandis** occurs at a higher horizon, is more robust and has shorter arm joints than **H. simplex**.

STENOCRINUS, nov. gen.

(Syn. *Heterocrinus* in part).

(*στενόσ*, narrow ; *κρίνον*, a lily).

Generic Diagnosis.—General form subcylindrical ; calyx small; arms long.

Basals five; of a more regular form than in *Heterocrinus*, angular at their superior margins. They form a cup, which spreads but little from the column upwards.

Radials irregular, consisting of one or two plates ; two of the rays—sometimes three—being composed of two segments each, the others of only one. The single plates are almost as large as any of the compound ones. Only four of the radials supported upon the basals ; the fifth one smaller, resting upon the truncate upper side of the azygous plate, and occupying toward the latter a similar position as the two sections of the compound radials toward each other. The smaller radial is transversely pentagonal, and resembles in outline a bifurcating plate. It supports upon its sloping right side the brachials; toward the left the ventral sac as in *Iocrinus*. Brachials generally four to each ray, the upper one axillary, and supporting the two main arms, which sometimes branch again, and give off at regular intervals, from alternate sides, strong, arm-like pinnules. All arm joints which have no pinnules are strictly quadrangular, while the pinnule-bearing joints have almost the form of bifurcating plates.

Axygous plate pentagonal, shorter than adjoining radials. Ventral tube, near the base composed of quadrangular, heavy plates, generally longer and narrower than the brachials. The structure of the tube in its upper portions not known. The plates of the ventral side have been observed only in *H. juvenis*, in which they are composed of five comparatively large interradial pieces, enclosing a small oral plate as in *Haplocrinus*. Column large, pentagonal, pentapartite, the sutures directed interradially, giving to the segments a radial position. Axial canal large, pentagonal; angles interradial.[1]

Geological Position, etc.—Stenocrinus is known only from the Silurian of America.

We refer to *Stenocrinus* the following species, all previously

[1] The columnar canal of *Stenocrinus* is correctly represented in fig. 12 of Pl. vi, not, however, in fig. 13, in which the rays should be directed interradially.

described under *Heterocrinus*, and noted under that genus in Rev. I, p. 70 :—

*__Stenocrinus heterodactylus,__ the type of the genus, and its variety *propinquus;* *__S. exilis__ Hall (not Meek); *__S. juvenis__; *__S. Milleri,__ and perhaps __Heterocrinus tenuis__ Billings.

To these we add :—

*1883. **Stenocr. bellvillensis** (W. R. Billings), **Heterocr. bellvillensis,** Ottawa Field Naturalist's Club, Trans. No. 4, p. 49 with plate.—Trenton limest. Bellville, Ont.

*(?) 1879. **S. geniculatus** (Ulrich), **Heterocr. geniculatus,** Journ. Cincin. Soc. Nat. Hist. (April), Pl. 7, fig. 13.—Utica Shale. Cincinnati, Ohio. This species differs too much from the other species to be left under **Stenocrinus,** but the only specimen which we examined was not sufficiently perfect to warrant a satisfactory generic description.

*1882. **S. pentagonus** (Ulrich), **Heterocr. pentagonus,** Journ. Cincin. Soc. Nat. Hist., p. 176, Pl. 5, figs. 10, 10 *a*.—Hudson River gr. Cincinnati, Ohio.

OHIOCRINUS, nov. gen.

(*Heterocrinus* Hall, in part.)

This form is closely allied to *Stenocrinus*, but differs from that in two points: the form of its arm appendages, and in the construction of its ventral sac.

The plates of the calyx are arranged as in *Stenocrinus*, and also the column is strong, pentangular and pentapartite. The arms, which are ten, do not bifurcate, and are provided with stout pinnules, given off alternately from every fourth or fifth plate. The pinnules are long, bifurcating, and extend to the tips of the arms.

The ventral tube rests upon the left sloping side of the right posterior radial; it ascends spirally, and in such a manner that adjoining convolutions touch each other, being perhaps suturally connected. It is composed of numerous hexagonal pieces, arranged alternately, and in longitudinal rows.

Column strong; indistinctly pentangular; pentapartite. The older stem joints are rather long pieces which have a well-marked pentapetaloid concavity upon their articular faces. The younger joints consist of five small convex leaflets, disconnected laterally, which fill the concavity of the older joints, exposing to view along the lateral face of the column a small trigonal piece. A similar, if not the same, columnar structure is found in *Stenocrinus*.[1]

[1] *Ohiocrinus* resembles *Stenocrinus* very closely, and can only be upheld by the form of the ventral tube. We never saw the appendage of *Stenocrinus*, but Mr. S. A. Miller claims it to be distinct, and this induced us to make the separation.

Geological Position, etc.—Restricted to the Lower Silurian of America.

We place in this genus the following species:

*1866. **Ohiocrinus constrictus** (Hall), **Heterocrinus constrictus,** 24th Rep. N. Y. St. Cab. Nat. Hist., p. 210; also Geol. Surv. Ohio, Paleont., vol. i, p. 3, Pl. i, figs. 10 *a b*; W. & Sp., Rev. I, p. 15.—Hudson River gr. Cincinnati, Ohio.

*1866. **O. laxus** (Hall).—Type of the genus.—**Heterocrinus laxus,** 24th Rep. N. Y. St. Cab. Nat. Hist., p. 211, pl. 5, fig. 15; also Geol. Surv. Ohio, Paleont., vol. i, p. 14, Pl. i, figs. 8 *a b*.—W. & Sp., Rev., I, p. 70.—Hudson River gr. Cincinnati, Ohio.

*1882. **O. œhanus** (Ulrich), **Heterocr. (Iocrinus) œhanus,** Journ. Cincin. Soc. Nat. Hist., vol. v, p. 175, Pl. 5, fig. 9.—S. A. Miller, 1883, **Heterocr. œhanus,** Cat. Amer. Palæoz. Foss. (Edit. ii), p. 283.—Hudson River gr. Cincinnati, Ohio.

IOCRINUS Hall.

1879. Revision of the Palæocr., Pt. I, p. 70.
1882. P. Herb. Carpenter, Quart. Journ. Geol. Soc. London, p. 306.
1883. W. & Sp., Amer. Journ. Sci., vol. xxvi (Novbr.), pp. 370, 376.

The genus *Iocrinus* must be slightly modified, as stated in our recent notes "on *Hybocrinus*, *Baerocrinus* and *Hoplocrinus*." In that paper, to which we refer for further particulars, we gave at some length the reasons which impelled us to regard the large plate, which we had formerly called a radial, as representing the azygous plate, and the smaller pentangular plate above, as the right posterior radial.

Walcott discovered lately a new generic form, for which he proposed the name *Merocrinus*. It agrees with *Iocrinus* in the structure of the azygous side, and would probably be identical with that genus if it had not well-developed underbasals. That underbasals are entirely absent in *Iocrinus* is plainly shown by its strictly pentagonal column, in which the angles have a radial position.

Revised Diagnosis.—Dorsal cup broadly spreading and perfectly symmetrical to the top of the second circlet of plates; it is short, and resembles an inverted pentagonal pyramid with the five sides deeply concave.

Basals small, nearly equal. Radials five, four of them of equal form and height, comparatively large, strong and pentagonal; their upper sides truncated throughout their entire width for the reception of the brachials. Adjoining these radials, in the same ring, is the azygous plate, which has not only the form but general appearance of the four radials. It supports upon its truncate upper side the fifth radial, that of the right posterior ray. The latter, which resembles in form a large bifurcating plate, supports upon its right upper side the brachials, and toward the left the first plate of the anal tube, being thus a radial, but partly with interradial functions. The radials in all five rays are followed by five to six brachials, the upper one bifurcating, the others quadrangular, all wider than long, and those of adjoining rays meeting laterally. These are succeeded by the regular arm plates.

Arms long, gradually tapering to the tips; bifurcating at regular intervals, and most of their branches bifurcating once or twice again; each division extending to the general height of the arms. Arm joints quadrangular, resembling those of the brachials, but somewhat narrower.

The ventral sac, at its posterior side, consists of a single row of rather large and strong plates, extending up to the full length of the sac, and forming all the way up a keel-like projection. In general appearance, these plates, which rest against the sloping side of a radial, resemble the brachials and arm plates, although they are somewhat higher and not as wide. Both sides of the ridge-like projection are indented for the reception of other plates. At each side there are two pieces connected to each median plate, one abutting against the middle part, and the other placed opposite the suture. These plates are very short and wide, longitudinally arranged; they are curved so as to form a deep transverse groove, their lower sides turned up and forming a transverse ridge. The plates do not meet horizontally, but have a narrow open space at the top of the ridge, which in perfect specimens is covered by a row of minute pieces, apparently with a pore or small opening at the place of juncture with the larger plates. The sac is composed of five rows of these plates, which are connected laterally by a straight suture all the way up.

Column strong, sharply pentagonal, its angles in a line with the radial plates.

We add the following species to our former list:—

1883. **Iocrinus trentonensis** Walcott, Adv. sheets of 35th Rep. N. Y. St. Cab. Nat. Hist., p. 4, Pl. 17, figs. 7, 8.—Trenton limest. Trenton Falls, N. Y.

FAMILY XIX.—ANOMALOCRINIDÆ W. and Sp.

ANOMALOCRINUS Meek and Worthen.

1879. Revision Palæocr., Pt. i, p. 72.
1879. S. A. Miller, Journ. Cincin. Soc. Nat. Hist. (Decbr., p. 6).
1882. S. A. Miller, ibid. (April, p. 14).

This genus differs from the Heterocrinidæ in the form of the calyx, which is depressed and not obconical, and in the arrangement of the pinnules. It agrees with them in the plates at the azygous side, which we misunderstood in our former description, and this renders a redescription necessary, which we substitute in place of our former one.

Revised Diagnosis.—General form depressed, calyx comparatively large, rather shallow, subglobose; arrangement of plates extremely irregular, scarcely two plates being of equal size.

Basals five, small, subequal, partly hidden by the column.

Radials irregular, all differing in size and form; simple or compound; sometimes divided vertically. The left antero-lateral radial is compound, composed of two pieces; that of the opposite side and the anterior radial are simple. The left postero-lateral radial is the largest plate in the calyx, and either simple or bisected vertically, composed of two nearly equal parts. The lower segment of the left antero-lateral radial is subquadrangular, the angle along the basi-radial suture being so obtuse as to form almost a straight line; upper side truncate and slightly convex. The upper segment is irregularly hexagonal, truncate above and below, much wider at the lower than at the upper side, widest across the lateral angles. The two together have almost the dimensions of the single radials, but, in place of being wider than high, they are higher than wide, with a narrow concavity for the reception of the brachials. The fifth radial—the right postero-lateral one—rests against the truncate upper side of a large azygous plate, and as this stands in line with, and has nearly form and proportions of the lower section of the compound radial, and the radial plate the form of its upper segment, the two appear in the specimen as if forming jointly another compound radial. (See Diagr. Rev. i, Pl. ii).

There is also among the rays a great diversity in the number of brachials, and this gives to the specimen that abnormal, irregular outline which is so characteristic of the genus. Some of the rays have two, others three brachials, while the right posterior ray has generally four or more.

Arms long; bifurcating at regular intervals; widely divergent, rather stout at their origin; tapering upward. They are composed of a succession of rather long, quadrangular pieces, interrupted only by the axillaries which are pentangular, and which divide the main arm, and each division of the arm, into two equal parts. The pinnules are slender, composed of long pieces, given off from every arm joint, but at one side only in succession—not alternately—until the next bifurcation of the arm, when on both divisions they all change to the opposite side. By this arrangement there are always 8 to 10 pinnules in succession, first on one side, then on the other. The first pinnule occurs on the second arm plate, not on the first, but every succeeding plate is pinnulated with the exception of the bifurcating ones. The proximal pinnule after each bifurcation is considerably heavier and longer, almost arm-like, and bifurcating, the others are simple. The arm furrows are shallow but wide, only one side having sockets for the reception of pinnules.[1]

The ventral sac is tubular, and rests upon the left side of the posterior radial as in the Heterocrinidæ. The proximal plate of the tube is large, subquadrangular, and is succeeded by other apparently large pieces. Of the plates at the ventral side little is known. S. A. Miller mentions two rows of small pieces near the ventral tube, but, as nothing is known as to their arrangement, they may be covering plates.

Column very large, almost circular, pentapartite, highly ornamented; central canal large, star-shaped, the projections located interradially. The structure of the column along the axial canal resembles that of *Barycrinus* and *Vasocrinus*, with which *Anomalocrinus* agrees also in the form of the calyx.

Geological Position, etc.—Lower Silurian of America. The only known species are: *Anomalocrinus caponiformis* Lyon, and *A. incurvus* Meek and Worthen, which have been previously noted.

Family XX.—BELEMNOCRINIDÆ S. A. Miller.

S. A. Miller has proposed for the genus *Belemnocrinus* a separate family, in which we fully agree. It cannot be placed in any of the other groups, without depriving them of their best distinctive characters. It forms a link between *Heterocrinidæ*

[1] Our descriptions of arms and pinnules in this interesting genus were made from a most beautiful specimen in the collection of J. H. Harris, Esq., of Waynesville, O., who had the kindness to send it to us for description.

and *Cyathocrinidæ*, resembling the former in the absence of underbasals and in the arm-structure, the *Cyathocrinidæ* in the arrangement of plates at the azygous side and of the ventral tube. As the most characteristic features we mention the extremely small visceral cavity, in which the genus resembles *Apiocrinus* of the *Neocrinoidea;* the comparatively large size of the basals; the absence of underbasals; the position of the azygous plate in line with the five radials; the large porous ventral tube, and the condition of the pinnules, which are given off regularly at certain intervals, not alternately from every joint.

Belemnocrinus was referred by White to the *Cyathocrinidæ*, and he described the calyx to be composed of three rings of plates. We have shown in 1877 that the part which he took to be the "basals" is the upper stem-joint, and that the dorsal cup consists of only two rings of plates. We further directed attention to the affinities between *Belemnocrinus* and the recent genus *Rhizocrinus*, which had been pointed out also by Pourtales, in the Memoirs of the Museum of Comp. Zoology, vol. iv, No. 9, p. 29. The construction of the dorsal cup in the two genera is very similar, however, in *Rhizocrinus*, the sutures between the basals are fused together; while in *Belemnocrinus* they are plainly visible, and the former has no anal plate and no ventral sac.

Belemnocrinus was placed by Zittel among the *Poteriocrinidæ*, although it has neither the arm structure nor the pinnules of that family, nor the azygous plate, and not even underbasals.

The name *Belemnocrinus* was used in 1876 by Munier-Chalmes (Jour. Conch., Ser. 3, vol. xvi, p. 102) for certain basal plates, evidently of a Blastoid, and changed by Oehlert to *Belocrinus*, 1882 (Extr. du Bull. Soc. Géol. de France, Ser, 3, p. 362).

BELEMNOCRINUS White.

(Pl. 5, figs. 10 and 11.)

1862. White, Proc. Bost. Soc. Nat. Hist., vol. ix, p. 14.
1866. Meek and Worthen, Proc. Acad. Nat. Sci. Phila., p. 251.
1868. Meek and Worthen, Geol. Rep. Illinois, iii, p. 463.
1877. W. and Sp., Amer. Jour. Sci. (April), p. 253.
1879. Zittel, Handbuch der Palæont., i, p. 362.

(Not *Belemnocrinus* Mun.-Chalmes = *Belocrinus* Oehlert.)

Generic Diagnosis.—Dorsal cup small, narrow, sometimes almost tubular.

Basals five, very large, long, narrow, of somewhat irregular shape, forming an ovoid to cylindrical cup. The cup is nearly solid, having only a small central canal, and a shallow subconical excavation at its upper end, the latter forming a part of the visceral cavity.

Radials five, always smaller than the basals, enclosing an anal plate. They are subquadrangular, slightly excavated at their upper side, and support four (exceptionally five) brachials, of which the upper one is bifurcating and gives off the arms. Arms two to each ray, simple throughout, composed of compound joints, with one or two syzygies in each joint; the upper segment giving off a strong pinnule. The oblique upper faces of the epizygal or pinnules-bearing joints are arranged alternately, and this gives to the arms a strongly waving, zigzag outline. At the extremities of the arm the pinnules are generally given off from every joint. Pinnules long, arm-like, bifurcating once or twice, like arms. With the arms the pinnules also correspond in length, all of them extending to the same height.

Anal plate resting between two of the radials and upon one of the basals. This plate, which resembles the radials in form, supports a large ventral sac, composed of numerous hexagonal plates, alternately arranged, with slit-like openings along their lateral edges, which meet with corresponding slits in the adjoining plates.

Other parts of the ventral side unknown. Column with or without lateral cirrhi; more or less sharply pentangular, the outer angles radial, the rays of the central canal and the columnar cirrhi directed interradially.

Geological Position, etc.—Known only from the two divisions of the Burlington limestone.

1877. **Belemnocrinus florifer** W. and Sp., Amer. Journ. Sci. (Ser. 3), Vol. xiii, p. 256.—Upper Burlington limestone. Burlington, Ia.

1877. **B. Pourtalesi** W. and Sp., Amer. Journ. Sci. (Ser. 3), Vol. xiii, p. 258.—Lower Burlington limest. Burlington, Iowa.

1862. **B. typus** White (type of the genus), Proc. Bost. Soc. Nat. Hist., Vol. ix, p. 14.—W. and Sp , 1877, Amer. Journ. Sci. (Ser. 3), Vol. xiii, p. 254.—Upper Burlington limest. Burlington, Iowa.

1866. **B. Whitei** Meek and Worthen, Acad. Nat. Sci. Phila., p. 251; also Geol. Rep. Illinois, iii, p. 463, Pl. 18, figs. 4 *a, b, c*.—Lower Burlington limest. Burlington, Iowa.

(?) HOLOCRINUS W. and Sp.

(ὅλος solid, κρίνον a lily.)

The above name is proposed to include a species which was lately described from rather imperfect specimens by Mr. Picard, under the name of *Encrinus Beyrichi*, but which certainly is no *Encrinus*. We entertain little doubt that the species must be referred to the Belemnocrinidæ; we are, however, not quite so sure that it is generically distinct from the typical form, which depends upon the presence or absence of the anal plate. No anal plate has been described in this species, and it is more than probable that none was present. It perhaps represents one of those transition forms, which in their earlier life were good Palæocrinoids, but by resorption of the interradial plates attained, to some extent, the characteristics of the earlier Neocrinoidea.

Generic Diagnosis.[1]—Dorsal cup strictly pentahedral; constricted above the basals. Basals large, forming an almost solid subglobular body, without underbasals. Radials very small, quadrangular, supporting three to four narrow brachials, the upper one bifurcating. There are two arms to each ray which remain simple. Arms thin, composed of short, cuneate joints, with rather stout pinnules.

Column pentangular, and, as in *Belemnocrinus florifer*, provided with long cirrhi, given off at intervals in whorls from the nodal joints, and extending up, and partly covering, the calyx and the lower portions of the arms.

The only known species is:

*1884. **Holocrinus Beyrichi** (Picard), W. and Sp., Zeitschr. d. Deutsch. geolog. Gesellsch., Jahrg. 1883.—Muschelkalk. Sondershausen, Germ.

FAMILY XXI.—CYATHOCRINIDÆ Roemer.

(Emended Zittel, emended W. and Sp.)

a. DENDROCRINITES.

MEROCRINUS Walcott.

1883. Adv. sheet 35th Rep. N. Y. State Cab. Nat. Hist., p. 2.

In the arrangement of the plates at the azygous side and in the construction of its ventral tube, this genus has close affinities with the Heterocrinidæ, but differs from them in having under-

[1] Our diagnosis is made from the figure of Mr. Picard's imperfect specimen.

basals. In addition to Walcott's typical species, we refer to *Merocrinus: Dendrocrinus curtus* Ulrich.

Generic Diagnosis.—Dorsal cup very small; short and extending laterally but little beyond the periphery of the upper stem joint.

Underbasals five, comparatively large, seen distinctly in a side view. Basals short, all hexagonal; alternating with four of the radials and the azygous plate, which all are of similar form, pentangular, wider than long. The four radials support upon their truncate upper face a row of brachials, the azygous plate from the same level the fifth radial. The right posterior radial has the same form as the azygous plate, but, while the latter is angular below, the radial has an angular upper side, giving off toward the left the ventral tube, and toward the right a row of brachials. There are generally six or more brachials to each ray, composed of short quadrangular pieces, except the upper which is axillary. Arms long, bifurcating; without pinnules; tapering toward the tips; composed of quadrangular joints. The bifurcations take place at regular intervals, and both arms of the same division are of equal size.

Column round, very strong, composed of unusually narrow joints.

Locality, Position, etc.—Lower Silurian of America.

*1879. **Merocrinus curtus** (Ulrich), **Dendrocrinus curtus,** Cincin. Soc. Nat. Hist., vol. ii (April), Pl. 7, fig. 14.—Utica shale. Cincin., O.

1883. **M. corroboratus** Walcott, Adv. sheet 35th Rep. N. Y. St. Cab. Nat. Hist., p. 4, Pl. 17, fig. 6.—Trenton limest. Trenton Falls, N. Y.

1883. **M. typus** Walcott, *Ibid.*, p. 3, Pl. 17, fig. 5.—Trenton limest. Trenton Falls, N. Y.

CARABOCRINUS E. Billings.

(Revised by W. and Sp.)

1856. E. Billings, Rep. Geol. Surv. Canada, p. 275.
1859. E. Billings, *Ibid.*, Decade iv, p. 30.
1879. W. and Sp. Revision I, p. 143.
1881. Walter R. Billings, Trans. Ottawa Field Natur. Club, p. 34.

In Part I of this Revision we placed *Carabocrinus* among the doubtful genera. It was founded by E. Billings upon certain peculiarities among plates of the azygous side, resembling otherwise closely *Cyathocrinus.* When Billings proposed the genus, the azygous side had been observed only in a single specimen, and as the plates were arranged very differently from those of other genera, we suspected that the type specimen was a malformed or recuperated *Cyathocrinus.* This view, however, must be given up, since other specimens have been found which show the plates under similar conditions. Mr. Walter R. Billings informed us, in 1880, of the discovery of two more specimens in which the azygous plates were arranged as in E. Billings' type. These specimens were afterwards noticed by him in the Transactions of the Ottawa Field Naturalist's Club of 1881, p. 35.

Carabocrinus was described by E. Billings—using our terminology—to be constructed of five underbasals, four of them pentagonal, the fifth hexagonal; five basals, three of them hexagonal, one heptagonal and one pentagonal, the latter smaller than the others; of five radials; three azygous plates, one of them supported upon the hexagonal underbasal, a second upon the small pentagonal basal, the third between two radials. Consulting the generic diagram, Decade iv, p. 30, we find that the small, pentagonal basal (subradial plate of Billings) has scarcely half the size of the other basals, and the first azygous plate is placed at its left side, contrary to all other Cyathocrinidæ. This structure seemed to us so improbable that before accepting it we applied to Prof. Whiteaves of the Canada Survey Museum for the type specimen. We now found that in Billings' diagram the plate in question is represented considerably larger than it is in the specimen, the so-called "azygous plate," to the left of the former, smaller, that the basals at their lower sides form in the specimen a much more obtuse angle, almost a straight line, and that the underbasals are comparatively smaller.

From our diagram it will be seen, that the second or basal ring really consists of six plates, four of them equal, the fifth one nearly as high but somewhat narrower, the sixth subquadrangular, small, not more than half the size of the former. That the latter piece which is united with the azygous plate by a horizontal suture is a basal—subradial of Billings—seems to us exceedingly doubtful, the more as the adjoining plate meets all the requirements of a basal. This plate, which Billings called the first azygous piece, and which we take to be the posterior basal in conformity with other Cyathocrinidæ, has an azygous plate at its right side, and this supports with its right upper sloping side a special anal plate. The small plate within the basal ring, which is only known in this genus, is, we think, a supplementary azygous plate of no fundamental importance, a plate bearing to the regular azygous plate similar relations as the small accessory interradials in some specimens of *Archæocrinus sculptus* to the regular interradials.

We offer the following :—

Revised Generic Diagnosis.—Underbasals five, of variable form and size; four of them quadrangular, but only three equal; the fourth one, that facing the azygous side, narrower; the fifth pentagonal, truncate above. *Carabocrinus* is closely allied to *Dendocrinus* and *Homocrinus*, but differs from both in the number and arrangement of its azygous plates.

Basals five, four of them hexagonal; the one toward the right of the azygous plates heptagonal; that on the left side somewhat smaller, truncate below, and occupying the full width of the upper side of the pentagonal underbasal.

Radials heptagonal, the upper side excavated for the reception of the brachials, which occupy about one-third the width of the plate. The brachials, so far as known, consist of two or sometimes three pieces, the upper one sharply wedgeform. Arms, compared with the size of the calyx, remarkably short; composed of quadrangular joints with parallel sutures; bifurcating; tapering gradually to their tips. The branching is similar to that of *Cyathocrinus*, and the arms throughout, as in that genus, are devoid of pinnules.

Plates at the azygous side three. A supplementary azygous plate rests between the basals and extends to half their height. The regular azygous plate is placed between the upper lateral portions of the five basals, and upon the supplementary piece; supporting with its left upper side the anal plate, with its right side the right postero-lateral radial. The anal plate resembles the radials in form and proportion, but its upper face is irregularly convex, and is bordered by a row of small pieces which form a part of the ventral tube.

Column comparatively small, obscurely pentangular, with a large, sharply pentagonal canal. The column is quinquepartite, the sutures arranged alternately with those of the underbasals.

Locality, Position, etc.—Known only from the Trenton limestone of Canada, but we found detached plates, apparently of this genus, in rocks of the same age near Knoxville, Tenn.

The following species have been described :—

1856. **Carabocrinus radiatus** Billings. Type of the genus, Geol. Surv. Canada, p. 276; also 1859, ibid. Decade iv, p. 30, Pl. 2, figs. 3 a–c; also W. and Sp., Revision i, p. 144.—Trenton limest. Ottawa, Can.

1859. (?) **C. tuberculatus** Billings, Geol. Surv. Can., Decade iv, p. 33, Pl. 10, figs. 2 a–c.—Hudson River. gr. Island of Anticosti.

1859. **C. Van Courtlandti** Billings, Geol. Surv. Can., Decade iv, p. 32, Pl. 2, fig. 4.—Trenton limest. Township of McNab, Can.

EUSPIROCRINUS Angl., Rev. I, p. 143.

AMPHERISTOCRINUS Hall.

1882. 11th Geol. Rep. Indiana of 1881 by Collett, p. 278.

This is one of the few genera of the *Cyathocrinidæ* which have only three underbasals, and this distinguishes it readily from *Homocrinus*, with which it agrees in the plates of the azygous side.

Generic Diagnosis.—Underbasals three, two equal and with truncate upper sides; the third one-half smaller, angular above. Basals five; two of them resting entirely upon the two large underbasals; pentagonal; the two alternating with them hexagonal; the posterior one, which has a truncate upper side, heptagonal. The latter is larger and supports toward the right a pentangular azygous plate; at its truncate upper side a large anal piece; along the left side a radial. The azygous plate is followed by the anal plate, which is laterally connected with the right posterior radial. The radials are pentagonal, with a small semicircular excavation for the reception of the arms. Only one brachial is known, which is quadrangular and extremely small. All other parts are unknown.

The only known species is :—

1882. **Ampheristocrinus typus** Hall, 11th Ann. Geol. Rep. Indiana by Collett, p. 278, Pl. 15, figs. 17–18.—Niagara gr. Waldron, Indiana.

DENDROCRINUS Hall, Rev. I, p. 75.

The following species must be added to our list :—

*1856. **Dendrocrinus angulatus** (Billings), **Palæocrinus angulatus**, Geol. Surv. Canada, p. 269; also Decade IV, Pl. 3, figs. 6 *a b*.—**Cyathocrinus angulatus**, Rev. I, p. 85.—Trenton limestone. Ottawa, Canada.—In examining the type-specimen in the Canada Survey Museum, we found it to be a good **Dendrocrinus**. Toward the right of the basals, underneath the postero-lateral radial, it has a good-sized azygous plate, which at its left sloping upper side supports an anal piece, exactly as in **Dendrocrinus**. The species has a strong ventral tube, of which only the transverse section is seen.

1881. **D. erraticus** S. A. Miller, Journ. Cincin. Soc. Nat. Hist. (December), 1881.—Hudson River group. Cincinnati, Ohio.

1880. **D. navigiolum** S. A. Miller, Journ. Cincin. Soc. Nat. Hist. (October), p. 4, Pl. 7, figs. 5, 5 *a*.—Utica slate. Cincinnati, Ohio.

1883. **D. retractilis** Walcott, 35th Rep. N. Y. St. Mus. Nat. Hist. (Extr. p. 5), Pl. 17, fig. 4.—Trenton limest. Trenton Falls, N. Y.

HOMOCRINUS Hall, Rev. I, p. 77.

This genus has been lately so often confounded with *Poteriocrinus*, that for better information, we point out their distinctive characters. *Homocrinus* differs from *Poteriocrinus* in the more slender form of the calyx, in having no plates of the ventral tube within the line of the first radials, in being provided with horseshoe-shaped articular facets, pierced by a round dorsal canal, and in having at least three brachials. Contrary to *Poteriocrinus*, the arms are not pinnulated, and they are composed of quadrangular joints with parallel lines of union. Its relations are much closer with *Parisocrinus*, which, however, has no separate dorsal canal, and the first plate of the tube rests within the calyx.

We add the following species :—

*1879. **Homocrinus ancilla** (Hall), **Dendrocrinus ancilla,** Trans. Albany Inst., vol. x (Abstr. p. 9); also 11th Geol. Rep. Indiana by Collett, p. 271, Pl. 15, fig. 19.—Niagara gr. Waldron, Indiana.

*1858. **H. curtus** (Müller), **Poteriocrinus curtus,** Verh. d. naturh. Verein f. Rheinlande xii, p. 80, Pl. 10, figs. 2–3; also Neue Echinod. Eifl. Kalk., p. 230, Pl. 2, fig. 3.—Schultze, 1866, Echin. Eifl. Kalk., p. 46, Pl. 5.—W. and Sp., **Parisocrinus curtus,** Rev. i, p. 115.—Devonian. Eifel, Germany.

*1882. **H. davisanus** (S. A. Miller), **Poteriocrinus davisanus,** Journ. Cincin. Soc. Nat. Hist., p. 226, Pl. 9, figs. 4, 4 a–b.—Upper Helderberg gr. Deputy, Indiana.

*1882. **H. nettelrothanus** (S. A. Miller), **Peteriocrinus nettelrothanus,** Journ. Cincin. Soc. Nat. Hist., p. 227, Pl. 9, figs. 5, 5 a.—Upper Helderberg gr. Deputy, Indiana.

*1876. **H. nucleus** (Hall), **Dendrocrinus nucleus,** 1st Edit. 28th Rep. N. Y. St. Mus. Nat. Hist., Pl. 15, figs. 7–9.—**Cyathocrinus nucleus,** 2d Edit. ibid., p. 136.—Niagara gr. Waldron, Indiana. The arrangement of the plates at the azygous interradius are not like in **Cyathocrinus** as Hall suggested, but exactly like in **Homocrinus.**

*1863. **H. polyxo** (Hall), **Cyathocrinus polyxo,** New Sp. Foss. Niagara group, p. 5; 28th Rep. N. Y. St. Cab. Nat. Hist. 1st Edit., Pl. 15, figs. 10–17.—Ibid. 2d Edit. p. 135; also W. and Sp., Rev. i, p. 87; 11th Rep. Indiana by Collett, 1882, p. 264, Pl. 14, figs. 10–17.—Niagara gr. Waldron, Indiana.

PARISOCRINUS W. and Sp., Rev. i, p. 115.

Closely allied to *Homocrinus* is *Parisocrinus*, which we made a subsection of *Poteriocrinus*. In doing so, we were not aware that this form is devoid of pinnules. In our descriptions we only pointed out the great resemblance which it has to *Cyathocrinus*, especially in the branching of the arms, but finding the azygous side constructed as in *Poteriocrinus*, we placed it with that genus. More perfect specimens which have since been discovered leave not the least doubt that it is very distinct from *Poteriocrinus*, and a true Cyathocrinoid.

Revised Generic Diagnosis.—General form turbinate. Underbasals large, equal. Basals five, three of them hexagonal; the two connecting with the azygous side heptagonal. The radials are rarely larger than the basals; four of them are equal, the fifth one has an additional side for the reception of the lower plate of the ventral tube. Articular face horseshoe-shaped, supporting a row of three brachials, of which the upper one is axillary. Arms composed of long slender joints, branching like those of *Cyathocrinus* and without pinnules. The azygous side is arranged as in *Poteriocrinus*, with three plates in the calyx. Ventral tube long, cylindrical, composed of alternately arranged rows of hexagonal pieces, with a pore at each angle. Column round.

Geological Position, etc. — Subcarboniferous. America and England.

We place here *Parisocrinus intermedius*, *P. nereus*, *P. perplexus*, *P. tenuibrachiatus*, *P. quinquangularis*, *P. radiatus* and *P. salignoideus;* but *Poteriocrinus curtus*, which we referred to it in Pt. I, p. 115, is a *Homocrinus*.

b. *Botryocrinites.*

ATELESTOCRINUS, nov. gen.

'ατελέστος, incomplete; κρίνον, a lily.

Pl. 6, fig. 4, and Pl. 9, fig. 4.

We have had, for several years, a very remarkable Crinoid from the Burlington limestone, which could not be placed in any of the established genera. At first we took it to be an abnormal specimen, with only four radials, and a small non-arm-bearing plate at the anterior side, and therefore did not describe it. It resembles *Belemnocrinus* in its general appearance, but differs in having underbasals, and curiously enough, these have a similar cylindrical form, and are as solid as the basals in that interesting genus.

We have since obtained from the Burlington and Keokuk transition bed near Burlington, and from the lower part of the Keokuk limestone proper of Tennessee, two additional specimens, clearly of the same genus, but of a different species. Both specimens show the same irregular structure, *i. e.*, four arm-bearing radials, and in line with them a small azygous, non-arm-bearing plate, thus proving that the apparent irregularity is a persistent character.

Generic Diagnosis.—Form of calyx elongate, bell-shaped, the sides concave, constricted along the suture between basals and underbasals. Underbasals five, large, forming an almost solid ovo-cylindrical body, pierced only by a longitudinal canal. Basals long and narrow, widening above, irregular in form; three of them hexagonal, two heptagonal. Radials four, of nearly equal size, with an obtuse facet covering the greater part of the width of the plate. Anterior radial non-arm-bearing. Like the regular radials, it alternates with the basals, has the same general height, but less than half their width. Brachials from two to four, exceptionally five; comparatively strong; with parallel articular lines, except the upper one, which is axillary. Main arms eight, which from every second joint, alternately, give off armlets, or arm-like pinnules of less than half the size of the main arms, but extending to the same height and branching. The arm joints, from which the branches are given off, are formed almost like axillary plates, one side, however, being shorter and slightly more obtuse. The alternate joints are quadrangular. Whether these and the axillaries are united by syzygy, could not be ascertained from the specimens.

Azygous plate large, resting between the upper sloping sides of two basals, and against the right posterior radial. It supports towards the left the anal plate, and at its truncate upper side the first plate of the tube. Nothing is known of the ventral side. Column obtusely pentangular, with a medium-sized central canal.

Attelesocrinus delicatus, nov. sp

Calyx bell-shaped; twice as high as wide, greatly constricted along the sutures between basals and underbasals. Underbasals forming a comparatively long ovo-cylindrical body. Basal cup funnel-shaped, resting upon the underbasals as if proceeding from their inner cavity. The basals are delicate plates, elongate, gradually increasing in width. Arm-bearing radials wider than high; each one supporting two brachials. The latter fill nearly the entire width of the preceding plate, and are twice as wide as the true arm plates. Anterior radial narrow, less than half the width of the arm-bearing radials. Arms two to the ray, tapering gradually to their tips, where they become extremely delicate; they have a waving outline, are composed of long joints, and give off armlets alternately from every second plate. All armlets extend to the tips of the arms, and branch once or twice. Their size along the lower part of the arms is only half that of the main arms, but higher up they are of almost equal thickness. Column obtusely pentangular.

Geological Position, etc.—Lower Burlington limestone. Burlington, Iowa.

Atelestocrinus robustus, nov. sp., Pl. 9, fig. 4.

Larger and much more robust than the preceding species; less constricted between basals and underbasals; the form of the latter, taken together, more oblate. Basals twice as long as wide. Arm-bearing radials heavy, wider than high; the anterior radial less than one-third the size of the others, hexagonal. Azygous side with four plates in the calyx, two of them constituting parts of the ventral tube; alternately arranged. Brachials four; three of them quadrangular, the upper one axillary; all rather large, but decreasing in size upwards. Arms long, comparatively heavy at the base, but tapering rapidly to the tips, where they become very delicate. They are composed of quadrangular, rounded joints, with parallel sutures, giving off armlets alternately from every second joint. The armlets are much thinner, and more pinnule-like than in *A. delicatus*, but extend like those to the height of the arms, and bifurcate in a similar manner.

Geological Position, etc.— Burlington and Keokuk Transition bed near Burlington, Iowa, and at the base of the Keokuk limestone, White's Creek Spring, near Nashville, Tennessee.

VASOCRINUS Lyon, Rev. i, p. 97.

STREPTOCRINUS W. and Sp.

στρεπτὸς, twisted; *κρίνον*, a lily.

Ophiocrinus Angelin, 1878. Rev. i, p. 97.

The name *Ophiocrinus* is preoccupied by Salter, who proposed it in 1856 for a Rhodocrinoid from Southern Africa, which, however, is not properly defined. Semper also used the name in 1868 for a Neocrinoid, and again Charlesworth, but without publishing the description. The Swedish form, therefore, requires a new name, for which we adopt *Streptocrinus*, in allusion to the convoluted state of the ventral tube.

***Streptocrinus crotalurus** (Angelin), **Ophiocrinus crotalurus**, Iconogr. Crin. Suec., p. 24, Pl. 4, figs. 8 a–c.—Upper Silurian. Gothland, Sweden.

BOTRYOCRINUS Angelin, Rev. I, p. 97.

SICYOCRINUS Angelin, Rev. I, p. 99.

BARYCRINUS Wachsmuth, Rev. I, p. 99.

The genus *Barycrinus* differs from other Cyathocrinidæ in having a shallow calyx, constructed of heavy plates, arms massive, and composed of short joints. These differences are so marked that we have strong doubts whether it ought to be placed in this family.

The diagram of *Barycrinus*, Pl. I, fig. 3, in Part I of this Revision, is incorrect as to the axial canal, which should have shown the processes *radial*, instead of interradial. On page 101, of Part I, we were made to say that the sections of the column of *Barycrinus* are radial and the sutures interradial, whereas it should be that the sections of the column are "*interradial* and the sutures *radial;* the opposite of *Heterocrinus*, in which they are interradial."

No new species have been described since our list, but *Arachnocrinus bulbosus* (Hall), W. and Sp., was referred by S. A. Miller erroneously to *Barycrinus*.

Cyathocrinus subtumidus M. and W., which we took to be a *Barycrinus*, must be changed back to *Cyathocrinus*. The species is closely allied to *Cyathocrinus barydactylus* W. and Sp.

c. *Cyathocrinites.*

CYATHOCRINUS J. S. Miller, Rev. I, p. 79.

Through the kindness of Prof. Whiteaves we had an opportunity to examine E. Billings' type specimens of *Palæocrinus* in the Canada Survey Museum. The specimen of *P. striatus*, upon which the genus was proposed, is very imperfect, and may be a *Carabocrinus*, *Dendrocrinus*, or a new genus. The construction at the ventral side, to which E. Billings attached so much weight, is that of the Cyathocrinidæ generally. They nearly all have ventrally five interradial plates resting against the radials, and alternate rows of covering plates. Heretofore we have placed *Palæocrinus angulatus* Billings under *Cyathocrinus*, but we satisfied ourselves from the original specimen that it is a true *Dendrocrinus.*—*Cyathocrinus fasciatus* Hall, is a synonym of *Macrostylocrinus Meeki*; *Cyathocrinus hamiltonensis* Worthen, a synonym of *Cyathocrinus parvibrachiatus* Hall. *C. nucleus* and *C. polyxo* Hall are now referred by us to *Homocrinus*; *C. waldronensis* to *Macrostylocrinus.*—*Cyathocrinus graphicus* Bigsby (not Hall) is *Platycrinus graphicus.*

1879. (?) **Cyathocrinus Harrisi** S. A. Miller, Journ. Cincin. Soc. Nat. Hist., vol. ii, Pl. 15, fig. 2.—Keokuk limest. Crawfordsville, Ind.

We leave this species for the present under *Cyathocrinus*, although aware that it represents a very different generic form. In some respects the species closely resembles *Belemnocrinus florifer*, and might almost be considered identical with it, if the column did not indicate a dicyclic base. The column of both species is sharply pentagonal, and beautifully fringed with whorls of cirrhi, but while in *Belemnocrinus florifer* the outer angles of the column are directed radially, the cirrhi interradially, the very opposite is the case in *Cyathocrinus* (?) *Harrisi.* Neither can the species be referred to our genus *Atelestocrinus*, as this is remarkable for its large underbasals, nor in fact to any other known to us, and we should make it the type of a new genus if the two specimens which we examined were more perfect. The specimen in the collection of Mr. Harris, which he had the kindness to send us for examination, leaves us in doubt whether the so-called azygous plate of Miller does not represent the anterior radial. Among the Fistulata the anterior ray very frequently supports a single arm, which either remains simple or branches on a level with the second bifurcation in the other rays, and this may be the case here. Miller in describing the species, we think, had in mind the Silurian genus *Iocrinus*, in which the plates of the ventral sac take the form of arm plates, but these are given off laterally from the azygous plate and not, as it would be here, from the truncated upper side of the anal piece.

1869. **Cyathocrinus inspiratus** (?) Lyon, Trans. Amer. Philos. Soc., vol. xiii, p. 457, Pl. 27, fig. k.—Keokuk gr. Crawfordsville, Ind. The description is not sufficient for specific identification.

1882. **C. marshallensis** Worthen, Bull. i, Ill. St. Mus. Nat. Hist., p. 33, Geol. Rep. Ill., vol. vii, p. 310, Pl. 30, fig. 4.—Kinderhook gr. Marshalltown, Ia. (A connecting link with **Parisocrinus.**)

*1844. **C. Milleri** McCoy (**Atocrinus Milleri**), Synops. Carb. Foss. Ireland, p. 123, Pl. 25; F. Roemer, 1855, Leth. Geogn. (2d Ed.), p. 246, Pl. 4, fig. 12; Bronn's Klassen d. Thierreichs, Pl. 28, fig. 6.—Subcarb. Ireland.

(?)1880. **C.** (?) **stillativus** White, Proceed. Nat. Mus. for 1879, p. 258, Pl. 1, figs. 9, 10; 12th Ann. Rep. Terr. for 1878, by Hayden (Author's Ed., p. 125, Pl. 35, figs. 3 a, b).—Carboniferous. Collected 30 miles west of Humboldt, Kansas. This is no **Cyathocrinus**; it evidently belongs to the Poteriocrinidæ, but the specimen is too imperfect to be referred properly.

*1865. **C. subtumidus** Meek and Worthen, Proceed. Acad. Nat. Sci. Phila., p. 151; **Barycrinus subumidus** Meek and Worthen, 1868, ibid., p. 340; also Geol. Rep. Ill., vol. v, p. 487, Pl. 13, fig. 3; W. and Sp.; **Barycrinus subtumidus,** 1879, Rev. i, p. 87.—Keokuk limest. Green Co., Ill., and White's Creek Springs, Tennessee.

1881. **C. Van Horni** S. A. Miller, Journ. Cincin. Soc. Nat. Hist., vol. iv (October), Pl. 6, fig. 3.—Niagara gr. Chicago, Illinois.

(?) SPHÆROCRINUS Roemer.

In referring *Sphærocrinus* to the genus *Cyathocrinus* (Rev. I, p. 83), we overlooked the fact that Roemer's type has separate dorsal canals piercing the radials. Whether this character is sufficient for generic distinction is a question which has never been brought up for discussion. It is in this regard worthy of notice that this structure occurs exclusively in species from the Silurian and Upper Devonian, never in the Carboniferous, neither in *Cyathocrinus* nor other genera. Whether all species of *Cyathocrinus* from Gothland and Dudley possess this structure, cannot be ascertained from the figures, but if they do, it may form the basis of a separation which seems to us very desirable. If the genus *Sphærocrinus* is accepted, it will probably include not only *Sphærocrinus geometricus* Goldfuss, Roemer's typical species, but many others.

ARACHNOCRINUS M. and W., Rev. I, p. 92.

In our former list we erroneously placed *Poteriocrinus pisiformis* Roemer under *Arachnocrinus*. From specimens which we obtained lately in western Tennessee, and in which the azygous side and also the brachials are preserved, we are convinced that it is a *Lecanocrinus*.

GISSOCRINUS Angelin, Rev. I, p. 89.

ACHRADOCRINUS Schultze.

1879. Zittel, Handb. d. Palæont., i, p. 364.
1866. Schultze, Echin. Eifl. Kalk., p. 101.

Schultze in defining this genus thought it to be closely allied to *Gasterocoma*, and Zittel and de Loriol place it among the Gasterocomidæ. In our opinion, the similarity between *Gasterocoma* and *Achradocrinus* is more superficial than real. *Gasterocoma* has five underbasals, and the column in addition to the axial canal is provided with four peripheral vessels, which are altogether unrepresented in the other form. The two agree only in the position of the anal aperture. The affinities of *Achradocrinus* are much closer with *Sphærocrinus*, from which it differs only, as far as known, in the position of the anal plate.

Generic Diagnosis.—Dorsal cup deeply cup-shaped; symmetry decidedly bilateral. Underbasals five, equal, of medium size, extending beyond the column, and visible in a side view. Basals five, four of them angular above, the posterior one truncate, and supporting an anal plate. Radials all meeting laterally, three of them equal; the two postero-lateral ones deeply excavated for the reception of the anal plate, which they inclose on three sides by meeting above. The radials are slightly notched at their upper margin, and have upon the outer side of the plate a narrow, horseshoe-like articular facet, pierced by a small dorsal canal, which is located at some distance from the notch. At the azygous side there is only an anal plate, which is subquadrangular, its lateral margins arched, its upper face narrower and excavated for the ventral sac, which is cylindrical and placed between this plate and the lateral extensions of adjoining radials. The tube has a ventral position owing to the strongly inflected upper portions of the radials. Arms unknown. Column circular; with a small central canal.

The only known species is:

1866. **Achradocrinus ventrosus** Schultze, Echin. Eifl. Kalk., p. 101, Pl. 12, fig. 6.—Devonian. Eifel, Germany.

CODIACRINUS Schultze.

1866. Schultze, Monogr. Echin. Eifl. Kalk., p. 31.
1879. Zittel, Handb. d. Palæont., i, p. 364.

Codiacrinus is closely allied to *Achradocrinus;* the anal plate, however, is here, we think, fully resorbed by the radials, and the basals consist only of three plates.

Generic Diagnosis.—Of small size; in the form of a poppy-head, reversed bell-shaped, or subovoid. Plates thin. Symmetry strictly pentamerous.

Underbasals three, forming a pentagon; two of them larger and hexagonal, the third smaller and rhomboidal. Basals equal, pentangular. Radials equal; all touching laterally; upper face concave, with a narrow semicircular lateral articular facet for the reception of the brachials, and with a separate dorsal canal. There is no anal plate in the dorsal cup. Nothing is known of the ventral side, nor of the arms.

The only known species is:

1866. **Codiacrinus granulatus** Schultze, Monogr. Echin. Eifl. Kalk., p. 31, Pl. 3, fig. 9.—Devonian. Eifel, Germany.

LECYTHIOCRINUS White.

1880. White, Proceed. Nat. Mus., p. 256.
1880. White, 12th Ann. Rep. Terr. for 1878 by Hayden, p. 122.
1880. Worthen, Bull. i, Illinois St. Mus. Nat. Hist., p. 37.
1880. Worthen, Illinois Geol. Rep., vol. vii, p. 317.

This name must not be confounded with *Lecythocrinus*, Müller, which represents a very different generic form. The adoption of such similar names, even if permitted by the generally accepted rules, should be avoided. The species for which it was proposed agrees in the arrangement of its calyx plates with *Codiacrinus*, except the articular facet of the radials, which is wider, directed upwards (not obliquely as in that genus), and it has distinct ligamentous fossæ, but apparently no central canal.

1882. **Lecythiocrinus Adamsi** Worthen, Bull. I, Ill. St. Mus. Nat. Hist., p. 37; also Geol. Rep. Ill., p. 317, Pl. 30, fig. 8.—Coal measures. Peoria Co., Ill.

1880. **L. olliculæformis** White, Proc. Nat. Mus. for 1879, p. 256, Pl. 1, figs. 4, 5.—12th Ann. Rep. Terr. by Hayden, for 1878, p. 124, Pl. 35, figs. 2 *a*, 6.—Coal measures. Near Humbold, Kansas.

Family XXII.—POTERIOCRINIDÆ.

It has been stated that the distinction between Poteriocrinidæ and Cyathocrinidæ is based principally upon their different mode of articulation. The articulation, however, in the Poteriocrinidæ undergoes certain modifications, and toward the close of the Carboniferous even the calyx begins to show signs of being capable of slight expansion, if not mobility, the plates being frequently provided with a fossa along their margins; while in others the plates are united by syzygy. Those fossæ which extend over the whole surface of the opposed faces not only occur between the radials, but extend in a vertical direction to the basi-radial suture. That they lodged bundles of ligament is almost beyond doubt, and Dr. P. H. Carpenter, whom we consulted on this subject, regards this union as a suture, but "less close, with longer ligaments, and therefore more expansible and movable, than in an ordinary suture." A syzygial union is found among the species which Trautschold referred to the genus *Cromyocrinus*, and seems to extend in some of them even to the suture between basals and underbasals, the striation being plainly visible along the suture lines. In some of these genera the articulation between brachials and arm plates is as highly differentiated as in most of the Neocrinoidea, and much more so than in some of them.

The progressive development in the mode of articulation that takes place from the earlier to the later Poteriocrinidæ is, no doubt, of some classificatory value, but we have not been able, as yet, to separate them on this ground, as the respective parts are generally in an imperfect state of preservation, and there appear to be no other distinguishing characters. Moreover, a comparison of the earlier Poteriocrinidæ, such as *Scytalocrinus*, *Scaphiocrinus*, *Pachylocrinus*, *Cœliocrinus* and *Graphiocrinus*, with the latter genera *Eupachycrinus*, *Zeacrinus*, *Hydreionocrinus*, *Ceriocrinus*, *Erisocrinus*, and of the latter with *Encrinus*, shows that the two sections shade into one another by such easy gradations, that in many cases it is absolutely impossible to draw a dividing line.

The genera of the Poteriocrinidæ are principally based upon the arrangement of the plates at the azygous side, the form of the calyx, the proportionate size of the ventral sac, and the branching of the arms. Some of the genera have a well-developed azygous plate, a special anal piece, and one of the plates supporting the ventral sac enclosed within the calyx. Others, such as *Graphiocrinus* and *Ceriocrinus*, have no azygous plate, but only an anal piece; while in *Erisocrinus*, *Stemmatocrinus* and *Encrinus* no such plate is found, either within the ring of radials or below. In the same degree as palæontologically the calyx grows more symmetrical, the ventral sac decreases in size, and probably disappeared entirely in *Encrinus*, which is closely allied to the Poteriocrinidæ. Along with these modifications, others are going on which take place in the arms. Throughout every genus, a development goes on from the uniserial to the biserial arm structure, a feature which has not been observed in any other family of the Fistulata, and which has no parallel throughout the Neocrinoidea if we exclude *Encrinus*, which we regard as a somewhat higher developed Poteriocrinoid. *Encrinus*, especially, offers in its arm structure a very striking example. Among its species are found arms in all stages of development, some having single quadrangular joints, others two rows closely arranged. The same variations are found in the arms of *Eupachycrinus*, *Ceriocrinus* and *Erisocrinus;* while in the earlier Poteriocrinites the arms never pass beyond the interlocking stage. That the biserial arm structure was developed from single cuneate joints, and not only palæontologically, but also in the growing animal, we had opportunity to observe in a very young *Encrinus liliiformis*, in which the arms, to about two-thirds their height, are composed of single joints, which gradually become more cuneate, and toward the tips are interlocking. This one case, we think, alone would be sufficient evidence to prove that the biserial arm structure is the higher form, if it was not confirmed by other specimens of this and other groups. If *Encrinus* were a Neocrinoid, as supposed by Zittel, De Loriol and Carpenter, the Neocrinoidea would begin their existence with the highest differentiated arms known to us, and the arms of all other Neocrinoidea up to the Comatulæ of the present seas, would appear to have remained persistently in their larval state. This does not seem to us to favor the idea of *Encrinus* being a Neocrinoid.

Comparing *Erisocrinus* with *Encrinus*, the only noticeable difference in their fossil state is the presence of a single brachial in the former, and two in the latter. To this P. H. Carpenter alluded (Chall. Rep., p. 154), admitting it to be "the only point of difference about which we are enabled to speak with certainty." This character, however, is not restricted to *Encrinus*; we find it more or less among all Poteriocrinidæ, but exclusively there and in the Encrinidæ. The two brachials are always joined by suture, not by articulation, and this is the case in *Encrinus*, in which the two pieces are united by syzygy and form actually one plate. The compound brachial is scarcely more than a specific character, and hence has no value as a distinction between two orders.

Carpenter takes not only *Encrinus*, but also *Erisocrinus* and *Stemmatocrinus* to be Neocrinoidea, because they have no anal plate. Anal plates, he states, "are absent in *Erisocrinus* as in *Encrinus*, and since a ventral tube or sac like that of *Cyathocrinus* is always found associated with a system of anal plates, the lowest of which is intercalated between two radials, it seems rash to postulate its presence in the symmetrical *Erisocrinus*." That our conclusions were not so "rash" as Carpenter suggested is emphatically proved by the fact that an anal plate has actually been discovered by Dr. White in *Erisocrinus*. It is located above the radials, being enclosed among the interradial plates, where we should have expected it from analogy with other groups. Anal plates are absent also in two genera of the Cyathocrinidæ, in *Codiacrinus* Schultze, and *Lecythiocrinus* White, which both have a perfectly symmetrical dorsal cup. But does that make them Neocrinoidea? What more do we know of the ventral structure of the Poteriocrinidæ than of *Encrinus* and *Erisocrinus*? If *Encrinus* is a Neocrinoid, why not all Poteriocrinidæ? Nobody ever saw the ventral covering in any Poteriocrinoid—we have only found the ventral sac. Yet from analogy with *Cyathocrinus* and allied forms in which a vault has actually been observed, it was generally supposed that vault plates were present also in the Poteriocrinidæ. We think the width of the brachials, which in this family frequently occupy the entire width of the radials, gives a satisfactory explanation why the vault plates are not preserved in forms like these. The plates either rested against the sloping edges of the radials as in *Stemmatocrinus Trautscholdi*, or only against their articular extensions as in *Symbathocrinus*. It is even very possible that the interradials were partially or wholly resorbed by the muscular processes of the radials, as these became developed in the growing Crinoid.

The subdivisions of *Poteriocrinus*, which we proposed, have been accepted by Wetherby and Williams, but ignored by S. A. Miller and Prof. Worthen.[1]

Extensive collections made by us during the last two years, enable us to give additional information respecting these divisions. *Parisocrinus* proves to be not only a good genus, but, moreover, is a Cyathocrinoid, having no pinnules. *Pachylocrinus* is closer allied to *Zeacrinus* than to *Poteriocrinus*, and is probably identical with *Philocrinus.* De Koninck described this genus with a monocyclic base, and the calyx strictly pentahedral, but from appearance it had underbasals and azygous plates, and is identical with *Pachylocrinus.* We have redefined *Scytalocrinus* and *Decadocrinus*, which should both be ranked as subgenera under *Poteriocrinus*, and likewise *Scaphiocrinus.*

Mr. Percy Sladen, in a paper "On the genus Poteriocrinus and allied forms" (read before the Geol. and Polyt. Soc. at Yorkshire in 1877), separated the English Carboniferous Poteriocrinites into four groups: *Poteriocrinus*, *Dactylocrinus*, *Scaphiocrinus* and *Zeacrinus.* To the typical form he referred: *P. crassus*, *P. spissus*, *P. conicus. P. plicatus*, *P. impressus*, *P. radiatus* and *P. quinquangularis.* We agree with him as to the first four species, but we think the last three are Cyathocrinidæ and should be referred to *Parisocrinus.* Mr. Sladen, unfortunately, figured

[1] S. A. Miller, in the 2d Ed. of his Catal. of Pal. Foss., called them "subgenera of doubtful utility." Prof. Worthen gives the following reasons for refusing their acceptance (Bull. i, Illinois St. Mus. Nat. Hist., p. 4): "First, I see no beneficial result that is likely to come from cumbering the nomenclature of paleontology with such terms, and secondly, because any proposed subgeneric formula that groups together such diverse forms as *Zeacrinus maniformis* Y. and Sh., and *Poteriocrinus Biselli* Worthen, can be of no practical advantage in the study of this group of Crinoids, and hence, until some satisfactory generic characters can be pointed out by which they may be separated, it seems advisable to include them all under the generic name originally proposed by Miller for them." If our good friend had read our paper more carefully, he would have observed that we proposed our six subdivisions of *Poteriocrinus* with the distinct statement that we "scarcely deemed the characters upon which they are based sufficiently important even for subgeneric separation," and that we alluded in detail to the difficulty of referring the "*Zeacrinus*" *maniformis* to any of the sections. In proposing these subdivisions, however, we only followed the suggestion of Meek and Worthen in 1869 (Proc. Acad. Nat. Sci. Phila., p. 138 and note), where, after defining *Scaphiocrinus*, *Zeacrinus* and *Cœliocrinus* as subgenera under *Poteriocrinus*, they add, under the head of *Scaphiocrinus:* "The group, however, has been extended by Prof. Hall and others so as to include species presenting all the characters given above, and might be divided into several sections, distinguished from each other and from the

Parisocrinus radiatus to illustrate the genus *Poteriocrinus*, a species without pinnules, with the arms of a *Cyathocrinus*, but with a *Poteriocrinus* arrangement of azygous plates. Under *Dactylocrinus* he included *P. tenuis*, both of Miller and Austin, *T. isacobus* and *P. rostratus*, Austin (pars), Monogr. Rec. and Foss. Crin. Pl. 9, figs. 2 b, c (non 2 a, d). Comparing Austin's *P. tenuis*, which Sladen redescribed as *Dactylocrinus loreus*, with "*Poteriocrinus*" *radiatus*, there appears to be considerable difference between the two forms, but comparing it with *P. crassus*, Miller's typical species, the difference is not so very great. Austin's figure apparently was made from a very young specimen, as indicated by the unusually long arm joints, and it may be a somewhat aberrant form of *Scytalocrinus*. Sladen's name *Dactylocrinus* would have priority over *Scytalocrinus*, had not Quenstedt in 1876 used the same name for a different form. *P. isacobus* is, in our opinion, a good *Poteriocrinus*. Sladen refers to *Scaphiocrinus: P. latifrons*, Austin, which we take to be a *Pachylocrinus;* and to *Zeacrinus: Cupressocrinus impressus* (*Cupressocrinus calyx*, McCoy); *Poteriocrinus McCoyanus*, and *Zeacrinus Phillipsi*. We agree with him as to the latter species, but we doubt if the other three are sufficiently known to assert whether the calices belong to either *Zeacrinus*, *Eupachycrinus* or *Hydreionocrinus*.

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typical form, on quite as good characters as those distinguishing the latter from *Zeacrinus*." At the time of J. S. Miller the genus *Poteriocrinus* was fully sufficient to hold every species then known, but for each species then known one hundred have been discovered since.

When we attempted to revise the Poteriocrinites we found a confusion such as existed in no other group of the Palæocrinoidea. The subdivisions that had been proposed were so indistinctly defined, and contained such diverse elements, that they rather increased the difficulty instead of diminishing it. As a temporary remedy we proposed our subdivisions, and expecting they would eventually prove to be distinct genera, we applied to them at once generic names. It was at the option of Prof. Worthen to accept these divisions or not, but in adding some fifty or more species to the three hundred already described, he surely would have aided in the identification of his species, and science generally, by referring them to those groups. This would have lightened the labors of others, who are now compelled to look up for comparison every one of his species. Besides, if Prof. Worthen had consulted the Revision, he might have avoided a number of synonyms, which "cumber the nomenclature of paleontology" more seriously than those few systematic names. It is somewhat curious that after refusing to accept the subgenera proposed by us and Prof. Hall, Prof. Worthen repeatedly employs the specific names which had already been used by previous writers in one or the other of those subgenera.

a. *Poteriocrinites.*

POTERIOCRINUS J. S. Miller.

Rev. I, p. 111.

Dorsal cup obconical; plates delicate and frequently covered with wrinkles or radiating plications. Radials with a semicircular scar, facing outward, and provided with a transverse articular ridge. Brachials one; laterally constricted; sutures gaping. Arms long and branching; composed of wedge-formed plates. Ventral sac long, constructed of six longitudinal rows of short transverse plates forming a tube; one of these rows resting upon the anal piece, another upon the third azygous plate. The plates of the tube, which are heavier along their median line, are provided laterally with transverse ridges or plications, which all have long open slits along their margins. Column circular.

We add the following species to our list:

1882. **Poteriocrinus Clarkii** Williams, Proc. Acad. Nat. Sci. Phila., p. 21, Pl. 1, fig. 4.—Chemung gr. Steuben Co., N. Y.
Var. alpha, ibid., p. 22, Pl. 1, fig. 5.—Chemung gr. Ithaca, N. Y.

1882. **P. cornellianus** Williams, Proc. Acad. Nat. Sci. Phila., p. 18, Pl. 1, figs, 1, 2, 3.—Chemung gr. Ithaca, N. Y.

1836. **P. impressus** Phill. (not McCoy, 1854 = **Hydreionocrinus McCoyanus,** nor Richter and Unger, 1860). Geol. Yorkshire, p. 205, Pl. 4, fig. 1.—Austin, 1843, Rec. and Foss. Crin., p. 10, fig. 6.—W. and Sp., Rev. i, p. 120.—Sladen, 1877, On the Genus Poteriocrinus, p. 8.—Bristol, England.

1882. **P. otterensis** Worthen, Bull. i, Ill. St. Mus. Nat. Hist., p. 14: also Geol. Rep. Illinois vii, p. 283, Pl. 28, fig. 4.—Otter Creek, Jersey Co., Ill.

Species having the characters of the Poteriocrinites, but not sufficiently known to be referred to the proper genus:

P. æmulus Hall, 1879, Eleventh Indiana Rep., p. 266, is probably a **Homocrinus** (?).

1880. **P. anomalos** Wetherby, Journ. Cincin. Soc. Nat. Hist. (July), p. 15, Pl. 5, fig. 6.—Kaskaskia gr. Pulaski Co., Ky.—This is one of the most perplexing species of this group. It agrees neither with **Graphiocrinus,** nor **Decadocrinus,** nor **Scaphiocrinus,** nor **Eupachycrinus,** and really shades into all of them.

1882. **P. arachnæformis** Worthen, Bull. i, Ill. St. Mus. Nat. Hist., p. 13, Pl. 28, fig. 12: also Geol. Rep. Illinois, vii, p. 281, Pl. 28, fig. 12.—Keokuk limest. Warsaw, Ill.

P. Bockschii Geinitz. Only known to us from quotations.

P. calyx Hall, 1879 (non De Koninck, 1853), is only defined from basal plates.—Niagara gr.

1882. **P. clytis** Worthen, Bull. No. 1, Ill. St. Mus. Nat. Hist., P. 16 (not **P. clytis** on p. 25); also Geol. Rep. Ill., vii, p. 294, Pl. 30, fig. 10.—St. Louis limest. Monroe Co., Ill.—A very young specimen, as seen by the form of the brachials and arm joints; it probably had 10 arms in its adult state.

1849. **P. crassimanus** McCoy (not **P. crassimanus** Eichw.), Ann. and Mag. Nat. Hist. (Ser. ii), vol. iii, p. 245.—Contrib. Palæont., p. 106.—Carboniferous, Derbyshire.

1882. **P. illinoisiensis** Worthen, Bull. i, Ill. St. Mus. Nat. Hist., p. 10; also Geol. Rep. Illinois, vii, p. 289, Pl. 28, fig. 17—Warsaw limest. Warsaw, Ill.

1844. **P. inequidactylus** McCoy, Carboniferous Foss. Ireland, p. 179, Pl. 26, fig. 8.—Carboniferous. Ireland.

P. minimus Austin (not Ad. Roemer) is probably a synonym of **Scaphiocrinus isacobus.**

1882. **P. similis** Worthen, Bull. i, Ill. St. Mus. Nat. Hist., p. 23; also Geol. Rep. Illinois, vii, p. 295, Pl. 30, fig. 12.—Kaskaskia limest. Monroe Co., Ill. This is evidently a young specimen, probably of one of the other species.

1882. **P. validus** Worthen, Bull. i, Ill. St. Mus. Nat. Hist., p. 18; also Geol. Rep. Illinois, vii, p. 287, Pl. 28, fig. 16.—Warsaw limest. Warsaw, Ill.

SCAPHIOCRINUS Hall, Rev. I, p. 112.

(Emend. W. and Sp.)

Dorsal cup obconical to semi-ovoid; all its plates closely united by suture. Radials truncate above, the articular ridge filling almost the entire width of the upper face. Brachials long, simple or compound, similar in form to the radials but truncate below; line of articulation gaping. In species with compound brachials, the two segments have the form and proportions of the one plate in the others, and are joined by suture. Arms long, branching; arm joints rather long, wedge-form. Azygous side as in *Poteriocrinus.* Column obtusely pentagular.

Poteriocrinus Jesupi Whitfield, Amer. Mus. Nat. Hist. N. Y., Bull. i (Decbr., 1881), is evidently a synonym of *P. Swallovi* M. and W. (compare Ill. Rep., ii, Pl. 16, fig. 4), although Whitfield thinks it distinct in the bifurcation of the arms, and in the number and arrangement of the anal plates. In the type specimen of *P. Swallovi* only two bifurcations of the arms were preserved, and Meek and Worthen remarked on p. 84, that the arms in the upper parts "seemed to be simple" in this species. The latter is not confirmed by our specimens, of which many have arms and ventral sac beautifully preserved; they all show essentially the same bifurcations as Whitfield's specimen. Slight variation in the number of arm joints in one of the bifurcations cannot be regarded as a good specific character, and even an additional division of the arms may take place in the same species. The apparent variation in the number of "anal" plates is explained by the fact that in the type of *P. Swallovi* the arms accidentally cover the lower portion of the ventral sac, exposing to view only four plates; while in Whitfield's specimen a much greater portion of the ventral sac is visible.

The following species are to be added to our former list:

a. *With simple brachials.*

*1882. **Scaphiocrinus kaskaskiensis** (Worthen), **Poteriocrinus kaskaskiensis,** Bull. i, Ill. St. Mus. Nat. Hist., p. 27; also Geol. Rep. Ill., vii, p. 300, Pl. 30, fig. 15.—Kaskaskia limest. Near Chester, Ill.

*1882. **S. latidactylus** (Worthen), **Poteriocrinus latidactylus,** Bull. i, Ill. St. Mus. Nat. Hist., p. 8; also Geol. Rep. Ill., vii, p. 275, Pl. 28, fig. 6.—Keokuk limest. Hamilton, Ill.

*1884. **S. obscurus** W. and Sp. (**Poteriocrinus tenuidactylus** Worthen), Bull. i, of the Ill. St. Mus. Nat. Hist., p. 6 (not p. 10; nor **Pot.** [**Scaph.**] **tenuidactylus** M. and W., 1865); also Geol. Rep. Illinois, vii, p. 271, Pl. 28, fig. 13.—Keokuk limest. Keokuk, Iowa. The specific name being preoccupied by M. and W. in Geol. Rep. Ill., iii, p. 490, Pl. 18, fig. 10, we propose for this species the above name.

*1882. **S. occidentalis** (Worthen), **Poteriocrinus occidentalis** Worthen (not Shum.), Bull. i, Ill. St. Mus. Nat. Hist., p. 10; also Geol. Rep. Illinois, vii, p. 278, Pl. 29, fig. 2.—Keokuk limest. Hamilton, Ill. The name **Pot. occidentalis** was preoccupied, in 1852, by Owen and Shum., Geol. Rep. of Wisc., Iowa and Minnesota, p. 596, Pl. 5 b, fig. 5; but, as it has since been referred to **Agassizocrinus,** we propose retaining Worthen's name for the above species.

*1882. **S. okawensis** (Worthen), **Poteriocrinus okawensis,** Bull. i, Ill. St. Mus. Nat. Hist., p. 24; also Geol. Rep. Illinois, vii, p. 296, Pl. 29, fig. 2.—Kaskaskia gr. Okaw River, Ill.

*1882. **S. Orestes** (Worthen), **Poteriocrinus Orestes,** Bull. i, Ill. St. Mus. Nat. Hist., p. 7; also Geol. Rep. Illinois, vii, p. 273, Pl. 27, fig. 3.—Keokuk limest. Keokuk, Iowa. (Compare with **Scaph. Coreyi** M. & W.)

*1882. **S. popensis** (Worthen), **Poteriocrinus popensis,** Bull. i, Ill. St. Mus. Nat. Hist., p. 23; also Geol. Rep. Illinois, p. 296, Pl. 29, fig. 12.—Kaskaskia gr. Pope Co., Ill.

*1882. **S. propinquus** (Worthen), **Poteriocrinus propinquus,** Bull. i, Ill. St. Mus. Nat. Hist., p. 26; Geol. Rep. Ill., vii, Pl. 29, fig. 9.—Kaskaskia gr. Monroe Co., Ill.

*1882. **S. Salteri** (Worthen), **Poteriocrinus Salteri,** Bull. i, Ill. St. Mus. Nat. Hist., p. 21; Geol. Rep. Ill., vii, Pl. 29, fig. 18.—Kaskaskia gr. Chester, Ill.

1880. **S. spinifer** Wetherby, Journ. Cincin. Soc. Nat. Hist. (July), p. 13, Pl. 5, fig. 5.—**Graphiocrinus spinifer** S. A. Miller, 1883, Catalogue Amer. Pal. Foss. Ed. ii, p. 287.—Kaskaskia gr. Pulaski Co., Ky.

*1882. **S. spinobrachiatus** (Worthen), **Poteriocrinus spinobrachiatus** (not Hall), Bull. i, Ill. St. Mus. Nat. Hist., p. 20; also Geol. Rep. Ill., vii, p. 290, Pl. 29, fig. 1.—Kaskaskia gr. Monroe Co., Ill. Hall described in 1861 a species under **P.** (**Scaphiocrinus**) **spinobrachiatus,** which we referred in Rev. i, p. 123, to **Graphiocrinus.**

*1882. **S. varsoviensis** (Worthen), **Poteriocrinus varsoviensis,** Bull. i, Ill. St. Mus. Nat. Hist., p. 20; also Geol. Rep. Illinois, vii. p. 290, Pl. 28, fig. 15.—Warsaw limest. Warsaw, Ill.

*1882. **S. venustus** (Worthen), **Poteriocrinus venustus,** Bull. i, Ill. St. Mus. Nat. Hist., p. 24; also Geol. Rep. Ill., vii, p. 297, Pl. 29, fig. 13.—Kaskaskia gr. Monroe Co., Ill.

Syn. **P. peculiaris** Worthen, (described Bull. i, Ill. St. Mus. Nat. Hist., p. 25, as **Pot. clytis**), Geol. Rep. Ill., vii, p. 298, Pl. 29, fig. 10.—The specimen from which the species was described has an anomalous arrangement of anal plates.

b. *With compound brachials.*

*1882. **S. briareus** (Worthen), **Poteriocrinus briareus,** Bull. i, Ill. St. Mus. Nat. Hist., p. 12; also Geol. Rep. Ill., vii, p. 279, Pl. 27, fig. 4.—Keokuk limest. Keokuk, Ia., and Bono, Ind. The specific name is given at all places as **P. briærius,** but evidently was intended for **Pot. briareus.**

*1882. **S. Burketi** (Worthen), **Poteriocrinus Burketi,** Bull. i, Ill. St. Mus. Nat. Hist., p. 5; also Geol. Rep. Illinois, vii, p. 270, Pl. 28, fig. 8.—Keokuk limest. Hamilton, Ill.

*1882. **S. coxanus** (Worthen), **Poteriocrinus coxanus,** Bull. i, Ill. St. Mus. Nat. Hist., p. 4; also Geol. Rep. Illinois, vii, p. 269, Pl. 27, fig. 1.—Keokuk limest. Keokuk, Iowa.

S. cultidactylus Hall, 1859, was redescribed and figured Geol. Rep. Illinois, vii, p. 301, Pl. 30, fig. 1.

*1884. **S. extensus** W. & Sp., **Poteriocrinus asper** Worthen, not **Pot.** (**Pachylocr.**) **asper** (W. & Sp., Rev. i, p. 116), Bull. i, Ill. St. Mus. Nat. Hist., p. 11; also Geol. Rep. Illinois, vii, p. 278, Pl. 27, fig. 8.—Keokuk limest. Keokuk, Iowa.

Poteriocrinus asper being preoccupied, we propose the above name in place of it.

*1882. **S. iowensis** (Worthen), **Poteriocrinus iowensis,** Bull. i, Ill. St. Mus. Nat. Hist., p. 6; also Geol. Rep. Illinois, vii, p. 272.—Keokuk limest. Hamilton, Ill.

*1844. **S. macrocheirus** (McCoy), **Cyathocrinus macrocheirus,** Synop. Carb. Foss. Ireland, Pl. 25, figs. 8, 10.—Subcarboniferous, Ireland. (This species has three brachials.)

*1873. **S. montanaensis** (Meek), **Poteriocrinus montanaensis,** Ann. Rep. U. S. Geol. Rep. Terr. for 1872, p. 469; also White, 12th Ann. Rep. of the Terr., by Hayden, for 1878, p. 128, Pl. 33, fig. 6 a.—Carboniferous. Virginia City Montana.

*1882. **S. nauvooensis** (Worthen), **Poteriocrinus nauvooensis,** Bull. i, Ill. St. Mus. Nat. Hist., p. 13; also Geol. Rep. Illinois, vii, p. 282, Pl. 28, fig. 10.—Keokuk limest. Nauvoo, Ill.

*1882. **S. pikensis** (Worthen), **Zeacrinus pikensis,** Bull. i, Ill. St. Mus. Nat. Hist., p. 304; Geol. Rep. Ill., vii, Pl. 30, fig. 3.—Burlington limest. Pike Co., Illinois.

*1882. **S. sculptus** (Worthen), **Poteriocrinus sculptus,** Bull. i, Ill. St. Mus. Nat. Hist., p. 21; also Geol. Rep. Illinois, vii, p. 292, Pl. 29, fig. 8.—Kaskaskia gr. Monroe Co., Ill.

(**Poteriocrinus subramulosus** Worthen, Ill. St. Mus. Nat. Hist., p. 14; Geol. Rep. Illinois, vii, p. 284, is a synonym of **Pot.** (**Scaphiocrinus**) **Swallovi** M. & W. This species passes from the upper part of the Upper Burlington into the Keokuk limestone).

SCYTALOCRINUS W. and Sp., Rev. I, p. 116.

Syn. *Dactilocrinus* Sladen, 1877 (not Quenstedt), in part (On the genus Poteriocrinus, p. 4).

General form, including arms, slender, almost cylindrical. Dorsal cup obconical or bell-shaped; plates strong but not massive, connected by close suture. Underbasals well developed, bent upward and forming a conspicuous part of the calyx. Radials and brachials of nearly the same form, apposed faces truncate, with a transverse articular ridge and somewhat shallow fossæ; line of articulation gaping. The brachials either single or compound, generally elongate, constricted along the middle. They support two simple arms each, except in the anterior ray, which sometimes has but a single arm. Arms long, rather heavy, composed of quadrangular or slightly cuneiform joints; pinnules of moderate size. Azygous side as in *Poteriocrinus;* ventral sac tubular, with slit-like openings, and frequently spiniferous at the distal end. Column circular or obtusely pentagonal.

Additional species:—

a. *With single brachials.*

*1877. **Scytalocrinus loreus** (Sladen), **Dactylocrinus loreus** (**Poteriocrinus tenuis** Austin, non Miller), Mon. Rec. and Foss. Crin., Pl. 10, fig. 5.—On the genus Poteriocrinus, etc., p. 5.—Subcarboniferous. England.

*1821. **S. tenuis** Miller, Nat. Hist. Crin., p. 71, Pl. 21-23. **Dactylocrinus tenuis** Sladen, 1877, "On the genus Poteriocrinus, p. 5."

*1880. **S. Wachsmuthi** Wetherby, Journ. Cincin. Soc. Nat. Hist. (July), p. 12, Pl. 5, fig. 4.—Kaskaskia limest. Pulaski Co., Ky.

b. *With compound brachials.*

(**Poteriocrinus hamiltonensis** Worthen, 1882, Bull. i, Ill. St. Mus. Nat. Hist., p. 7; Geol. Rep. Illinois, vii, p. 273, Pl. 28, fig. 9, Syn. of **Poteriocr. (Scytalocr.) robustus** Hall).

*1882. **Scytalocrinus Talboti** (Worthen), **Poteriocrinus Talboti,** Bull. i, Ill. St. Mus. Nat. Hist., p. 17; also Geol. Rep. Illinois, vii, p. 287, Pl. 30, fig. 7.—St. Louis limest. Monroe Co., Ill.

DECADOCRINUS W. and Sp., Rev. I, p. 119.

Arms ten, rarely nine, the anterior ray sometimes undivided. Dorsal cup depressed, saucer-shaped, with a deep concavity along the basal regions. Underbasals small, not seen in a side view, and frequently covered almost entirely by the column. Form of radials and brachials and articulation as in *Scytalocrinus;* brachials simple or compound. Arms composed of single wedge-form joints, with keel-like projections at alternate sides, and with strongly waving or zigzag outlines. Pinnules unusually strong, placed far apart, and resembling armlets; composed of short cuneate joints, with spurs or keels upon their basal joints. Azygous side as in *Poteriocrinus.* Ventral sac more or less club-shaped; constructed of numerous rows of regularly arranged hexagonal pieces, with a pore at each angle. Column pentagonal, with rounded angles.

Decadocrinus agrees closely with *Graphiocrinus*, but the latter has no azygous plate, only an anal piece.

Additional species:—

a. *With simple brachials.*

*1882. **Decadocrinus columbiensis** (Worthen), **Poteriocrinus columbiensis**, Bull. i, Ill. St. Mus. Nat. Hist., p. 22; also Geol. Rep. Illinois, vii, p. 293, Pl. 19, fig. 6.—Kaskaskia limest. Monroe Co., Ill.

*1882. **D. fountainensis** (Worthen), **Poteriocrinus fountainensis**, Bull. i. Ill. St. Mus. Nat. Hist., p. 17; also Geol. Rep. Illinois, vii, p. 286, Pl. 30, Fig. 11.—St. Louis limest. Monroe Co., Ill.

*1881. **D. Milleri** (Wetherby), **Poteriocrinus Milleri** (not Worthen), Journ. Cincin. Soc. Nat. Hist. (January), Pl. 9, figs. 12, 13.—Kaskaskia gr. Pulaski Co., Ky.

*1882. **D. penicilliformis** (Worthen), **Poteriocrinus penicilliformis**, Bull. i, Ill. St. Mus. Nat. Hist., p. 8; also Geol. Rep. Illinois, vii, p. 276, Pl. 28, fig. 9.—Keokuk limest. Hamilton, Ill.

1882. **D. zethus** Williams. Proc. Acad. Nat. Sci. Phila., p. 27, Pl. 1, fig. 9.—Portage gr. Ithaca, N. Y.

b. *With compound brachials.*

1882. **D. gregarius** Williams. Proc. Acad. Nat. Sci. Phila., p. 22, Pl. 1, figs. 6, 7, 8.—Chemung gr. Ithaca, N. Y.

WOODOCRINUS De Koninck. Rev. i, p. 124.

(Emended W. and Sp.)

Syn. *Parisocrinus* W. and Sp. Rev. i, p. 115.
Syn. *Zeacrinus* Hall (not Troost) in part. Geol. Rep. Ia., vol. i, p. 544.
Syn. *Zeacrinus* Sladen, 1877. On the genus Poteriocrinus, etc., p. 7.
Syn. (?) *Philocrinus* De Koninck, 1862. Quart. Journ. Geol. Soc. London.

The ventral side of *Woodocrinus* has not been observed, but we may suppose from the spreading of the arms that its sac was rather bulky. This is further suggested by the great width of the azygous side, which, however, is composed of the same elements as in most Poteriocrinites, and is not structurally distinct as has been generally supposed. It has, like *Poteriocrinus*, within the calyx three azygous plates—the succeeding pieces forming the abactinal parts of the ventral sac—which for some distance, are exposed between the arms. It differs from *Scaphiocrinus* in the shortness of its arm joints and arms generally. This it shares, however, with *Pachylocrinus* as defined by us, and with *Zeacrinus* Troost.

In our description of *Zeacrinus* (Rev. i, p. 125), we stated the difficulty of separating it from *Woodocrinus*. The only difference, there noted, was the folding up and the smaller size of the arms in the former, and upon this distinction almost exclusively we based the separation. We also stated that the calyx in *Woodocrinus* was generally more turbinate, in *Zeacrinus* depressed with concave basal regions, but also to this rule we found exceptions among the species which had been referred to the latter. Equally impracticable would be a separation upon the arm joints, although these vary considerably among the typical species. The arms of *Zeacrinus magnoliaformis* are dorsally perfectly flat, those of *Woodocrinus macrodactylus* decidedly rounded, and Hall, Meek, Worthen and White placed under *Zeacrinus* species with flat, rounded and angular arms.

The species which we arranged in Pt. i, under *Pachylocrinus*, had been originally, with a few exceptions, described under *Zeacrinus*. Their arms, like those of the latter, are more or less closely folded up, and they dichotomize in a similar manner. All are composed of short quadrangular joints, and all have a club- or elongate balloon-shaped, ventral sac; while the sac in *Zeacrinus magnoliaformis* is pyramidal, with sharp lateral edges and concave sides. In the latter the form of the calyx is disk-like, in the others bowl-shaped. Mr. Percy Sladen, the only English writer who advocated the necessity of subdividing the original genus *Poteriocrinus*, placed *Poteriocrinus McCoyanus*, *P. calyx*, *P. granulosus* and *P. Phillipsii* under *Zeacrinus*. We fully agree with him that these four species cannot be retained under *Poteriocrinus*, having close affinities with *Zeacrinus*, but we believe the three former will prove to be *Hydreionocrinus*, his *Zeacrinus Phillipsii* a *Pachylocrinus* or *Woodocrinus*, as also *Poteriocrinus latifrons* Austin, which he referred to *Scaphiocrinus*. Sladen probably was not acquainted with Troost's type of *Zeacrinus*, as he took *Z. elegans* to be a typical form, an opinion in which we have shared until quite recently, when we obtained numerous beautifully-preserved specimens, both of "*Zeacrinus*" *elegans* and Troost's typical species, from the Kaskaskia limestone. The later forms differ from the earlier not only in the form of their ventral sac, but also essentially in the construction of their calyx. In the typical species the dorsal cup is disk-like, almost flat, the radials extremely large, touching with their acute lower angles the underbasals, thereby almost isolating the five basals. The basals in these species consist of minute trigonal pieces of irregular form, and also the underbasals are small, and rest deeply within the columnar concavity (Pl. 6, fig. 9). In the earlier form, notably "*Zeacrinus*" *elegans*, however, the basal cup is bowl-shaped, and the basals are comparatively larger. The arrangement of the azygous pieces upon which DeKoninck placed so much stress in defining *Woodocrinus*, is, in our opinion, not different from that of *Poteriocrinus* or *Scaphiocrinus*, only more plates of the ventral sac are exposed to view, owing to the width of the azygous side, and as we see no other distinction between *Woodocrinus* and our *Pachylocrinus*, we place the species which we had referred to the latter, including "*Zeacrinus*" *elegans* and a few others of the same type, under *Woodocrinus*, as this name has priority. Perhaps, if all American species were as distinct as "*Zeacrinus*" *elegans* from *Woodocrinus macrodactylus*, it might be possible to make the former the type of a separate group, but as we find all intermediate forms, from infolding arms to spreading arms, and two to five or more bifurcations, flat, angular and rounded arms, any such separation must be adandoned.

Philocrinus, De Koninck, from Punjaub, India, is probably, to judge from the figure, a species of *Woodocrinus*. We think it has azygous plates, but these were covered by matrix in DeKoninck's specimen. We also doubt if the arm plates of first and second order were laterally connected by suture; these evidently were free as in the Fistulata generally.

Revised Diagnosis.—Calyx sometimes obconical, more frequently depressed-bowl-shaped, and the underbasals bent inward, forming a concavity. Basals large, constituting a continuous ring beneath the radials. Azygous plates arranged as in *Poteriocrinus;* ventral sac slightly inflated. Brachials composed of one or two pieces, which jointly have the form and size of the radials; they are wider than long, and their lateral margins are fitted closely together as if they were united by suture. This infolding of the brachials extends also to the arm plates up to the second bifurcation; and is often found throughout the full length of the arms. The arm joints are short, quadrangular, rarely cuneate, the apposed faces, more or less parallel and flat, angular or rounded on their outer face. The arms dichotomize and each branch gives off one or more branches to the inner side of the ray, which either bifurcate again or remain simple. The articulation is the same as in *Scaphiocrinus.* Column circular, or obtusely pentangular.

The zoological position of *Woodocrinus* is probably between *Scaphiocrinus* and *Zeacrinus.*

Geological Position, etc.—The genus occurs only in the Subcarboniferous, and almost exclusively in the lower portions.

We place under *Woodocrinus* the following species, all of which were referred by us, Rev. i, p. 116, to *Pachylocrinus: Zeacrinus arboreus* Worthen, *Zeacrinus asper* M. and W., *Zeacrinus concinnus* M. and W., *Poteriocrinus latifrons* Austin, *Scaphiocrinus liliiformis* M. and W., *Zeacrinus merope* Hall, *Zeacrinus paternus* Hall, *Zeacrinus perangulatus* White, *Zeacrinus planobrachiatus* M. and W., *Pachylocrinus subæqualis* W. and Sp., and the following, which in Rev. i, p. 128, were placed under *Zeacrinus: Poteriocrinus bursæformis* White, *Zeacrinus elegans* Hall, *Zeacrinus ramosus* Hall, *Zeacrinus scobina* M. and W., *Zeacrinus serratus* M. and W., and *Zeacrinus troostanus* M. and W.

The following species are to be added :—

*1882. **Woodocrinus asperatus** (Worthen), **Poteriocrinus asperatus,** Bull. i, Ill. St. Mus. Nat. Hist., p. 12, also Geol. Rep. Illinois, vii, p. 280, Pl. 28, fig, 2.—Keokuk limest. Keokuk, Ia.

*1882. **W. claytonensis** (Worthen), **Poteriocrinus claytonensis,** Bull. i, Ill. St. Mus. Nat. Hist., p. 18; also Geol. Rep. Illinois, vii, p. 288, Pl. 30, fig. 6.—Warsaw limest. Adams Co., Ill.

*1862. (?) **W. cometa** (De Koninck), **Philocrinus cometa,** Quart. Journ. Geol. Soc. London, Pl. ii, fig. 1.—Subcarboniferous. River Indus, India.

1854. **W. macrodactylus** De Koninck. Type of the genus, Recherch. Crin. Belg., Suppl., p. 6, Pl. 8, figs. 1 a-d.—Subcarboniferous. Richmond, England.

*1882. **W. richfieldensis** (Worthen), **Poteriocrinus richfieldensis,** Bull. i, Ill. St. Mus. Nat. Hist., p. 15; also Geol. Rep. Ill., vii, p. 285, Pl. 30, fig. 5.—Waverly (Kinderhook) group. Richfield, O.

*1883. **W. tentaculatus** (Worthen), **Poteriocrinus tenuidactylus,** Bull., i, Ill. St. Mus. Nat. Hist., p. 10; **Poteriocrinus tentaculatus,** Geol. Rep. Ilinois, vii, p. 277, Pl. 28, fig. 11.—Keokuk limest. Keokuk, Ia.—Prof. Worthen finding the former specific name occupied, changed it to the latter. This species is a typical form of Woodocrinus, and has the heavy rounded arms as De Koninck's species.

ZEACRINUS (Troost MS.) Hall, Rev., i, p. 125.

Revised W. and Sp. (Pl. 6, fig. 9, and Pl. 9, fig. 3).

Zeacrinus differs from *Woodocrinus* (*Pachylocrinus*) in the form of the ventral sac, which, as described by us, is pyramidal, sharply angular and pointed at the upper end; while that of *Woodocrinus* is club-shaped, inflated above. The two genera differ also in the construction and form of the dorsal cup, which in *Zeacrinus* is much more depressed and disk-like. Basals exceedingly small, trigonal, deeply notched for the reception of the radials. The underbasals at the inner floor of the calyx are generally larger than they appear at the outer side, and the angles of the radials sometimes touch the underbasals. Plates of the calyx massive, especially the radials, their distal faces sloping outward; articular facets with muscular extensions. Arm plates generally flat, except the axillaries, which frequently are tuberculous. The arms dichotomize toward the inner side of the ray from each main division, the branches rarely dividing again. The arm joints are short, transversely arranged, those of the same rank slightly increasing in width upwards, those of the next order narrower by one-half than the preceding bifurcating plate. By this structure, the arms of each ray, and of the main divisions of the rays, form laterally a straight line, by means of which they fit in so closely against the arms of adjoining rays, that they often appear as if united by suture. Column round, comparatively small.

We now recognize under *Zeacrinus* only the following species, viz.: *Zeacrinus bifurcatus*, *Z. compactilis* Worthen; *Z. magnoliaformis* O. and N.; *Z. ovalis* Lyon and Cass.; *Z. Wortheni* Hall, and our new species *Z. nodosus*, all other species which were referred by us to this genus are found now under *Woodocrinus*.

Zeacrinus nodosus, nov. sp. (Pl. 6, fig. 3).

The largest known species of the genus. All plates of calyx and arms nodose, except basals and underbasals; the nodes on all axillaries, and the first plate of each succeeding order of arm plates, almost covering the entire surface of the plate; while at the intermediate plates the nodes have more the shape of small tubercles, arranged so as to occupy an excentric position, leaning slightly toward the wider or pinnule-bearing side, thereby forming along the arms two rows of nodes, alternately arranged.

Underbasals of medium size, extending beyond the column, forming a shallow inverted cup, decagonal at the outer side. Basals trigonal, very minute, irregular in size, the two anterior ones smaller than the others. Radials large; broadly truncate below; subquadrangular in outline but hexagonal; the three lower faces scarcely as wide as the lateral ones, and narrower by one-half than the upper side. Brachials 1×5; four of them triangular, giving off two arms each; the anterior one quadrangular, with only one primary arm. The arms bifurcate on the fifth plate, and again on the tenth to fifteenth; the higher divisions are not known. In this species, exceptionally, the inner arms branch again.

Azygous plate elongate, resting upon the underbasals; the right lateral face, which is slightly convex, abutting against the right posterior radial, its upper side supporting the anal plate; leaning with its left lateral side against the other radial, and with its lower sloping side against the adjoining basal.

Geological Position, etc.—Keokuk limestone. White's Creek Springs, near Nashville, Tenn.

CŒLIOCRINUS White, Rev. I, p. 131.

Syn. *Sphæronites* Phill., Palæoz. Foss. Cornwall, p. 135.

We have heretofore made *Cœliocrinus* a subgenus of *Hydreionocrinus*, owing to slight variations in the form and construction of the ventral sac, which we thought to be the only distinctive character. Beautiful specimens, however, which we obtained since in Kentucky, show that the two forms differ in their mode of articulation in a similar manner as *Woodocrinus* and *Zeacrinus*, *Scytalocrinus* and *Eupachycrinus*, which we ranked as full genera. In *Cœliocrinus* the calyx is conical, in *Hydreionocrinus* depressed—saucer-shaped.

Cœliocrinus is found also in Europe. Phillips, in his work on the Palæoz. Foss. of Cornwall, gives on Pl. 59 a good figure of what we take to be the balloon-shaped ventral sac of this genus. His figure was copied from the Geol. Trans. (new ser.), vol. iii, Pl. 20, which had been published with a note by Mr. Broderip, "calling attention to some analogy between this fossil and *Chelyosoma macleayanum*, a species of tunicate Mollusca, which has a few coriaceous plates on the upper surface only." Phillips, and apparently Austin, took it to be allied to *Echinospherites* of Wahlenberg, and called it provisionally *Sphæronites tessellatus*, which we propose to change into *Cœliocrinus tessellatus*.

In its arm structure *Cœliocrinus* leans decidedly toward *Woodocrinus*, but approaches *Hydreionocrinus* in the form of its sac-like appendage.

We have already referred to it *Cœliocrinus dilatatus* (Hall) White; *C. cariniferus* (Worthen) W. and Sp.; *C. lyra* (Worthen) W. and Sp.; *C. subspinosus* White, and *C. ventricosus* (Hall) White, and now add further:

*1840. **C. tessellatus** (Phill.), **Spæronites tessellatus**, Palæoz. Foss. Cornwall, p. 135, Pl. 59.—Subcarbon. (?). Locality (?).

HYDREIONOCRINUS De Kon., Rev. I, p. 123.

Wetherby, in a paper on the Crinoids of Pulaski Co., Kentucky, figured and described a new species of *Hydreionocrinus*, which he referred with doubt to *Hydreionocrinus* (*Zeacrinus*) *armiger* (M. and W.). Several fine specimens of this form, which we obtained lately at Sloan's Valley, Ky., show it to be specifically distinct from either *H. armiger* or *H. depressus* of the same locality. We propose for it the name *Hydreionocrinus Wetherbyi*, in honor of the discoverer of this interesting locality. The species, which was figured Journ. Cincin. Soc. Nat. Hist., vol. iii, figs. 7, 8, 9, 10, differs from *H. depressus*, with which it has probably the closest affinities, in the less depressed form of the dorsal cup, and in the basal concavity, which is shallow and almost restricted to the underbasals; while in the other the cup is deeply excavated, and the concavity includes even a portion of the radials. In our species, every brachial bifurcates, in the other only four; the anterior radial which is quadrangular, supporting a single primary arm. In the former all five radials are spiniferous, in the latter only four, and the spines are shorter and sharper. In *H. depressus* the primary arms branch four times, in *H. Wetherbyi* only twice, and the arms, which in the former taper to a small point, remain comparatively heavy in the latter. Again, in *H. depressus* the arm joints, from the second bifurcation upwards, are biserial, while in *H. Wetherbyi* they do not pass the interlocking stage. In the former the ventral sac is armed with ten spines which join along the centre, the latter has five only, and these enclose a variable number of small plates.

Hydreionocrinus (?) *orbicularis* De Koninck will be found under *Cromyocrinus*.

*1884. **H. Wetherbyi** W. and Sp.—**Hydreionocrinus (Zeacrinus) arminger** (M. & W.) Wetherby, Journ. Cincin. Soc. Nat. Hist., iii, p. 5, figs. 7–10.—Kaskaskia gr. Pulaski Co., Ky.

CROMYOCRINUS Trautschold.

(Reconstructed W. and Sp.)

1867. Trautschold, Crin. jüng. Bergkalk bei Moskau, p. 19.
1879. Trautschold, Monogr. Kalkbr. von Mjatschkowa, p. 117.
1879. Zittel, Handb. der Palæont., i, p. 360.

Syn. *Eupachycrinus* in part (W. and Sp.), Revision i, p. 133.
Syn. *Hydreionocrinus* in part (De Koninck); Syn. *Agassizocrinus* in part (Worthen); Syn. *Poteriocrinus* in part (McCoy).

Placing *Cromyocrinus* as a synonym under *Eupachycrinus*, we found it impossible to uphold the genus upon any of the characters that had been pointed out by Trautschold. Wetherby has asserted (Journ. Cincin. Soc. Nat. Hist., iii, p. 8), that the genus was " well fitted to embrace all those species having three or more anals, a body composed of comparatively heavy, convex plates, and ten arms composed of a single row of joints." He further proposed to refer to *Eupachycrinus* all those species of this group having one or more anals, heavy rounded calyx plates, ten to fourteen arms, and these composed of a double series of interlocking plates. The biserial arm structure, which is only a higher form of the uniserial one, is as closely intermingled with the latter in the Russian form as in the typical *Eupachycrinus*, and also the plates of the calyx are heavy and convex in both groups. The only distinction of Wetherby upon which perhaps a separation of the species referred by us to *Eupachycrinus* might be established, is the number of azygous plates. We can separate the species with a single plate from those with three pieces, as proposed by White. A division of this kind, however, does not in the least affect *Cromyocrinus*, which, like the typical *Eupachycrinus*, has three azygous plates. But *Cromyocrinus* differs from the typical form of *Eupachycrinus*, in the form of the calyx, the relative size of the various plates, and in their mode of union. In all American species of *Eupachycrinus*, the form is depressed, more or less saucer-shaped, and the underbasals, which are very small and totally covered by the column, rest within a deep concavity together with the lower portions of the basals. The latter plates, and also the radials, are comparatively large, the underbasals small. In *Cromyocrinus* the calyx is globular, constricted at the upper end, the underbasals large, extending conspicuously beyond the column and forming a shallow cup.

The basals are so extremely large, the radials so comparatively small, that the former, together with the underbasals, frequently constitute over three-fourths of the cup, while in *Eupachycrinus* the same parts occupy not more than half that space. Besides, the plates of *Cromyocrinus* are united by syzygy, and not by ligamentous fossæ, as in most species of *Eupachycrinus.*

Our attention was directed to these facts by a species figured and described by De Koninck under the name of *Hydreionocrinus* (?) *globularis*, which in a somewhat higher degree has all the characters of *Cromyocrinus*, and at the same time resembles certain forms described under *Agassizocrinus.*

To *Agassizocrinus* have been referred two very distinct groups, the one almost always without column or even columnar attachment, with a large almost solid, subglobular or semiovoid underbasal cup, nearly truncate upper side, and small basals. The other, always attached to a column, with comparatively small underbasals, stretched out horizontally so as to form a five-rayed star, and with extremely large basals partly on the same plane with the underbasals. The latter species, which include *Agassizocrinus globosus* and *Agassizocrinus papillatus*, both described by Worthen, agree most closely with *Hydreionocrinus* (?) *globularis* De Koninck; *Poteriocrinus nuciformis* McCoy; *Cyathocrinus* (?) *sangamonensis* M. and W., all previously referred by us to *Eupachycrinus*, and all agree equally well with *Cromyocrinus simplex* from Russia. These species, we think, might be arranged under *Cromyocrinus*, and the only thing which prevented us from doing so before, is the similarity with Trautschold's two other species (*Cromyocrinus geminatus* and *C. ornatus*), which in their arm structure and general form approach *Epachycrinus;* while they agree in other points with *Cromyocrinus simplex.*

Cromyocrinus is closely allied to *Agassizocrinus*, to which it holds a similar position as *Pentacrinus* to *Antedon.* We doubt if *Cromyocrinus* ever became detached from its column, while all species of *Agassizocrinus* lose their column comparatively early.

Generic Diagnosis.—Dorsal cup globular, constricted above; composed of heavy plates; sometimes (perhaps always) united by syzygy.

Underbasals comparatively large, plainly visible beyond the column, horizontally arranged and forming a sharply delineated star, or sometimes a very shallow cup with a slight depression for the attachment of the column; suture lines well defined. Basals large; generally as high or higher than wide; three of them equal, hexagonal; the two adjoining the azygous side heptagonal, larger and of a different form.

Radials all pentagonal; the lateral faces often so short as to give to the plates a trigonal outline; their outer faces abruptly depressed or rounded off toward the brachials; upper side straight, facing upward; articular ridge well developed and occupying the full width of the plate. The right posterior radial narrower than the others, its lower left side disturbed by the azygous piece. The azygous plate is very large, placed in a sloping position, its two lower sides resting between two basals, its left side against the adjoining radial. The small truncate upper side supports the first plate of the ventral sac, the right side faces the anal plate, which is always considerably smaller, and extends beyond the limits of the radials. Brachials one or two; short; laterally touching their fellows of adjoining rays. Arms 5 to 10 or more; heavy, composed of short quadrangular joints, which change into cuneate pieces and in some species interlock. Arm furrows wide; pinnules strong. Articulation between radials and brachials and between the lower arm joints by transverse ridges and fossæ.

Ventral sac imperfectly known, but evidently short. Column small, circular; axial canal minute.

Geological Position, etc.—*Cromyocrinus* is found in the upper portion of the Subcarboniferous of Russia, England, Scotland, Belgium, and of the United States.

We place here the following species :—

1867. **Cromyocrinus geminatus** Trautschold. Referred by us, Rev., i, p. 138, to **Eupachycrinus.**

*1873. **C. globosus** (Worthen), **Agassizocrinus globosus**, Geol. Rep. Illinois, vol. v, p. 557, Pl. 21, fig. 12.—Kaskaskia gr. Chester, Illinois.

*1858. **C. globularis** (De Koninck), **Hydreionocrinus** (?) **globularis,** Memoirs de Paléont., p. 21, Pl. 2, figs. 1–4.—Referred by us, Rev. i, p. 138, to **Eupachycrinus.**—Upper part of Subcarboniferous. Near Glasgow, Scotland.

*1849. **C. nuciformis** (McCoy), **Poteriocrinus nuciformis,** Ann. and Mag. Nat. Hist. (Ser. ii), not **P. nuciformis,** Goldfuss (Fischer); also 1854, Contrib. Brit. Palæont. by Sedgwick, p. 116.—Subcarboniferous. Derbyshire, England.

1879. **C. ornatus** Trautschold. Referred by us, Rev., i, p. 138, to **Eupachycrinus.**

*1867. **C. papillatus** (Worthen), **Agassizocrinus papillatus,** Bull., i, Ill. St. Mus. Nat. Hist., p. 36; also Geol. Rep. Ill., vii, Pl. 29, fig. 17.—Kaskaskia gr. Monroe Co., Ill.

*1861. **C. sangamonensis** (M. and W.), **Cyathocrinus** (?) **sangamonensis**). Referred by us, Rev., i, p. 138, to **Eupachycrinus**.

1867. **C. simplex** Trautschold (Type of the genus). Formerly referred by us to **Eupachycrinus**.

EUPACHYCRINUS M. and W., Rev., i, p. 133.

(Restricted, W. and Sp.).

Accepting the genus *Cromyocrinus*, we have to consider only those species in which the cup is depressed or saucer-shaped, with small underbasals hidden from view and placed at the end of the basal concavity. These species, however, are divisible again into two groups: a, species with three azygous plates within the dorsal cup, *i. e.*, the typical form of *Eupachycrinus*, and: b, species with a small anal plate, partly extending into the equatorial regions, for which White proposed the genus *Ceriocrinus*. Accepting also this division (see *Ceriocrinus*), and admitting into *Eupachycrinus* such species as "*Cromyocrinus*" *gracilis* Wetherby, which has but five arms, and *Eupachycrinus spartarius*, Miller, with fourteen arms, we must modify our former generic formula so as to admit species with five to fifteen arms in place of ten, as we had previously given it. Thus restricted, *Eupachycrinus* is a strictly American genus, embracing only the following species: *Eupachycrinus Bassetti* Worthen, *E. Boydii*, *E. crassus*, Meek and Worthen, *E. formosus* Worthen, *E. orbicularis* (Hall), *E. quatuor-decim-brachiatus* (Lyon), *E. subtumidus* Worthen, *E. tuberculatus* M. and W., and *E. verrucosus* White, all previously reported, and perhaps also *E. platybasilis* White, which is very imperfectly known, and may be a *Zeacrinus*.

We also place here:—

1882. **Eupachycrinus asperatus** Worthen, Bull. i, Ill. St. Mus. Nat. Hist., p. 34; also Geol. Rep. Illinois, vii, p. 311, Pl. 29, fig. 4.—Kaskaskia gr. Monroe Co., Illinois.

*1880. **E. gracilis** (Wetherby), **Cromyocrinus gracilis**, Journ. Cincin. Soc. Nat. Hist., p. 4, Pl. 16, figs. 2 a, b, c.—Kaskaskia gr. Pulaski Co., Ky.

*1847. **E. maniformis** (Shum.), **Zeacrinus maniformis**. This species was referred by us Rev. i, p. 117, to **Scytalocrinus**.

* **E. Moorei** (Whitfield), **Zeacrinus Moorei**, Paleont. Ohio, vol. iii, Pl. 11, figs. 6, 10.—Coal measures. Hocking Co., O. (not published).

1882. **E. monroensis** (Worthen), Bull. i, Ill. St. Mus. Nat. Hist., p. 34; also Geol, Rep. Ill., vii, p. 312, Pl. 19, fig. 16.—Kaskaskia gr. Monroe Co., Illinois.

1879. **E. spartarius** S. A. Miller, Journ. Cincin. Soc. Nat. Hist. (April), Pl. 8, fig. 2.—Kaskaskia limest. Pulaski Co., Ky.

Syn. **E. germanus** S. A. Miller, ibid., Pl. 8, fig. 3.

TRIBRACHIOCRINUS McCoy.

1847. McCoy, Ann. and Mag. Nat. Hist., xx, p. 228.
1859. Pictét, Traité de Paléont., vol. iv, p. 321.
1884. F. Ratte, Proceed. Linnæan Soc. of New South Wales, vol. ix, Part 4.

(Diagram, Pl. 6, fig. 5).

This genus was originally proposed for a single specimen from the Subcarboniferous of Australia. According to McCoy, it differs from *Cyathocrinus* and allied genera by having only three arms. The cup is described as cupuliform, large, composed of three plates in the proximal ring, 5 plates in the succeeding one, followed by 1×3 radials, 3 interradials, and one or two anal plates. A similar explanation of the plates has been given lately by Mr. Ratte, who described another species in which "the second radials," the brachials according to our terminology, were preserved. Mr. Ratte had the kindness to send us an excellent cast of the type specimen, examination of which leads us to infer that the third ring of plates in the calyx was composed of seven pieces, of which five were radials, the two others azygous plates, but that none of them are interradials. In three of the radials, the articulating faces form a straight horizontal line, and only these plates are apposed by regular brachials, the two others, those of the two antero-lateral rays being angular and higher at their distal ends. The general outline of the two last mentioned plates, indicates that they are compound plates, each representing a radial and a bifurcating brachial, which probably became anchylosed. They evidently supported two arms, one at each side; while the three radials with articulated brachials apparently bear but a single arm like *Cromyocrinus simplex* Trautchold. Ratte observed in *Tribachiocrinus corrugatus* along the ventral surface between the brachials, "the casts of very small plates, irregular in shape, which doubtless belong to the so-called voûte (vault), or outer part covering the calyx as in *Rhodocrinus*, for instance." We seriously doubt if these plates, which he figures on Pl. 68, fig. 2, are any such thing as vault plates; we believe if they are plates at all, that they formed a part of the disk, and as such were covering pieces. The radials enclose the azygous plate proper and an anal piece as in most of the Poteriocrinidæ. *Tribachiocrinus* is not such an aberrant genus, as it was supposed to be. It is closely allied to *Cromyocrinus* and *Agassizocrinus*, and like them has large basals, comparatively small radials, and an unusually large azygous plate, followed by the anal piece and proximal plate of the ventral tube. It differs, however, from both genera in the number of underbasals, and the peculiarities in the radial regions which have been mentioned.

Revised Generic Diagnosis.—Dorsal cup globose; composed of heavy plates. Underbasals three, comparatively large; two of them larger than the other, but not of equal size; the smaller piece placed in a vertical line with the anterior radial (Pl. 6, fig. 5). Basals five, extremely large, very irregular in form; the posterior one heptagonal and larger than any of the rest; that to the left pentagonal; the three others hexagonal. The upper side in four of the plates is angular, in the other truncate, supporting the right postero-lateral radial.

Radials five; irregular in form and size, the postero-lateral one considerably smaller than the others. The two posterior radials as well as the anterior one pentangular, truncate above, and they support a short subquadrangular brachial; the two antero-lateral ones hexagonal, angular above, supporting on each side an arm. The line of articulation between the three former radials and their respective brachials is widely gaping, and the mode of articulation similar to that of all later Poteriocrinidæ. The brachials, although short, are twice as wide at their union with the radials as along their upper ends, which are truncate, moderately concave, each supporting a single arm. The two other radials, which have angular upper faces, are slightly constricted along their upper ends so as to indicate an anchylosis of brachials and radials.

Nothing is known of the ventral surface except imperfect impressions of small pieces. The azygous plate is unusually large, subquadrangular or trapezoidal; placed obtusely between the posterior basal and the right postero-lateral radial; its upper angle, which extends almost to the top of the radials, is slightly truncated and supports the ventral tube, its left upper side abuts against a large subquadrangular anal plate. Column apparently small and circular.

1847. **Tribrachiocrinus Clarkei** (Type of the genus) McCoy, Ann. and Mag. Nat. Hist., Vol. XX, p. 228, Pl. 12, Figs. 2, a.b.c.-Pictet 1857, Traite de Paleont., Vol. IV, p. 321.—Carboniferous.—Australia.

1884. **T. corrugatus** Ratte, Proceed. Linnean Soc. of New South Wales, Vol. IX, Pt. 4.—Carboniferous.—Australia.

b. *Graphiocrinites.*

GRAPHIOCRINUS De Koninck, Rev. i, p. 121.

Graphiocrinus has a bilateral symmetry, and is in some respects higher developed than the preceding genera, owing to the absence of the azygous piece. It has only an anal plate, and this is small and placed between the radials, resting upon the truncate upper side of the posterior basal. The ventral sac is cylindrical, and in *Graphiocrinus rudis* composed of longitudinal rows of subquadrangular pieces. We have not been able to examine the tube in other species, and hence are not aware whether the arrangement of these plates is of generic value. The species heretofore referred to *Graphiocrinus* have but a single brachial and ten arms; we have, however, in our collection an undescribed species with only five arms.

No additional species have been described.

BURSACRINUS M. and W., Rev. i, p. 123.

Syn. *Synyphocrinus* Trautschold, Bull., 1880.

In a paper "Ueber *Synyphocrinus*," Trautschold described a new species from Moscow, for which he proposes the above generic designation. He asserts that it differs from *Poteriocrinus* and allied genera in having "pentagonal, roof-like second radials, and these provided along the ventral side with two thorn-like processes, separated by the tentacle furrow;" that the third radials had similar processes and re-entering angles, overlying and covering the roof of the preceding plate; that the upper truncate side supported two bifurcating plates; that the species had no pinnules, and that the vault rested upon the thorn-like extensions of the third radials. We think Trautschold misunderstood his specimen. From his own figures and descriptions it is evident that the calyx, as in other Fistulata, contained a single radial, and that all succeeding plates were free, and true arm plates. His "second radial" is grooved for the reception of the "tentacle furrow," and, as shown by its form, a regular bifurcating plate, his remarkable "third radial" represents the two proximal arm plates, placed aside of each other, given off from the plate below. That pinnules were present in this species is shown even by the figure in which their faces are plainly represented. The processes at the inner side have no generic value, they are in connection with the articular faces of the plates, and are found, more or less, in all later Poteriocrinidæ. Prof. Trautschold overlooked the only important distinction between his form and *Poteriocrinus.* His species has a single anal plate within the dorsal cup, while *Poteriocrinus* has three. However, in this character *Synyphocrinus* resembles *Graphiocrinus*, and especially the subgenus *Bursacrinus*, which has the same general form, a similar funnel-shaped underbasal cup, and also branching arms.

It is possible that *Poteriocrinus meekianus* Shum. (Swallow's Geol. Rep. Missouri) is a *Bursacrinus*, but it may be a *Barycrinus.* Only the dorsal cup is known.

Additional species :—

*1881. **Bursacrinus cornutus** (Trautschold), **Synyphocrinus cornutus**, Bull. Moscow, Ueber **Synyphocrinus**.—Berg-Kalk. Mjatschkowa, Russia.

(?) Subgen. **PHIALOCRINUS** Trautschold, Rev., i, p. 124.

CERIOCRINUS White (not Koenig).[1]

(Emend. W. and Sp.).

1880. White, U. S. Geol. Surv. under Hayden for 1878. Paleont., Nos. 2–8 (Author's Ed., p. 12).

Syn. *Eupachycrinus* (in part), W. and Sp., 1878; M. and W., 1873.

Syn. *Eriosocrinus* (in part), White, 1879.

Ceriocrinus is very interesting as representing a link between the unsymmetrical *Eupachycrinus* and the symmetrical *Erisocrinus.* The three are very similar, and some of the species cannot be separated even specifically, unless the azygous side is exposed. We were at first inclined to follow Meek and Worthen in placing species with one and three anal (azygous) plates under *Eupachycrinus*, which has three in its typical form, and to separate those only which have no azygous plates within the dorsal cup. Our way of disposing of this question was contrary to the rules laid down by ourselves among other groups, but we took it to be a case of rapid and extravagant development, and as such possibly only of specific value. A similar view, but in a somewhat different direction, was taken by Dr. White, who placed in his *Ceriocrinus* species having an "anal plate" between the radials (none below), together with species in which a similar plate is supported by the radials (beyond the limits of the dorsal cup), and he ranked *Ceriocrinus* as a subgenus of *Erisocrinus.*

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[1] Koenig's genus has not been accepted (see De Loriol, Monogr. des Crin. Foss. de la Suisse, 1877, p. 61).

We are not satisfied whether the piece resting *upon* the radials (White's fig., 5 a) is equivalent to the one *between* the radials (his fig., 5 c), it is at least possible that the former is the anal plate, the latter a plate of the tube, or, as it is generally called, the third anal plate. We, therefore, cannot agree with White in considering the two forms generically identical, and much less specifically. If the difference in the two specimens was to be explained by individual development, that perhaps the anal piece had been resorbed in the adult, the specimens should differ in size, which is not the case. Throughout the coal-measures we find both forms side by side and of nearly equal size, a certain proof that the modification took place in the genus, and not in the individual. We must therefore either separate the two forms generically, or unite both with *Eupachycrinus.*

We stated under *Eupachycrinus* that we separate from that genus all species with a single azygous plate, and these we place under *Ceriocrinus.* Contrary to White, however, we exclude those species in which that plate rests upon the radials, which we place under *Erisocrinus.* Whether *Erisocrinus* and *Ceriocrinus* are full genera or only subgenera of *Eupachycrinus*, or the latter two of *Erisocrinus*, is a question which we leave open.

Ceriocrinus occupies the same relative position to *Graphiocrinus* as *Zeacrinus* to *Woodocrinus*, and as *Eupachycrinus* to *Scytalocrinus*, their differences being more of degree than of kind.

We refer to *Ceriocrinus* the following species:—

*1875. **C. Craigii** (Worthen), **Eupachycrinus Craigii**, Rev. i, p. 138.

*1873. **C. fayettensis** (Worthen), **Eupachycrinus fayettensis**, Rev. i, p. 138.

1866. **C. inflexus** (Geinitz), **Cyathocrinus inflexus**, Carbon. and Dyas in Nebraska, p. 62, Pl. 4, fig. 20; White, 1876, **Scaphiocrinus carbonarius** (not M. and W.). Powell's Rep. Geol. Uinta Mts., p. 89; White 1880, **Ceriocrinus inflexus**, 12th Ann. Rep. Terr., by Hayden for 1878 (author's ed., p. 127).—Carboniferous. Grand and Green River. Utah and Nebraska.

*1858. **C. hemisphericus** (Shum.), **Scaphiocrinus** (?) **hemisphericus**, Trans. St. Louis Acad. Sci., vol. i, p. 221. Meek 1872, Final Rep. on Nebraska, p. 147, Pl. 5, Fig. 4, and Pl. 7, fig. 1; also Geol. Rep. Ill., iii, p. 561, Pl. 24, fig. 5.—Carboniferous. This species we took (Rev i, p. 138) to be a synonym of **Eupachycrinus Craigii**, but, if Meek's identification is correct, it is a good species. The plates, which in the latter are strongly spiniferous, are in the other but little convex.

1880. **C. planus** (White), **Erisocrinus planus** (Type of the genus), Proc. U. S. Nat. Mus., vol. ii, p. 257, figs. 6–7. White 1880, **Erisocrinus** (**Ceriocrinus**) **planus**, 12th Ann. Rep. Terr., by Hayden, for 1878, Author's copy, p. 127, Pl. 35, fig. 5 c (not 5 a = **Erisocrinus** White).—Coal measures. Humbold River, Ky.

c. *Erisocrinites.*

ERISOCRINUS Rev. i, p. 139.

Admitting *Ceriocrinus*, we place under *Erisocrinus* all species in which no azygous plates are represented at the dorsal side, but we also include those in which a plate of the ventral tube rests upon the radials. In all probability was the latter piece always present in this genus. The structure of the arms is the same as in *Encrinus* and *Eupachycrinus.*

The only new species to be added in the list is:

*1880. *Erisocrinus Whitei* W. and Sp., *Erisocrinus* (*Ceriocrinus*) *planus* (in part). White 12th Ann. Rep. Terr. by Hayden for 1878 (Author's copy, p. 127, Pl. 35, Fig. 5a (not 5c = *Ceriocrinus planus*). Distinguishing the specimen Fig. 5c specifically, we propose the above name for the other to avoid confusion.

STEMMATOCRINUS Trautschold, Rev. i, p. 141.

In Part I, we separated *Stemmatocrinus* from *Erisocrinus* only subgenerically, from the fact that it agrees with that genus in all its particulars, except that the underbasals consist of a single plate instead of five in the other, which we explained by anchylosis. This explanation was doubted by Carpenter, who in the Chall. Rep., p. 152, says: "the plate in question appears to me much more truly represented by the central pentagonal piece on which the basals rest, and it is obviously what Schultze calls 'eine fünfseitige aus der Erweiterung des obersten Säulengliedes gebildete Platte.'" And again: "the analogue of the development of the other calyx plates indicates that they (the underbasals) are primitively five separate plates like their homologues in the apical system of Ophiurids and starfishes; and a theory which would homologize them with a plate that first appears as a simple ring seems to me to run counter all true notions of morphology." We confess that we do not understand Carpenter's argument, for we believe *Stemmatocrinus* had primitively five plates, which were united by anchylosis leaving no vestige of the sutures. Similar cases of anchylosis among basals and underbasals have been observed among other Palæocrinoidea and even among Neocrinoidea. In one of the two species of the recent genus *Rhizocrinus*, the basals are distinctly divided, in the other united by anchylosis. In *Platycrinus* it is absolutely impossible to discover a suture between the basals, the anchylosis between the plates is complete, and only in comparatively few species the place of union is still indicated by a depression. Such is the case also in *Dolatocrinus* and *Stereocrinus.* In *Agassizocrinus* an anchylosis takes place between the underbasals, all suture lines disappear in the older specimens. In *Eupachycrinus ornatus* and *Eupachycrinus gemmiformis*, which occur in the same bed with *Stemmatocrinus cernuus*, the sutures are frequently not visible, and the plates apparently constitute a solid disk which in form and proportions resembles that of *Stemmatocrinus.*

STEMMATOCRINUS TRAUTSCHOLDI[1] nov. sp.

(Pl. 9, figs. 7 and 8.)

Of large size. Dorsal cup subglobose; plates heavy. Underbasals of medium size, anchylosed, forming a solid pentangular plate with concave sides, the latter with a somewhat waving outline. The plate is slightly convex, except the columnar attachment which is rather deeply impressed. There are absolutely no sutures visible either upon the dorsal aspect or upon the inner floor. The centre is perforated by a minute star-shaped canal, with rays directed radially. Basals about as long as wide, pentagonal in outline, but really hexagonal, the two lower sides having together the length of the four others; their upper sides convex.

Radials once and a half to twice as long as wide; concave along their basi-radial suture, along their distal side slightly excavated. The articular faces are directed upward and occupy nearly the full width of the plates. The articulation with the brachials is by a transverse ridge with a central canal and shallow fossæ. Brachials two, both extremely short but deep. They are followed by several short, cuneate pieces. The upper part of the arms is not known.

The specimens show traces of interradial plates resting against the inner edges of two radials, of which the places of attachment are plainly visible (Pl. 9, fig. 8), and detached plates were placed aside of them.

Geological Position, etc.—From the Keokuk limestone near Nashville (White's Creek), Tenn. The original specimens, some thirty in number, are in our collection.

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[1] In honor of Prof. Trautschold of Moscow, Russia, the author of the genus, who had the kindness to send us a beautiful series of the Mjatschkowa Crinoids.

Family XXIII.—ENCRINIDÆ Pictet.

J. S. Miller refers the genus *Encrinus*, together with *Pentacrinus*, to his Articulata, *Poteriocrinus* to his Semiarticulata. Zittel, and after him De Loriol, to the Articulata of Müller; while they refer the closely allied *Poteriocrinus* to Müller's Tessellata. The mode of articulation is identical in *Encrinus* and the later Poteriocrinidæ, as pointed out in our general remarks on the Fistulata, and our notes on the Poteriocrinidæ. A separation, therefore, in the sense of either Miller or Müller, cannot be carried out practically. A ventral covering was never found to be preserved in *Encrinus*, and as the same thing happens to be a rule among all fossil Neocrinoidea, it was postulated that this genus had an open perisome, and as such was a Neocrinoid. However, the ventral surface is also unknown among the Poteriocrinidæ, which are universally regarded as Palæocrinoids. Neither is the absence of azygous plates in the dorsal cup exclusively found among Neocrinoidea—we need only allude to *Codiacrinus*, *Ceriocrinus* and *Erisocrinus*—nor the presence of two brachials (three radials), which was pointed out by Carpenter a good distinctive character. The latter is a very common occurrence among the Poteriocrinidæ, among which we failed even to make it a generic distinction. We are willing to admit that *Encrinus* constitutes a transition form toward the Neocrinoidea, it is even possible that in the adult the interradials became partly or wholly resorbed, but it is otherwise so closely connected with the Poteriocrinidæ that we must regard it a Palæocrinoid or place also the Poteriocrinidæ among the Neocrinoidea.

Pictet, and after him Dujardin and Hupé, placed *Encrinus* under the Pycnocrinidées, which they subdivided into *Encriniens*, *Apiocriniens* and *Pentacriniens*. This division was accepted by De Loriol in his work on the Swiss Crinoids, but in his later monograph on the Crinoids of France he followed Zittel, who made it the type of a distinct family of the Neocrinoidea. All writers preceding us, with the exception of Zittel, described *Encrinus* with 3×5 radials, although the two upper plates are laterally free,* and morphologically and functionally identical with the brachials of the Poteriocrinidæ.

We agree with De Loriol and Zittel that Von Meyer's genus *Chelocrinus*, which is based on species having a second bifurcation in the arms, cannot be sustained. His *Dadocrinus*, however, seems to be a good generic form, and will be treated by us as such. We separate from the Encrinidæ Picard's *Encrinus Beyrichi*, which we refer to the Belemnocrinidæ. Von Meyer's genus *Calathocrinus*, which some writers assert to be identical with *Encrinus*, is known only from a single imperfect specimen.

ENCRINUS (Lamarck), J. S. Miller.

1816. Lamarck, Descr. des Animaux sans vertebrés (Ed. i), vol. ii, p. 435.
1821. Miller, A Natural History of the Crinoidea, p. 37.
1823. Schlotheim, Nachtr. z. Petrefactenkunde, p. 335.
1826–33. Goldfuss, Petrefacta. Germ., vol. i, p. 177.
1857. Pictet, Traité de Paléont. (Ed. ii), vol. iv, p. 337.
1857. Beyrich (in part), Ueber die Crinoid. d. Muschelkalk (Berl. Acad. d. Wissenschaften).
1876. Quenstedt, Petrefactenk. Deutschlands, vol. iv, p. 455.
1877. De Loriol, Monogr. Crin. Foss. de la Suisse, p. 7.
1879. Zittel, Handb. d. Palæontologie, i, p. 383.
1882. De Loriol, Paleont. Francaise (Ser. I), Crinoidea, p. 6.

Syn. *Entrochus* and *Trochites* Agricola; *Chelocrinus* and perhaps *Calathocrinus* v. Meyer, (?) *Tetracrinus* Cotullo, *Flabellocrinus* Klippstein, and (?) *Cassianocrinus* Laube.

Generic Diagnosis.—Dorsal cup regularly pentamerous; short, saucer-shaped; composed of 5 underbasals, 5 basals and 5 radials, all equal in size and form; there being no azygous plates.

Underbasals minute, rhomboidal, forming together a five-rayed star; entirely covered by the top stem joint. Basals small, hexagonal, for the greater part hidden by the column. They rest with their lower sides between two underbasals, are laterally united, support with their sloping upper sides the radials, and form jointly a pentagon with almost straight sides. The radials are large, subquadrangular; their distal sides once and a half as wide as their lower or proximal sides; they are thick, heavy, the faces toward the basi-radial suture somewhat hollowed out, showing shallow fossæ, while their lateral faces indicate a syzygial union.

Brachials two, the first quadrangular, the other pentangular; they are heavy plates with straight lateral faces by which they abut against the apposed faces of adjoining plates. The upper plate is axillary, supporting two arms, which either remain simple, or of which one or both from the second plate branch again. Arms massive, composed of short transverse plates, which in their upward arrangement change from quadrangular pieces with strictly parallel sides to cuneiform and gradually interlocking plates; some of them, however, possess a fully developed biserial arm structure. The union between radials and first brachials, and also between the axillaries and proximal arm plates is by articulation, the apposed faces having highly developed facets with transverse ridges, and a central canal and fossæ. The two brachials are united by syzygy, as also the two proximal arm joints.

In *Encrinus*, the inner floor of the dorsal cup is grooved by five primary canals, which, as they pass outward, bifurcate within the basals, and the ten secondary canals thus formed proceed to the radials, and thence after dividing again to the arms. These grooves which are by no means restricted to *Encrinus* or to the Neocrinoidea, are, according to P. H. Carpenter (his paper on the Oral and Apical system of Echinoderms, Quart. Journ. Microsc. Sci. London, 1880, p. 362), passages for the fibrillar cords going out from the interradial angles of the chambered organ.

Nothing is known of the ventral surface, except in a young specimen in which we thought to observe a few plates of a ventral tube. The interradial plates, owing to the large size of the articular facets, must have been small at any time, and possibly were absorbed in the adult. Column composed of circular joints without cirrhi.

Geological Position, etc.—Muschelkalk, Trias. Germany and Switzerland.

We recognize the following species:—

1847. **Encrinus aculeatus** v. Meyer, Leonh. Bronn's Jahrb., p. 576; also Palæontogr. i, 1851, p. 262, Pl 32, fig. 1; also Beyrich 1857, Crin. des Muschelk., p. 38, Pl. 1, figs. 16 a, b.—Muschelkalk, Trias. Upper Silurian, Germ.

1850. **E. Brahlii** Owerweg, Zeitschr. d. deutsch. geol. Gesellschaft, vol. ii, p. 6; also Beyrich, 1857, Crin. des Muschelk., p. 39, Pl. 2.—Muschelkalk, Trias. Rüdersdorf, Germ.

1856. **E. Carnalli** Beyrich (**Chelocrinus Carnalli**), Zeitsch. d. deutsch. geol. Gesellsch. p. 10; also Leonh. Bronn's Jahrb. (1856), p. 28.—Muschelkalk, Trias. Rüdersdorf, Germ.

1877. **E. Grephini** De Loriol, Crinoides Foss. de la Suisse, p. 12.—Muschelkalk. Meyenbühl, near Basle, Switzerl.

1816. **E. liliiformis** Lamarck, Descr. des Animaux sans vertébres, 1 édit., vol. ii, p. 435, Schlotheim 1820, Petrefactenk., p. 335.—Agassiz, 1835, Prodr. Mem. Soc. Sci. nat. de Neuchatel, vol. i, p, 195.—Dujardin (in Lamarck), 1840, Descr. des Animaux sans vertébres, 2me édit., vol. ii, p. 651.—Desor, 1845, Notice sur les Crinoides Suisses, p. 3; Bull. Soc. Sci. nat. de Neuchatel, vol. i, p. 211.—Pictet, 1857, Traité de Paléont., 2me édit., vol. iv, p. 337, Pl. 102, fig. 4.—Beyrich, 1857, Ueber die Crin. des Muschelkalkes, p. 1, Pl. 1, fig. 1–12.—Strombeck, 1856, Ueber Missbildungen von **E. liliiformis,** Palæontographica, vol. iv, p. 168, Pl. 31.—Dujardin et Hupé, 1862, Suites à Buffon Echinoderms, p. 164.—Ooster, 1865; Syn. des Echin. des Alpes Suisses, p. 10; Moesch, 1867, der Aargauer Jura, pp. 26, 27–30 (Beiträge z. Geol. Karte der Schweiz, 4te Liefer.); Greppin, 1870, Descr. géol. du Jura bernois, p. 13.—Moesch, 1874, der südliche Aargauer Jura, p. 4, Anhang, p. 6.—Quenstedt, 1876, Petrefactenk. Deutschl., vol. iv, p. 455, Pl. 106, figs. 143–184.—Bronn, Klassen des Thierreichs (Actinozoa), vol. ii, Pl. 29, fig. 3.—De Loriol, Crinoid. Foss. de la Suisse, 1877, p. 9.—Zittel, Handb. d. Palæont., i, p. 383.—Muschelkalk Trias. Germany and Switzerland.

Syn. **Lily encrinite,** 1808, Lamarck, Organ. Remains, vol. ii, p. 14, figs. 1–3.

Syn. **Encrinites moniliformis** Miller, 1821, A Nat. Hist. of the Crinoidea, p. 37, Pl. 1, 2, 3; also Goldfuss, 1826–33, Petrefacta Germ., vol. i, p. 177, Pl. 54.

Syn. **Pentacrinus entrocha** Blainville, 1834, Manual d'Actinologie, p. 257, Pl. 28, fig. 2, and ibid., p. 657.

Syn. **Encrinus entrocha** D'Orbigny, 1839, Monogr. des Crinoid., Pl. 18; also D'Orbigny, 1850, Prodrome, vol. i, p. 178.

1835. **Encrinites Schlotheimi** Quenstedt, Wiegm. Arch., ii, p. 227, vol. 4, fig. 1; also 1852, p. 614; also **Chelocrinus Schlotheimi** H. v. Meyer, 1837, in Leonh. Bronn's Jahrb., p. 316, and Mus. Senkenb., ii, 1837, p. 262, vol. 16, fig. 9; also Bronn, Lethæa (Edit. 3), Bd. iii, 1851, p. 48, vol. 13, fig. 3.—E. Beyrich. Ueber die Crinoid. des Muschelk., 1857, p. 34, vol. i, fig. 13.—Muschelkalk, near Göttingen, Germany.

Syn. **Chelocrinus pentactinus** H. v. Meyer, 1837, Leonh. Bronn's Jahrb., p. 316; also 1837, Mus. Senkenb., ii, p. 262, vol. 16, fig. 8; also L. v. Buch, 1848, in Leonh. Bronn's Jahrb., p. 690.

Syn. **Encrinus liliiformis,** Ueber Missbildungen, Strombeck, 1849, Zeitschr. d. deutsch. geol. Gesellsch., i, p. 163; 1855, Palæontogr., iv, p. 177.

Syn. **Encrinus pentactinus,** Bronn, 1837, Leonh. Bronn's Jahrb, p. 30, vol. 2, 1851; also Lethaea Geogn. (Ed. 3), Bd. iii, p. 47, Pl. 13, fig. 1.—Also Geinitz, 1838, Leonh. Bronn's Jahrb., p. 530.

DADOCRINUS v. Meyer.

1847. v. Meyer, Leonh. Bronn's Jahrb., p. 575.

1851. v. Meyer, Palæontographica, i, p. 266.

Syn. *Encrinus* (in part), L. v. Buch, Bericht Berl. Acad., 1845, p. 27; also Beyrich, Ueber Crinoideen des Muschelk., p. 42; also De Loriol, 1877, Crin. Foss. de la Suisse, p. 8; also Zittel, Handb. d. Palæont., i, p. 383.

This genus has not been accepted by Beyrich, Zittel, nor De Loriol. It was proposed by H. v. Meyer for a species previously described by L. v. Buch under the name of *Encrinus gracilis.*

The latter has a turbinate calyx, underbasals (observed by Beyrich not by H. v. Meyer), an apparently round stem; ten arms which are not very closely folded, composed of cuneiform flat joints, and pinnules which are alternately arranged. The totally different form of the dorsal cup seems to us sufficient to warrant the generic separation. L. v. Buch's typical specimen came from Recaoro, Italy, and was supposed by Beyrich to be identical with certain fragments which had been discovered in the Trias of Upper Silesia, too imperfect, however, for critical comparison. From this locality a more perfect specimen was found lately by Mr. H. Kunisch, who figured and described it in the Zeitschrift d. deutsch. geol. Gesellsch. Jahrg., 1883, under the title "Ueber den ausgewachsenen Zustand von *Encrinus gracilis* Buch." We cannot altogether agree with Mr. Kunisch in his views. The Silesian species is, in our opinion, essentially different from the Italian one. The column is pentagonal in place of circular; the arms rounded, angular at the outer face, and the pinnules are given off alternately from every second joint, every other one being united by syzygy; contrary to the typical species, which has flat arms, cuneiform joints, and of which every joint is pinnule-bearing. The distinctions are so obvious that a specific separation is necessary, and we propose for the Silurian species the name *Dadocrinus Kunischi.* To explain the diversity in the arm-structure by individual growth is at variance with the observations made upon recent as well as fossil Crinoids. We agree that the arms undergo important modifications in their growth, but we do not find cuneate arm joints turning into quadrangular ones, though frequently the opposite is the case; nor that single joints are undergoing segmentations and are uniting again by syzygy. The angles of the column in *Dadocrinus Kunischi* are directed interradially, thus proving theoretically the base to be dicyclic, which could not be ascertained from the specimen.

We propose the following:—

Revised Generic Diagnosis.—Form of dorsal cup obconical. Underbasals small, covered by the column; basals forming an elongate hexagonal cup. Radials comparatively smaller than in *Encrinus*, but yet twice as large as the basals. Brachials in number, form and articulation as in *Encrinus.* Arms long, uniserial, composed of single or compound joints, the latter united by syzygy; pinnules long, and placed far apart. Column round or pentangular, with or without cirrhi.

1845. **Dadocrinus gracilis** (L. v. Buch), v. Meyer, **Encrinus gracilis**, Bericht d. Berl. Acad., p. 27.—**Dadocrinus gracilis** H. v. Meyer (Type of the genus), 1847, Leonh. Bronn's Jahrb., p. 575; also Palæontogr., i, p. 266, Pl. 31, fig. 2 and Pl. 32, figs. 4, 5, 6; Pl. 31, figs. 9, 13; Pl. 32, fig. 7.—**Encrinus gracilis** Beyrich, Ueber die Crin. d. Muschelk., p. 42, Pl. 1, fig. 15.—Muschelkalk Trias. Recaoro, Italy.

*1884. **D. Kunischi** W. and Sp. Described and figured by Mr. Kunisch as **Encrinus gracilis**, Zeitschr. d. Deutsch. geol. Gesellsch., Jahrg., 1883, p. 195, with plate.—Muschelkalk. Upper Silesia.

Family XXIV.—ASTYLOCRINIDÆ Roemer.

The Astylocrinidæ embrace only the genus *Agassizocrinus*, which Pictet referred to the Comatulidæ, Zittel to the Poteriocrinidæ. Roemer included in this family *Marsupites*. We place here provisionally the genus *Edriocrinus*, which, however, in all probability, forms a family by itself, being sessile in early life, and having no underbasals.

AGASSIZOCRINUS Troost.

(Pl. 5, fig. 17.)

1850. Troost, Journ. Am. Ass. Adv. Sci. Camb. Meeting, p 60.
1851. Owen and Shum., Journ. Acad. Nat. Sci. Phila. (n. ser.), vol. ii.
1853. Shumard, Marcy's Rep. Red River Exped., of Louisiana, p. 173.
1852. Owen and Shum., Geol. Rep. Ia., Wisc. and Minn., p. 597.
1858. Hall, Geol. Rep. Iowa, vol. i, Pt. ii, p. 684.
1873. Worthen, Geol. Rep. Illinois, vol. v, p. 556.
1874. Meek, Amer. Journ. Sci. (Ser. 3), vol. vii, No. 41, p. 484.
1879. Zittel, Handb. d. Palæontologie, i, p. 361.
Syn. *Astylocrinus*, 1854, F. Roemer, Leth. Geogn. (Ausg. 3), p. 229; also Dujardin and Hupé, 1862, Hist. natur des Zooph. Echin., p. 159.

The name *Agassizocrinus* appears in Troost's List of the Crinoids of Tennessee, but the genus was not defined until 1853, when Shumard, in Marcy's Report on the Red River Expedition, published Troost's MS. of *Agassizocrinus dactyliformis*, which he accompanied with a short generic description of his own. *Astylocrinus* was proposed by Roemer as late as 1855, when he described under the name *Astylocrinus lævis*, a nearly perfect specimen from a plaster cast, sent to him by Shumard's brother with Troost's name *Agassizocrinus dactyliformis* attached. There cannot be the least doubt as to the priority of *Agassizocrinus*, but it is probable that Roemer's specimen, which was Troost's type, is specifically distinct from the one figured by Shumard under Troost's name, and hence we recognize Roemer's specific name.

Detached plates of *Agassizocrinus* are found in great abundance throughout the Kaskaskia group, but perfect calices are extremely rare. The cause of this is perhaps explained by the mode in which the different plates are united with one another. Only the underbasals seem to have been united by common suture, and these, as a rule, are the only plates which are not found disconnected in the fossil. The apposed faces of the succeeding plates are vertically and horizontally provided with rather conspicuous ramifying furrows, which enter the surface of the plates (Pl. 5, fig. 17). The ramifications vary somewhat, even among corresponding plates, but those of apposed faces correspond with each other, and together form small tunnels, which branch once or twice, growing narrower at their outer ends. Between basals and underbasals there are generally three of these furrows to each plate; but they unite to one on entering the underbasal cavity, where they seem to communicate with certain pits or openings, which have been overlooked by previous writers.

The underbasals form an almost solid disk, with a shallow, cup-shaped inner cavity. The latter contains six deep pits or chambers, closed at the bottom, a central one surrounded by five others. These pits either contained the lower part of the chambered organ, or they indicate where the vessels extended down from the chambers into the larval stem. It is possible that the axial canals which descend from the body cavity were lodged in these chambers, together with the vessels of the latter, and this might explain the apparent communication of the pits with the radiating furrows above mentioned. But it may be possible, also, that the furrows lodged groups of ligamentous fibres, by which the union of the plates was rendered firmer and closer than it would be when only two smooth surfaces were apposed. The plates, however, as a general rule, are found to be disconnected, and the radials at their lateral faces possess fossæ, thus proving there existed a certain degree of mobility between the calyx plates generally. Similar ramifying furrows were discovered by us in the genus *Barycrinus* between the apposed articular facets of radials and brachials, plates which evidently were not united by a close suture.

Agassizocrinus in the earlier stages was attached by a column, but led a free life later on, when the scar to which the stem had been attached was gradually obliterated, so as to leave no traces behind. The secretion of calcareous matter extended over the greater part of the underbasal disk, which became more elongate, until at last the suture lines between the plates disappeared entirely, although in the young Crinoid these are well marked. Owing to the very considerable changes of form, which occur in the growing animal, it is extremely difficult to identify the species of this genus, and we fear that several of those described represent merely different stages of the same species.

Agassizocrinus globosus and *A. papillatus* Worthen have been referred by us to *Cromyocrinus;* his *A. hemisphericus*, in which the underbasals do not extend beyond the column, is either *Eupachycrinus* or *Scytalocrinus*, probably the latter.

Generic Diagnosis.—Form of calyx elongate, composed of massive plates, and containing a comparatively small visceral cavity.

Underbasals extremely large; obconical; almost solid; with a very small inner cavity. Young specimens have an articular scar for the attachment of a column, pierced by an axial canal; this, however, becomes obliterated soon after the Crinoid enters free life. The inner cavity lodges the chambered organ, and is provided with six deep pits, a central one surrounded by five others, which either constitute the chambers of this organ or their lower extensions.

Basals large, three of them hexagonal, two heptagonal, but they appear to be pentagonal and hexagonal, owing to the convex form of the two lower sides. The heptagonal plates enclose, and partly support, the azygous pieces, consisting of the azygous plate proper, which has a sloping position and is generally large, a smaller anal plate, and the first plate of the ventral tube. The size and form of the tube is not known, but it was evidently small, perhaps similar to that of *Cromyocrinus*, with which *Agassizocrinus* agrees in the arrangement of its azygous plates.

Radials unusually small; wider than high; the upper face truncate; they are all pentagonal, four of them of nearly equal size, the fifth one considerably smaller and of irregular form. The articular facets are on a level with the outer edges of the plates, they are somewhat extended inward, and pierced by a transverse axial canal. The articulation between calyx and arms is regularly bifacial, resembling that between the oval stem-joints of *Platycrinus*. The brachials are single, axillary, and abut laterally against each other. The arms are long, rather stout, rounded, and composed of short, cuneate pieces. Pinnules strong.

The mode of union between the plates of the calyx is variable.

The underbasals were united by a common suture, the lines of which in the adult Crinoid are completely obliterated. The basals possess, among each other, and where they meet the underbasals and radials, ramifying furrows along their faces, which, together with similar furrows on apposed faces, form tunneled passages, probably containing ligament; the lateral faces of the radials, however, are excavated for fossæ.

Geological Position, etc.—Restricted, so far as known, to the Kaskaskia group of America.

The following species have been described :—

1873. **Agassizocrinus carbonarius** Worthen, Geol. Rep, Ill., v, p. 566, Pl. 24, fig. 4. —Coal measures. Shelby Co., Ill.

1873. **A. chesterensis** Worthen, Geol. Rep. Ill., v, p. 558, Pl, 21, fig. 9.—Kaskaskia gr. Chester, Ill.

1851. **A. conicus** Owen and Shum., Journ. Acad. Nat. Sci. Phila. (n. ser.), vol. ii, p. 93, Pl. xi, fig. 6.—Geol. Rep. Iowa, Wisc., and Minn., p. 597, Pl. 5 b, fig. 6. —Meek and Worthen, 1873, Geol. Rep. Illinois, Pl. 21, fig. 8.—Kaskaskia limest. Chester, Illinois.

1858. **A. constrictus** Hall, Geol. Rep. Iowa, vol. i, p. 687, Pl. 25, fig. 10.—Kaskaskia gr. Chester, Illinois.

1850. **A. dactyliformis** Troost, Type of the genus. List Crin. Tenn. Cambr. Meet., p. 60; Shum. 1853, Marcy's Rep. Red River, p. 173.—Hall 1858, Geol. Rep. Iowa, vol. i, p. 685, with diagram.—Kaskaskia gr. Chester, Ill., and Crittenden Co., Ky.

1858. **A gibbosus** Hall, Geol. Rep. Iowa, vol. i, p. 686, Pl. 25, fig. 6.—Worthen 1873, Geol. Rep. Ill., v, Pl. 21, fig. 11.—Kaskaskia gr. Chester, Ill.

A. gracilis Troost is a catalogue name.

*1855. **A. lævis** (Roemer), **Astylocrinus lævis** (Second type of the genus), Leth. Geogn. (Ausg. 3), p. 229, Pl. 4, fig. 13.—Kaskaskia gr.

*1852. **A. occidentalis** Owen and Shum. (**Poteriocrinus occidentalis**), Journ. Acad. Nat. Sci. Phila. (n. ser.), vol. ii, p. 92, Pl. xi, fig. 5; also Geol. Surv. of Iowa, Wisc. and Minnes., p. 596, Pl. v *b*, fig. 4.—(Probably a young specimen of **A. gibbosus** Hall).—Kaskaskia gr. Chester, Illinois.

A. pentagonus Worthen, Geol. Rep. Ill., v, p. 556, Pl. 21, fig. 10.—Kaskaskia gr. Chester, Illinois.

1852. **A. tumidus** Owen and Shum., Journ. Acad. Nat. Sci. Phila., vol. ii, p. 90, Pl. xi, fig. 3; also 1852, Geol. Surv. of Iowa, Wisc. and Minnes., p. 595, Pl. v *b*, fig. 3.—Kaskaskia gr. Chester, Illinois.

(?) EDRIOCRINUS Hall.

1859. Hall, Pal. Rep. N. York, vol. iii, pp. 199 and 143.
1862. Hall, 15th Rep. N. York. St Cab. Nat. Hist., p. 115.
1868. Meek and Worthen, Geol. Rep. Illinois, vol. iii, p. 119.
1879. Zittel, Handb. d. Palæontologie, i, p. 350.
1883. P. H. Carpenter, Ann. and Mag. Nat. Hist. (May, 1883), p. 333.

Edriocrinus led a life similar to that of *Agassizocrinus*, being attached in its larval state, and free-floating in the adult. It differs from that genus, however, in having no underbasals and no stem, being simply attached by the basals. In its sessile state it resembles the recent genus *Holopus*, with which it also agrees in having an undivided base.

Generic Diagnosis, etc.—Sessile in its larval state; free-floating in the adult, being attached by the lower end of the basals.

Basals unusually large, elongate, closely anchylosed so as to show no suture lines at the outer face; internally, however, there are indications that the base might have been bisected. In the young animal the form of the base is irregular and linear, in the adult subglobose or deeply bowl-shaped, and the scar by which the animal was attached, becomes totally obliterated by heavy deposits of calcareous matter. Owing to this deposit the outer form of the base differs considerably from the form of the inner cavity, which grows gradually narrower toward the bottom, and frequently ends in a sharp point. The walls are massive at their lower parts, thin at the upper edge, which shows six excavated faces for the attachment of five radials and an anal plate.

Radials comparatively small, quadrangular, articular facet but slightly excavated, occupying the full width of the plates; provided with a transverse articular ridge. The anal plate is in line with, and has the length of the radials, but is narrower; it supports a small plate, but beyond that nothing is known of the anal apparatus. The structure of the ventral surface has not been observed.

The arms are broad at the base, composed of extremely short transverse pieces, of which ten or more occur between the first bifurcation. Nothing is known of pinnules, nor of the condition of the ventral furrow.

Geological Position, etc.—*Edriocrinus* occurs in the Helderberg group of America, in which portions of the basal cup are rather abundant.

1859. **Edriocrinus pocilliformis** Hall, Pal. Rep. N. York, iii, p. 121, Pl. 5, figs. 8–12; also 1868, Geol. Rep. Illinois, iii, p. 370, Pl. 7, figs. 5 *a*, *b*.—Lower Helderberg gr. Albany, New York and Perry Co., Mo.

1862. **E. pyriformis** Hall, 15th Rep. N. Y. St. Cab. Nat. Hist., p. 116, Pl. 1, figs. 23 and 24.—Upper Helderberg gr. Utica, New York.

1859. **E. sacculus** Hall, type of the genus. Pal. Rep. N. York, vol. iii, p. 143, Pl. 87, figs. 1–22.—Oriskany sandst. Cumberland, Maryland.

Family XXV.—CATILLOCRINIDÆ W. and Sp.

The group of Crinoids for which we propose the name Catillocrinidæ consists only of the genera *Catillocrinus* and *Mycocrinus*, which have been distinctly separated by all previous writers. *Catillocrinus*, which was described by Meek and Worthen as closely allied to *Symbathocrinus*, was referred by Zittel and De Loriol to the Pisocrinidæ, which we regard as a mere subdivision of the Symbathocrinidæ. The form, when we include the arms, is similarly cylindrical, the arms rest likewise directly upon the first radials, and are composed of a single series of plates. *Pisocrinus* even has irregular radials, which is so characteristic of this family, but beyond that the two groups are quite distinct. *Mycocrinus*, according to Schultze, forms a family by itself. He took it to be a Crinoid without arms, which, in place of arms, he thought had been provided along the ventral surface with numerous ambulacral grooves. Zittel, and also De Loriol, have placed *Mycocrinus* among the genera which were said to be imperfectly known.

In the Catillocrinidæ, the calyx is composed of only two series of plates, and these are most remarkable for their extremely irregular form and distribution. The radials are massive, especially at the upper margins, where they are transversely truncated on the same plane all round. The radial plates differ in form and size. Those of the two antero-lateral rays, as a rule, are much larger than the three others, but, while at their upper margin they are from three to six times as wide as the others, all are at the basi-radial suture about equal in width. The anterior, and both postero-lateral rays, rarely possess more than one arm each, but in the two antero-lateral ones the arms are always numerous. Every arm articulates directly upon the truncate upper margin of the radial without the aid of axillary pieces, and remains simple from the base up. The arms are in contact all around the calyx, and are composed of a single series of very similar pieces. They connect with the inner cavity by a peculiar groove, which follows the truncate upper face of the radials. This groove contains the ambulacral canal and food passage, and there is underneath, separated by a solid partition, another groove, which near the inner margin penetrates the plate, and takes a distinctly downward course toward the inner cavity, which throughout this family is exceedingly small.

The ventral surface has not been observed, but there is sufficient evidence to prove that it was similar to that of the other Fistulata.

Catillocrinus has its closest affinities with *Calceocrinus.* The radials of the three anterior rays agree in form and distribution so closely with the radials of *Calceocrinus*, that we thought at first that it also possessed but three rays, and that the two irregular plates toward the posterior side were anals and not radials. This interpretation had to be given up when we found both these plates to be arm-bearing. In *Calceocrinus* the postero-lateral rays are entirely absent or transformed into anal plates; while in *Catillocrinus* those rays are represented in a rudimentary form.

The Catillocrinidæ are meagre in forms and belong to the rarest Crinoids. They are restricted, so far as known, to the Devonian of Europe and to the Subcarboniferous of America.

CATILLOCRINUS Troost.

(Pl. 5, figs. 15, 15 *a* and 16.)

1850. Troost, List. Crin. Tenn. Proc. Amer. Assoc. Ad. Sci., p. 60.
1860. Shumard, Trans. Acad. Sci. St. Louis, vol. ii, p. 358.
1868. Meek and Worthen, Geol. Rep. Ill., vol. iii, p. 465.
1873. Meek and Worthen, Ibid., vol. v, p. 504.
1879. Zittel, Handb d. Palæontologie, vol. i, p. 348.
1882. De Loriol, Paléontologie Française, Crinoids, vol. xi, p. 46.
Syn. *Nematocrinus* Meek and Worthen, 1866, Proc. Acad. Nat. Sci. Phila., p. 251.

Troost published the name *Catillocrinus* in his List of the Crinoids of Tennessee, without generic diagnosis. The first description was given in 1866, by Shumard, in a foot-note to his Catalogue of the Palæozoic Fossils of North America, from specimens of *Catillocrinus Tennesseæ.* He described the calyx as composed of three series of plates: the "basals" which were said to be covered by the column, and the "primary" and "secondary radials."

Through the kindness of the late Dr. James Knapp of Louisville we have had an opportunity to examine several well preserved calices of the above species, and can state positively that it has but two series of plates. It seems that Shumard took the proximal joint of the column, which is generally attached, for basal plates, and the edges of the basal disk proper for "primary," the true radials for "secondary" radials.

Of *Catillocrinus Wachsmuthi* no descriptions were given of the plates in the calyx, but the arm structure of the genus was here for the first time described. Meek and Worthen, who had not seen Shumard's description of *Catillocrinus*, and being unacquainted with the arrangement of plates, referred their species at first to *Symbathocrinus*, not, however, to the typical form, but to a new subgenus, for which they proposed the name *Nematocrinus*. On a republication of the species, in vol. iii, of the Geological Report of Illinois, the above name was abandoned, and the species placed under *Catillocrinus*.

In *Catillocrinus Bradleyi*, Meek and Worthen undertook to describe also the plates of the calyx, but without applying to them their proper terms. They simply designated them as plates of a first and of a second series, except a few plates in the second series which they introduced as "anals (?)." Of the five plates in this series, three are easily recognized as radials, but also the two others, although much smaller and very irregular in form, are radials, as both are arm-bearing.

The one toward the right supports at one end an arm, at the other an elongate narrow anal plate, which abuts against the sides of the proximal arm joints, and has nearly their form, being only somewhat larger. Bigsby (Thesaurus Devonico-Carboniferus, p. 224) places *Catillocrinus* as a synonym of *Calceocrinus*.

We propose the following:—

Revised Generic Diagnosis.—General form, when the arms are folded, elongate-cylindrical. Calyx in form of a shallow basin or cup, concave at the bottom, uniformly truncate at the upper margin. It is composed of two series of plates; the upper one supporting the arms, which are very numerous. Test exceedingly thin along the basals, thickening rapidly upwards.

The basal disk is apparently undivided; the greater part hidden by the column. It is irregularly pentagonal, three of its sides being nearly equal, the other two, which are adjoining, equal to one-half the larger ones. The side opposite the two smaller sides extends considerably beyond the column, while at the other side the basal disk is either altogether invisible, or reduced to a very narrow band. This want of regularity has been observed in all specimens, and seems to be characteristic of the genus.

Radials five, very irregular in form, those of the antero-lateral rays much larger than the rest. The two larger plates, whose upper margins constitute fully three-fourths of the periphery at the top of the radials, occupy together less than one-half of the circumference of the basal cup. This disproportion is caused by the peculiar form of the other radials, which, notwithstanding the great spreading of the calyx, diminish in width upwards. The anterior radial is much smaller, heart-shaped, with strongly convex lateral edges, which converge almost to a point at the top of the calyx. The basi-radial suture is somewhat concave, and fully as wide as that of the larger plates. The two postero-lateral radials together are very little larger than the anterior one; that toward the right is smaller, very narrow, wider at the bottom than at the top, and triangular when the sides are straight; but when these are curved, which is more frequently the case, it is somewhat lunate. The other radial is quadrangular, fully twice as high as wide, and of equal width throughout.

The articular surface of the radials is provided with conspicuous grooves and intervening ridges, the former with a depression near the outer margin of the plate. The grooves along the surface take a tortuous or undulating course, and near their inner end turn rather abruptly toward the anterior radial. The latter plate has generally but one groove, which is deeper than any of the others and perfectly straight, but when it has two grooves, as is exceptionally the case in *Catillocrinus Tennesseæ*, these unite before entering the inner cavity. The two larger radials contain numerous grooves—the number varying with the species—that toward the right, as a rule, has more than the one on the left. The former radial has been observed to have in *C. Tennesseæ* 27 to 31 grooves, in *C. Wachsmuthi* 16 to 20; the plate toward the right in the former species has from 21 to 23, the opposite one 15 grooves. The two small irregular radials have, so far as observed, only one groove each.

In perfect specimens, the grooves are lined by two rows of short, transverse pieces, which partly cover the groove, but leave underneath a good-sized passage. The plates rest upon the ridges, where they abut against their fellows from adjoining grooves. With the exception of the ridges and grooves, the truncated upper side of the radials forms a uniform plane, interrupted only by a small elevation along the left side of the quadrangular radial. This elevation is occupied by a small, elongate anal plate, which abuts against the two proximal joints of adjoining arms. The plate is placed on a level with the arm joints, has a like width and, therefore, is easily mistaken for an arm plate.

The anal plate supports a very stout appendage, composed of a single row of exceedingly large and heavy plates, longitudinally arranged, which, instead of forming into a tube as in the case of other Fistulata, are transversely curved like arm joints, leaving a rather shallow, semicircular furrow on the inner side. These plates are along their back extremely heavy, as thick as the radials at their upper margins, but they thin out toward their ends, and approaching the furrow become extremely delicate. The proportions of the plates are well shown by our figure of *Catillocrinus Wachsmuthi* (Pl. 5, fig. 16), in which five of these plates occupy an inch, while in the same space there are seventeen arm joints. It must be further mentioned that up to that point the plates suffered no diminution in height nor in width, nor is there any decrease in the thickness of the wall, which in *Catillocrinus Wachsmuthi*, at the top of the fifth joint, is nearly two thirds of the whole width of the appendage. The cross section is semilunular except at the base. The stoutness of the plates on the one side, and the grooved structure on the other, are perhaps due to the great thickness of the radial plates upon which the tube rests; it had to be so necessarily in order to effect a communication with the inner cavity of the calyx. The groove was probably covered during life by perisomic plates. No traces either of a vault or a disk have been observed.

The arms rise directly from the truncated summits of the radials, without the intervention of axillary plates. There is an arm to every groove, and, hence, some of the radials, contrary to the rule in other Crinoids, support a large number of arms from the same level. The arms are simple, slender, comparatively long, scarcely rounded outwardly, of almost uniform size, and when closed they appear as if united into a solid wall. The arm joints are quadrangular, much longer and somewhat deeper than wide, with parallel sutures. Arm furrows deep, triangular.

The column is circular, composed of thin joints, the upper part is very stout but tapers rapidly downward.

Geological Position, etc.—The genus is apparently restricted to the Upper Burlington and Keokuk divisions of the Subcarboniferous of America.

The following species have been described :—

1868. **Catillocrinus Bradleyi,** Meek and Worthen, Proc. Acad. Nat. Sci. Phila., p. 342; also 1868, Geol. Rep. Illinois, vol. v, p. 504, Pl. 14, figs. 10 *a*, *b*.—Keokuk limest. Crawfordsville, Ind.

1850. **Catillocrinus Tennesseæ** Troost (Type of the genus). List Crin. Tenn., Proceed. Amer. Assoc., p. 60.—Shumard, 1868, Trans. Acad. Sci. St. Louis, vol. ii, p. 358.—Keokuk limest., Button-mould Knob, near Louisville, Ky.

1866. **Catillocrinus Wachsmuthi,** Meek and Worthen. (**Symbathocrinus [Nematocrinus] Wachsmuthi.**) Proceed. Acad. Nat. Sci. Phila., p. 251. **Catillocrinus Wachsmuthi,** 1868, Geol. Rep. Ill., iii, p. 465, Pl. 18, fig. 5.—Upper Burlington limest. Burlington, Iowa.

MYCOCRINUS Schultze.

1866. Schultze, Monogr. Echin, Eifl. Kalk., p. 222.
1879. Zittel, Handb. d. Palæontologie, vol. i, p. 380.

Schultze supposed that *Mycocrinus* had no arms, but his own figures and description indicate the contrary. The radials are provided close to the periphery, and in front of the ambulacral grooves, with well developed articular facets, pierced by transverse slits.

Mycocrinus resembles the last described genus very closely, but differs in the bipartite basal disk, the greater symmetry and regularity in the arrangement of the radials, and in the general form. We offer the following :—

Revised Generic Diagnosis.—Calyx in form of a mushroom, constructed of two series of plates, the upper series forming the thallus, the lower the stalk. The plates are massive, of very irregular form, and without ornamentation.

Basals two, large, unequal; one of them twice as large as the other. They are very heavy and form a distinct, subglobose, knob-like body, slightly truncate below for the reception of the column. Its upper side rises to form a low five-sided pyramid, near the outer margins of which there are twelve narrow slits parallel to the edges. Two of the sides have three slits each, the three others two each.

Radials five, resting with their inner edges upon the angular margin of the basal disk, each plate facing one of the five sides of the pyramid. They spread broadly outward from the edge of the basals, and extend far beyond their outer margins. Two of the radials are of equal width, much larger than the rest. These two are separated from one another at one side by two equal, much smaller plates, at the other by a single plate somewhat larger than the two others. The single plate is more than one-half narrower above than below, owing to an angular extension at the lower half of its two lateral faces, which fit closely into the adjoining excavated side of the large radials. Similar processes arise from the sides of the two smaller plates, but here only along the suture toward the larger one, the opposite suture being perfectly straight. By means of the lateral extensions, the large radials, which at their basi-radial suture have nearly the same width as the smaller ones, attain at their upper face three times the width of the other plates.

The articular surface of the radials is truncated, unusually thick, and closely resembles that of *Catillocrinus*. *Mycocrinus boletus* must have had fifteen arms, for there are fifteen rather shallow ambulacral grooves, which pass from near the periphery of the calyx to the radial centre. There are six upon each of the two large radials, and one upon each of the two smaller ones. The six grooves upon the two larger radials unite into one, and hence there are but five main trunks entering the inner cavity. The median part of every groove has a deep linear furrow, which takes a somewhat downward course, and penetrates the walls of the radials. Close to the periphery, outside of each groove, there is a well-marked slit-like axial canal, making fifteen in all, which pierce the radials throughout their full length, and enter the upper margins of the basals. These canals or tunneled passages are evidently axial canals, which entered through the twelve slit-like openings at the inner floor of the basals the chambered organ, and as such communicated with the arms.

The body cavity is very small, its width not equaling the thickness of the radials; its depth being less even than its width. Form of the arms, construction of summit and anus unknown.

The column seems to have been circular, with a small, round central canal. The only species is:—

1866. **Mycocrinus boletus** Schultze, Monogr. Echin. Eifl. Kalk., p. 222, Pl. 7, fig. 4. —Stringocephalenkalk, Devonian.—Nollenbach (Eifel), Germany.

FAMILY XXVI.—CALCEOCRINIDÆ Meek and W.

1878. Meek and Worthen, Geol. Rep. Illinois, v, p. 443.
1882. De Loriol, Paleont. Française, vi (Crinoides), p. 51.
Syn. *Chirocrinidæ*, Angelin, 1878, Icon. Crin. Suec., p. 22.
Syn. *Cheirocrinidæ*, Zittel, 1879, Handb. d. Palæont., i, p. 357.

The only known genus of this family has been variously referred to *Cheirocrinus* and *Calceocrinus*. As early as 1851, Hall, in the Geological Report of New York, vol. ii, p. 352, gave notice of a peculiar Crinoid from the Niagara group, of which he had obtained what appeared to be a bipartite base or pelvis showing a columnar attachment, for which he proposed the name *Calceocrinus*. In 1860, in the 13th Regents Report of the New York State Cabinet of Nat. History, the same author described under *Cheirocrinus* six new species of American Crinoids having a base similar to *Calceocrinus*, and which evidently belonged to that or a very closely allied genus. According to Salter (Murchison's Siluria of 1859), the name *Cheirocrinus* had been used by Austin in MS. for a similar form from the Wenlock limestone, but Eichwald had already in 1856 preoccupied the name for a certain type of Cystidea. Shumard was the first writer to direct attention to the probable identity of *Calceocrinus* with Hall's *Cheirocrinus*, and in his Catalogue of the Palæozoic Fossils of North America he added the name *Calceocrinus* in parenthesis to all described species of *Cheirocrinus*. In this he was followed in 1869 by Meek and Worthen, and in 1879, Hall himself adopted *Calceocrinus*, while both Angelin and Zittel have retained *Cheirocrinus*. It seems to us the latter name, according to established rules, cannot be upheld for Hall's type, because it was preoccupied by Eichwald for a Cystid, and even if it be true, as asserted by F. Schmidt (Acad. Imp. Sci. St. Petersburg, Ser. ii, vol. xi, No. 11), that Eichwald's *Cheirocrinus* is identical with *Glyptocystites*, which has priority, this would not alter the case. The same view was evidently taken by Meek and Worthen, who proposed, in case doubt should arise as to its identity with Hall's type of *Calceocrinus*, to change the name *Cheirocrinus* into *Eucheirocrinus*.

We would accept the latter name, had not Hall himself, who had the best opportunity to compare the type specimens, given preference to *Calceocrinus*. Bigsby, in the Thesaurus Devonico-Carboniferus, erroneously placed the genus *Catillocrinus* as a synonym under *Calceocrinus*.

Calceocrinus was made by Meek and Worthen, in 1873, the type of a distinct family, for which they introduced the name "*Calceocrinidæ*." This was adopted by De Loriol, but Angelin and Zittel in their classification apply the name "*Cheirocrinidæ*."

Calceocrinus differs in external appearances so essentially from all other Crinoids, that Hall introduced for its description a special terminology, which was adopted by all succeeding writers.

In this special names were given to parts of the calyx, which, as we will presently show, are represented in other genera, and hence should be designated by the same name, the more since some of his appellations conflict seriously with terms long ago established.

Hall divided the calyx into two parts. The one, which he called the "dorsal side," comprises the anterior side and not, as should be expected from the name, the aboral part; the other, which he designated as the "ventral side," by which are usually understood the oral or summit portions, represents the posterior side. According to Hall, the "dorsal side" consists of three—perhaps sometimes five—"basals," of the "upper and lower dorsal plate" *or the first and second anterior radials*, and of the right and left "dorso-lateral plate" or *lateral radials*. He further discriminates between "plates of the dorsal arm," *the brachials of the anterior ray*, and those of the "dorso-lateral arms," or *arm plates of the lateral rays*. The "ventral" side is described as being composed of the "ventral arching plate"— which actually consists of two pieces, and which either are *anal plates*, or non-arm-bearing radials—and succeeding these of a row of plates, longitudinally arranged, which were designated as "plates of the ventral side," but which are *plates of an anal tube*. There are besides summit or vault pieces which, however, were not described by Hall.

The most remarkable feature of this genus is represented by the basals, which are located on the posterior side of the calyx. They connect with the plates of the anterior side, which is truncated, toward the basals, not by suture as in the case of other Crinoids but by muscles and ligament, thus producing between basals and radials a marked articulation. There is a widely gaping suture along the articular line, which, as Meek and Worthen suggested, permitted the basals to be opened out on a line with the radials and other parts of the calyx. That the calyx was capable of bending at this point is well shown by a unique specimen of *Calceocrinus tunicatus* Hall, in the possession of Mr. James Love of Burlington, in which the main body stands out from the column at an angle of sixty degrees; while in most of the specimens which we have examined the crinoid hangs downward, almost parallel with the column. No specimen, however, shows the calyx in an erect position.

There are in this genus but three rays, which vary considerably in form and size. The two lateral rays are composed of a large radial, which is followed by two very small brachials. The anterior ray has two radials, which combined are smaller than the single lateral ones. The two are generally separated by the lateral radials which join between them, placing one of the plates at the upper, the other at the lower end of the calyx. This peculiar structure has evidently prevented all former writers from recognizing those plates as radials. That they are radials, and were gradually separated in the course of palæontological times, is proved by Hall's Silurian species *Calceocrinus chrysalis* and *Calceocrinus inæqualis* Billings,[1] by *C. radiculus* Ringueberg and *C. Barrandii* Walcott, in all of which the plates are narrowly elongate, and united by a short suture. In *Calceocrinus gothlandicus* of Upper Silurian age, they are separated, but the first radial extends almost to the second. In *Calceocrinus clarus* and *Calceocrinus Barrısi* from the Devonian, the distance that separates them is somewhat greater; while in all Subcarboniferous species the two plates stand widely apart.

Calçeocrinus agrees with *Catillocrinus* in the arrangement and form of its plates. In both of them the second ring consists of five extremely irregular pieces, but, while in the latter all five are arm-bearing, those of *Calceocrinus* are arm-bearing only in the three anterior rays. The two posterior ones are small and support a large tube. The corresponding plates in *Catillocrinus* support upon one end of their upper side an arm, upon the other a similar tube as *Calceocrinus*, and in both genera the two antero-lateral rays are far stronger developed than any of the others. The two forms resemble each other more closely than might be expected from Crinoids that differ so widely in their general aspect, as shown by changing *Catillocrinus* from its natural position into that of a *Calceocrinus*. This may be done theoretically by pressing the calyx sideways in such a manner that the basals are pushed over to one side, and the three arm-bearing radials to the opposite side. The lateral ones, however, owing to their large size naturally extend to the basal side, where they join the small postero-lateral radials, which, as stated, hold a similar position

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[1] It was Mr. Walter R. Billings, of Ottawa, who already in 1883 directed our attention to *Heterocrinus inæqualis* as being a *Calceocrinus*, and he informed us also that in this species the two anterior radials were joined by sutures.

as the anal plates in *Calceocrinus*, resting like them against the basals and supporting a similar anal tube. By thus changing the respective parts into a relative position, the affinities which exist between the two genera can be better appreciated. The form of the calyx, however, the articulation between the basals and radials, and the sloping position of the lateral rays is so unique, and strikingly different from *Catillocrinus* and other genera, that *Calceocrinus* must be referred to a distinct family.

The slight variations, which naturally occur in the branching of the arms, were taken by Hall, and Meek and Worthen, for specific distinctions. We fear these differences are too trifling to be regarded as such, and we have felt obliged to refer some of their species to our list of synonyms.

Postscriptum.—While our descriptions upon the Calceocrinidæ were in press, we received a paper from Mr. E. O. Ulrich (extracted from the 14th Ann. Rep. Geol. Surv. Minn., p. 104): Remarks upon the names Cheirocrinus and Calceocrinus, with descriptions of three new generic terms and one new species. The author subdivides the species heretofore known under *Calceocrinus* into three genera: *Cremacrinus*, *Deltacrinus* and *Halysiocrinus*, and applies to them the family name "Cremacrinidæ." There is, in our opinion, no valid reason for discontinuing the names *Calceocrinus* and *Calceocrinidæ.* The genus *Calceocrinus* was properly defined by Hall and others, and several species have been referred to it by them. Moreover, Meek and Worthen's name *Eucheirocrinus* would have priority, and also Calceocrinidæ, as both were proposed in 1873.

Under *Cremacrinus* Ulrich placed the species in which the two anterior radials (the two central plates of his) are connected vertically; under *Deltacrinus* those in which said plates are separated by the two lateral radials (his two large dorso-lateral pieces). This difference, we admit, exists between the Lower Silurian and Subcarboniferous species, but in the Upper Silur and Devonian the two forms pass gradually into one another, so as to make a generic separation impracticable. Ulrich's statement on p. 110, that *Cremacrinus* has "three primary radials," *Deltacrinus* "five," *Halysiocrinus* "eleven," is based altogether upon incorrect observation. All these species have but three arm-bearing radials—one of them compound—and the plates which Ulrich regarded as "eleven primary radials," are axillary brachials of ascending orders.—(May, 1886).

CALCEOCRINUS Hall (Revised by W. and Sp.).

1851. Hall, Geol. Rep. N. York, vol. ii, p. 352, Pl. 85, figs. 5, 6.
1866. Shumard, Trans. Acad. Sci. St. Louis, vol. ii, p. 358.
1869. Meek and Worthen, Proc. Acad. Nat. Sci. Phila., p. 73.
1873. Meek and Worthen, Geol. Rep. Illinois, vol. v, pp. 442 and 502.
1877. S. A. Miller, Cat. Amer. Palæoz. Fossils, p. 72.
1879. Hall, 28th Rep. N. York St. Cab. Nat. Hist. (Ed. ii), p. 146.
1882. De Loriol, Palæont. Francaise, Tome xi (Crinoides), p. 51.
1882. Ringueberg, Journ. Cincin. Soc. Nat. Hist., p. 120.

Syn. *Cheirocrinus* Hall (not Eichwald, 1856); Hall, 1860, 13th Rep. N. York St. Cab. Nat. Hist., p. 122; Salter, 1859, Murch. Siluria (Ed. 3), p. 535 (Catalogue name); Hall, 1862, 15th Rep. N. Y. St. Cab. Nat. Hist., p. 166; Zittel, 1879, Handb. d. Palæont., i, p. 358.
Syn. *Chirocrinus*, Angelin, 1878, Icon. Crin. Suec., p. 22.
Syn. *Pendulocrinus*, Austin MS. (Salter, Siluria, p. 535).
Syn. *Eucheirocrinus*, Meek and Worthen, Geol. Rep. Ill., v, p. 443.

In general form the specimens resemble a wilted flower, owing to the position of the calyx, which hangs downward along the column. The calyx is laterally compressed, especially at the juncture of basals and radials, where it is almost linear; while a transverse section across the median part of the radials and through the centre of the basal disk is decidedly triangular. The anterior side forms a flat body, broadly truncate at the lower end, constricted in the middle, and composed exclusively of the radial plates. The basals, which are placed upon the posterior side, are separated from the radials of the opposite side by a widely gaping articular line, occupying the lower end of the calyx. Along this line, probably, the upper part of the Crinoid could be bent upwards and be brought in an erect position. The posterior side is composed, in addition to the basals, of two non-arm-bearing plates, which face laterally the incurving sides of the radials, and support upon their upper side an extremely large ventral tube.

The basals jointly form a kind of semicircular disk, of which the straight line faces the truncated lower side of the anterior radial, and the curved part rests against the infolding lateral margins of the lateral radials, and against the two non-arm-bearing plates. The basal disk, which is slightly convex, is composed of three pieces, two of which are equal, the other large and of a very different shape. The two former taken together are lunate, and enclose within their arched sides the other plate, which lies transversely, and occupies almost the entire width of the truncated side of the basal disk. The articular facet for the attachment of the column has a lateral position, and is placed within the centre of the two equal pieces, without touching at any point the third plate. It is large, somewhat excavated, and divided vertically by the suture line.

The radials consist of four plates of very irregular arrangement. The two larger ones, those of the lateral rays, occupy more than two-thirds of the anterior side of the calyx, and support two small transverse brachials, of which the upper one is axillary. Two much smaller and very irregular plates, which are generally separated by the large lateral pieces, form the radial of the anterior ray. The large lateral radials are bent abruptly along their outer sides, so as to occupy considerable space upon the posterior side of the calyx. They are hexagonal—rarely pentagonal—angular at their upper and lower ends; one of the lower sloping sides abuts against the first anterior radial, the other against the basal disk. The sloping upper face connects at one side with the second anterior radial, the opposite side supports the first brachial plate. Of the lateral faces one meets the corresponding side of the opposite radial, the other an anal plate. In the anterior ray, the first radial is linear, but more frequently triangular, two of its sides resting within a re-entering angle formed by the lateral radials. The lower edge is generally wider, and constitutes the bottom part of the anterior face of the calyx, being on a level with the truncated edge of the basals, and united with them by muscular articulation. The articulating surface, near the outer margin of the component plates, is provided with a deep fossa, evidently for the lodgment of elastic ligament. A similar but narrower fossa is placed close to the inner margin of the plates, separated from the former by a narrow transverse ridge. The middle part of this ridge extends somewhat into the large fossa, and forms a kind of triangular projection which contains a small axial canal. The second anterior radial has nearly the same form as the first, but its position is reversed, the truncate side being directed upwards, the angle downwards, resting between the sloping upper sides of the adjoining basals. In *Calceocrinus chrysalis*, in which the first anterior radial joins the second, both plates are exceptionally quadrangular, and, therefore, the first lateral radials pentagonal instead of hexagonal. The plates above are free. There are two brachials in each lateral ray, a single one in the anterior one. The articular line between the lateral radials and brachials is widely gaping, the union between the two succeeding plates apparently by syzygy. They are closely fitted together in the specimens, and a suture is rarely discernible. The lower one is short and quadrangular, the upper one axillary. The brachial of the anterior ray is generally twice as wide as high, and truncate at its upper side.

It has been stated that in the lateral rays the first brachials are placed obliquely against the radials, in consequence of which these two rays lean over toward the posterior side. By this peculiar structure, the outer sloping faces of the bifurcating brachials are brought into a vertical, the inner ones into a horizontal position. The vertical side supports laterally another axillary, the horizontal side vertically a free arm. The former is followed again by an axillary on one side, and an arm on the other, and so on in the same manner to the last bifurcation, the axillary plates all arranged in a nearly horizontal line, the free arms having an upright direction. In species with but few bifurcations the position of the brachials is more erect.

The arms are composed of single joints, which are generally as long as wide; rounded exteriorly and provided with a deep triangular groove at the ventral side; they are comparatively long, rather stout at the base, but taper gradually upwards. The lateral arms, after their first bifurcation, do not branch again, but give off from every third or fourth joint a large arm-like pinnule, which extends to the end of the arm. The lower pinnule is less than half the size of the arm at the place of attachment; the one or two succeeding ones have nearly the same size as the arms at the place of their origin. The pinnule-bearing joints appear to be somewhat stouter owing to a thick callosity at their upper end, and their line of articulation is directed obliquely. The intermediate joints have parallel sides, which show neither fossæ nor radiations, and probably were united simply by suture. The anterior ray has but a single arm, which is given off in an upright direction. It is stouter than the lateral arms, and remains frequently simple throughout, but when it branches occasionally, the division takes place near the distal end.

Anal plates two, resting against the basals and the incurved wings of the lateral radials. Their upper side supports a row of very large and heavy quadrangular plates, which are longitudinally arranged and form the exterior side of an enormous anal tube, extending to the tips of the arms and perhaps beyond their limits, with scarcely any diminution in size. Like in *Catillocrinus*, only the posterior side of the tube is heavily plated, the anterior side being composed of very small and delicate plates.

The column is comparatively large, near the calyx composed alternately of shorter and longer segments, which soon turn altogether into long joints. Hall gives the column as very short; it was, however, of considerable length in some cases, as we have followed it up to a foot or more without reaching the root.

Geological Position, etc.—*Calceocrinus* makes its appearance in the Lower Silurian, but only in America. It struggled through the Devonian, and reached its greatest distribution in the earlier periods of the Subcarboniferous, but without flourishing abundantly. Throughout this long period of time, the species change but little, less than those of any other genus, and it is exceedingly difficult to point out specific differences, which in most of them are so slight that they hardly deserve the name. In Europe it has been found only in the Upper Silurian.

We recognize only the following species:—

1883. **Calceocrinus Barrandii** Walcott, 35th Rep. N. Y. St. Mus. Nat. Hist. (Author's Edit., p. 6), Pl. 17, figs. 1, 2.—Upper part of Trenton limest. Trenton Falls, New York.

1865. **C. Barrisi** Worthen, Geol. Rep. Illinois, iv, p. 510, with woodcut.—Hamilton group. Near Davenport, Iowa.

1869. **C. Bradleyi** Meek and Worthen, Proceed. Acad. Nat. Sci. Phila., p. 73; also 1873, Geol. Rep. Ill., vol. v, p. 502, Pl. 14, fig 9.—Keokuk limestone. Crawfordsville, Indiana.

1860. **C. chrysalis** Hall (**Cheirocrinus chrysalis**). Type of the genus.—13th Rep. New York State Cab. Nat. Hist., p. 123, with diagrams. Shumard, 1866, **Calceocrinus chrysalis,** Trans. Acad. Sci. St. Louis, vol. ii, p. 358.—Niagara group. State of New York.

1862. **C. clarus** Hall (**Cheirocrinus clarus**), 15th Rep. New York State Cab. Nat. Hist., p. 116, Pl. 1, fig. 17.—Shumard, 1866, **Calceocrinus clarus,** Trans. Acad. Sci. St. Louis, vol. ii. p. 358.—Zittel, 1879, Handb. der Palæont., i, p. 358, figs. 2, 4, 5 *a*.—Hamilton group. Ontario Co., N. Y.

1878. **C. gotlandicus** Angelin (**Chirocrinus gotlandicus**), Iconogr. Crin. Suec., p. 22, Pl. 16, figs. 6–14.—Zittel, 1879, Handb. der Palæont., i, p. 358, figs. 245, *b, c, d*.—Upper Silurian. Gothland, Sweden.

1859. **C. inaequalis** Billings (**Heterocrinus inaequalis**), Geol. Surv. Canada, Decade iv, p. 51, Pl. 4, fig. 7 *a*; Wachs. and Spr. Revision i, p. 70.—Trenton limestone, Ottawa.

1866. **C. perplexus** Shumard, Trans. Nat. Sci. St. Louis, vol. ii, p. 358.—Keokuk limest. Button-mould-Knob, Ky.

1882. **C. radiculus** Ringueberg Journ. Cincin. Soc. Nat. Hist., vol. v, p. 120, Pl. 5, fig. 4.—Niagara group. Lockport, N. Y.

1862. **C. stigmatus** Hall (**Cheirocrinus stigmatus**), Trans. Alb. Inst., vol. iv, p. 225 (Abstr. p. 31).—Shumard, 1866, **Calceocrinus stigmatus**, Trans. Acad. Sci. St. Louis, vol. ii, p. 358; also Hall, 1879, 28th Rep. N. York St. Cab. Nat. Hist., p. 147, Pl. 19, figs. 9–11; also 11th Ann. Rep. St. Indiana by Collett, 1881, p. 281, Pl. 19, figs. 9–11.—Niagara group. Waldron, Indiana.

1860. **C. tunicatus** Hall (**Cheirocrinus tunicatus**), 13th Rep. N. York St. Cab. Nat, Hist., p. 124, with diagram.—Shumard, 1866, Trans. Acad. Sci. St. Louis. vol. ii, p. 359.—Keokuk limestone. Keokuk, Iowa, Niota and Warsaw, Ill.

1860. **C. ventricosus** Hall (**Cheirocrinus ventricosus**), 13th Rep. N. Y. St. Cab. Nat. Hist., p. 123.—Shumard, 1866, Trans. Acad. Sci. St. Louis, vol. ii, p. 359.—Burlington limest. Burlington, Iowa.

Syn. **Cheirocr. dactylus** Hall, 1860, 13th Rep. N. York St. Cab. Nat. Hist., p. 123.—Burlington limestone.

Syn. **Cheirocr. nodosus** Hall, 1860, Ibid.—Keokuk limestone.

Syn. **Cheirocr. Wachsmuthi** Meek and Worthen, 1869, Proc. Acad. Nat. Sci. Phila.—Burlington limestone.

Syn. **Calceocr. dactylus** Shumard, 1866, Trans. Acad. Sci. St. Louis, vol. ii, p. 358.

Syn. **Calceocr. Wachsmuthi**, Ibid.

APPENDIX.

(*January*, 1886).

STEPHANOCRINIDÆ W. and Spr.

Through the kindness of Prof. R. P. Whitfield, to whom we are under lasting obligations, we had lately an opportunity to examine from the collection of the American Museum of Natural History of New York City, some valuable and unique specimens of the genus *Stephanocrinus*. Among these were 25 specimens of *Stephanocrinus angulatus* Conrad, two of them showing the brachial appendages—the so-called pinnules—and 18 specimens of *Stephanocrinus gemmiformis* Hall.

Stephanocrinus is one of those genera which prove to us how inappropriate it is to make Crinoids, Cystids and Blastoids distinct classes. The genus has been regarded by F. Roemer, Johannes Müller and Pictét to be a Cystid, by Messrs. Etheridge and Carpenter and S. A. Miller a Blastoid. Dujardin and Hupé —and apparently (?) Hall—refer it to the Crinoids; while Prof. Zittel was in doubt whether he should place it with the Blastoids or not. That it has certain affinities with either one of the three groups cannot be denied. It agrees by its oral and anal pyramid with certain forms of the Cystids, while in its general habitus and in the position of the ambulacra it agrees with the Blastoids; and yet it is, as we shall prove, unquestionably a Palæocrinoid.

It seems Roemer[1] had discovered sockets for the reception of brachial appendages, and probably these sockets and the valvular covering of mouth and anus induced him to place the genus with the Cystidea. Johannes Müller, who also regarded it a Cystid, makes the remark: "Nierenförmige Warzen am Ende der Strahlen des sternförmigen Feldes deuten auf die Gegenwart von Armen hin." Hall, in vol. ii, p. 351, of the New York Report, does not describe the appendages which he had discovered as Blastoid pinnules, but speaks of tentacula attached to the margin along a slight groove in the base of the depressions between the angular processes which ornament the summit of the body. These tentacula or *fingers consist of ten branches*, each composed of a double series of plates above, *but uniting below a series of coalescing plates which have a different arrangement.* It seems to us this description does not apply to ambulacral appendages, nor do we think that Hall took the genus to be a Blastoid. On p. 212 of the New York Report he called it a Crinoid, and in 1879 he placed it aside of well-known Palæocrinoidea. Pictét describes the base as composed of "five subradials," and "five basals," and the mouth as surrounded by "ten tentacles." Dujardin and Hupé place it among the Haplocrinidæ, between *Haplocrinus* and *Coccocrinus*, and also these writers describe within the radial groove a reniform impression for the reception of an arm, but thought to observe "lames paralleles" along the grooves. They regard, like Roemer, the central pyramid, the mouth, and the lateral aperture an ovarian opening.

Considering that Hall, Roemer, Müller, and Dujardin and Hupé, all describe at the outer end of the ambulacral groove a reniform scar for the attachment of an appendage, it is somewhat surprising that Etheridge and Carpenter place the genus among the Blastoids. They undertake to explain this by Hall's discovery of "ambulacral appendages . . . . like those of other Blastoids," and give it as their opinion that the reniform scar of Roemer "is nothing more than an infolded radial lip." We stated already that we thought Hall never regarded *Stephanocrinus* a Blastoid,

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[1] We do not possess Roemer's description of *Stephanocrinus* which appeared in Wiegmann's Archiv for 1850, and know it only from the quotations of subsequent writers.

and he certainly did not describe ambulacral appendages, but branching fingers, no matter what name he gave to the parts. We are confident that the depression at the end of the ambulacral groove really does exist, and that it is occupied by a second radial.

Stephanocrinus not only has two radials to each ray, but branching biserial arms, given off in a somewhat similar manner as the arms in the Platycrinidæ. The second radials are reniform, small, bifurcating, and rest within a semi-ovoid or horseshoe-shaped depression near the outer end of the ambulacral groove. They are succeeded by two or more axillaries of a higher order, which in the usual way give origin to ten arms to each ray. That these appendages, although they are equally thin and short, are not pinnules, is proved by the fact that all are supported by a radial plate, instead of being distributed separately along the sides of an ambulacrum. It is further shown by one of the New York specimens, in which in one of the rays the appendages became disconnected, and were deposited *en masse* at some little distance from the radials, without the least disturbance in their arrangement, a case which could not have happened if they were ambulacral pinnules.

The ambulacra of *Stephanocrinus* are constructed very differently from those of the Blastoids; they possess no side-pieces, no transverse furrows, no hydrospire pores, and no sockets for the reception of pinnules; they simply are covered by two rows of Saumplättchen, which enclose a tubular canal containing the food groove. The Saumplättchen or covering pieces of the same row are so closely anchylosed to one another, longitudinally, that it appears even under an ordinary magnifier, and in the most perfect specimens, as if there were but two elongate plates, one at each side. As such they were represented by Hall in his diagramatic figure, New York Geol. Rep., vol. ii, Pl. 48, fig. 1 *l*, in which the reniform plates at the outer end of the elongate pieces represent the second radials. The figure shows excellently the plates of the ventral side as they generally appear in the specimens; there is omitted, however, a suture along the so-called coronal processes, which Hall, as well as Roemer, thought he observed, but which were not accurately defined until 1883, by Etheridge and Carpenter (Ann. and Mag. Nat Hist., April, p. 239). They found the processes "divided into an outer part formed by the contiguous limbs of two adjacent radials, and an inner portion or deltoid,[1] and that the calyx consists of three rows of plates—the basals, radials and deltoids. The canals which contain the food grooves are in their usual preservation, more or less compressed, and in consequence thereof the two series of covering pieces became separated longitudinally, and appear in the specimens as if forming a deep groove upon the surface following the median line. Little of this groove, however, is seen in plump specimens.

Etheridge and Carpenter, and also Zittel, regard the two rows of anchylosed covering plates as constituting a single piece, and this, they think, represents the lancet plate of the Blastoids. Upon this point they make on p. 240 of their paper the following statement: "The paired linear plates in the ambulacra we believe to be single, and to represent the lancet plates of other Blastoids. They seem to be usually much eroded and to have a strongly marked median groove, which has been taken for a suture. Even when these plates are preserved the side plates of the ambulacra are generally missing; but since Hall has discovered specimens of *S. angulatus* still attaining ambulacral appendages like those of other Blastoids, we see no reason to doubt the existence of side plates and outer side plates. In fact, the former have been described in *S. pulchellus* by Miller and Dyer." We doubt if Etheridge and Carpenter ever saw a *Stephanocrinus* with either side pieces or outer side pieces, or ever will see one, and if Miller and Dyer found such plates in their *St. pulchellus*, we assert that their species is not a *Stephanocrinus*. Aside from the fact that the "so-called lancet pieces" are compound structures, we think it utterly impossible from the position which these plates occupy toward the oral plates, that they could represent lancet pieces, as in that case the food grooves would have to run out into the air in place of entering the interior.

In both of the New York species, the oral plates are on the same level with the covering pieces; they meet with each other so as to leave externally, when both plates are in position, no opening or passage. The only communication with the inner cavity,

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[1] We have substituted here *deltoids* for "*orals*," the latter term being used by Etheridge and Carpenter in their paper. When they wrote this they still regarded the deltoids as representing the orals, a mistake which Dr. P. H. Carpenter explained and corrected in his Challenger Report, p. 162.

in connection with the ambulacra, is beneath the covering plates through the canals or tunnels which we have described. These passages, which are closed at the bottom by the deflected lateral edges of two adjoining interradials, as in the case of *Cyathocrinus*, grow deeper and narrower on approaching the oral plates; while toward the arms they widen and divide, transmitting a branch to each main division of the rays. All this goes to prove that the passages are tubular canals, such as we find in the Palæocrinoidea, and that the apparent resemblance between the ambulacra of *Stephanocrinus* and those of the Blastoids, to a large extent, is superficial.

The oral pyramid, which is rather symmetrical in outline, occupies the very centre of the ventral surface. It is composed of five pieces of nearly equal size, which meet in the centre, and are so closely connected by suture that the lines of union are rarely seen in the specimens. A less close union seems to have existed toward the interradials, for the oral plates are but seldom preserved, when we find in their place a nearly circular opening.

The radials extend to the full height of the coronal processes, and resemble in their form closely the forked plates of certain Blastoids; while in Hall's figure (N. York Rep., vol. ii, Pl. 48, figs. 1 *h* and 2 *f*) they appear like the radials of a *Platycrinus*. Hall evidently mistook the cracks which so frequently are found at the base of the interradial processes, for sutures, and supposed the united limbs of two contiguous radials, formed a deltoid-shaped interradial plate.

The most interesting feature of *Stephanocrinus* unquestionably is the quinque-partite oral pyramid, which, we think, gives us valuable information regarding the undivided oral plate in other groups of the Palæocrinoidea. It was suggested by us on p. 55, that probably the central or oral plate of the Palæocrinoidea primitively consisted of five pieces, of which the suture lines gradually were obliterated by deposition of new material. In support of this theory we could only refer to the parallel cases of the basals and underbasals among which similar modifications took place not only palæontologically by anchylosis of one or more of the plates, but also in the growing Crinoid by deposition of limestone at the outer surface of the plates, as in the case of *Edriocrinus* and *Agassizocrinus*. We were unable at that time to point out a single Palæocrinoid in which the peristomial area was closed by five plates, and therefore regard the case of *Stephanocrinus* of the utmost importance, not only as confirming our suggestions, but as throwing light upon the orals of the Palæocrinoidea generally. Before, however, we discuss this question any further, it will be necessary to point out the relations of *Stephanocrinus* with other Crinoids.

Stephanocrinus, undoubtedly, is closely allied to *Allagecrinus*, *Haplocrinus* and *Pisocrinus*, and must be placed with them among the Larviformia, but, owing to marked differences in the form and arrangement of the arms, it cannot be arranged either with the Haplocrinidæ or Symbathocrinidæ, and it will be necessary to establish for it a separate family. Except in the arm structure, the affinities seem to be particularly close with *Pisocrinus*, which has similar interradial processes, formed likewise by the extended limbs of the radials; but as we know little or nothing of the oral plates and ambulacral structure in this genus, a critical comparison is difficult. It differs also from *Haplocrinus* in the position of the disk-ambulacra, which in the latter are subtegminal, in the other exposed to view. This, we explain by individual growth, and assert from palæontological evidence that *Stephanocrinus*, like *Cyathocrinus* and other Palæocrinoidea in its younger state passed through stages in which it closely resembled *Allagecrinus* and *Haplocrinus*. Admitting this, it will be interesting, and instructive, to transform theoretically the lower differentiated *Haplocrinus*, so as to conform with the conditions of the adult *Stephanocrinus*. To this end we open out the five ventral plates of *Haplocrinus*, so as to expose their ambulacral skeleton, and push the ambulacra and the oral plate, which latter occupies the central portions of this skeleton, in an outward direction, in such a manner that the covering pieces fill up the clefts between the interradial plates, and the oral plate the centre, increasing in size as the space gradually grows larger. Nothing further is necessary to complete the structure of *Stephanocrinus* but to extend the sides of the interradials laterally, so as to close the ambulacral groove from beneath. By these manipulations, in which, we think, we closely imitated the natural development as it took place among Palæocrinoids palæontologically, we placed the two genera in the same relative position, in hopes to arrive thereby at a satisfactory conclusion as to the morphological resemblance of the respective plates.

In *Stephanocrinus* interradials have been admitted, and the plates which do represent them correspond in our hypothetical Crinoid with the plates which we opened out to receive the ambulacra. The plates have relatively a similar position, both rest against the upper edges of two adjoining radials, and both support a small pyramid or disk, which in both cases not only occupies a strictly central position, but covers the peristomial area and closes the oral pole. Now, if this is true, what makes those plates interradials only in the one case and not also in the other, and why does the central disk which they enclose represent the oral pyramid in the one and something else in the other? That the central pyramid is quinque-partite in *Stephanocrinus*, coalesced in the other, is apparently the only structural difference between the two forms, and simply upon this ground the former has been regarded by Carpenter (Chall. Rep., pp. 269 to 271) an oral pyramid, and the central plate of *Haplocrinus* a so-called "orocentral," something totally unknown in Crinoid morphology and that of Echinoderms generally.

According to Carpenter the orals of *Haplocrinus* were represented by the five large ventral plates, although these, like the interradials of other Palæocrinoids, apparently cover the disk and tentacular vestibule, contrary to the case of the orals and summit plates generally which close only the peristomial area. If *Haplocrinus* did represent a permanent larval form of the Neocrinoidea instead of the Palæocrinoidea, Carpenter would be justified in regarding those five plates as orals, and could assert that the plates were in the growing animal, and in palæontological times carried inward by perisome, as he and Etheridge suggested to have been probably the case in the growing *Allagecrinus*, but we cannot find in the phylogeny of the older Crinoids the least evidence to justify that supposition. On the contrary, everything points at the conclusion that the orals, and other summit plates, had relatively the same proportions in the younger and lower forms, as in the adult and higher types; and we, therefore, regard the respective plates in *Haplocrinus* like those of *Stephanocrinus*, *Cyathocrinus* and the Blastoidea, which Carpenter, likewise, once regarded as orals, as true interradial plates. If the plates in *Haplocrinus* really were orals, and also the homologues of the six or more proximals of the Platycrinidæ and Actinocrinidæ, and of the five summit plates in *Stephanocrinus*, which all cover the peristomial area but not also the tentacular vestibule and the disk, it would follow that in the three latter the orals were carried inward by the calyx interradials by which they are surrounded, but not only, as perhaps might be the case in the Camarata, by their higher orders or upward growth, but even by the primary interradials. It would further suggest that in the earliest genera *Reteocrinus*, *Glyptocrinus* and allied forms, which have no proximals, the "orals" were unrepresented or resorbed. Also *Nanocrinus paradoxus* (Echin. Eifl. Kalk., Pl. 12, fig. 7 *i*) has no proximals, the covering pieces, according to our interpretation, rest directly against the central plate. This, we know, is the case in two undescribed species of *Talarocrinus*, which we discovered lately in Kentucky. In these species the central piece is relatively larger than the combined orals of *Stephanocrinus*, there are no proximals, and no other interradial plates touching the central plate. The covering pieces occupy here a similar position to the central plate—the coalesced orals—as in *Stephanocrinus* to the quinque-partite oral pyramid. There we have actual specimens, which in all essential points conform with the hypothetical Crinoid which we constructed.

From Carpenter's arguments (Chall. Rep., pp. 268–271) we conclude that he regards the hypothetical "orocentral" a kind of keystone, by which the actinal system is closed in a similar manner as at the opposite pole the dorsocentral is said to close the abactinal side. Unfortunately, however, this theory as stated, is not sustained by embryology. No such plate has ever been discovered among living Crinoids, not even in their larval state, before the opening of the tentacular vestibule, which is said to represent the condition of *Haplocrinus* morphologically. This difficulty Carpenter undertook to explain on p. 270 by stating, that if such a plate appeared "it would only be in the way, and have to undergo resorption to a greater or less extent." A weak argument considering that orals of recent Crinoids actually undergo that resorption. But, admitting it, what then became of the orocentral of *Stephanocrinus*, *Allagecrinus* and *Coccocrinus*, and what of the central piece in the oral pyramid of certain Cystidea? He states further "the former (basals) 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 (oro-central) in the vault of a Palæocrinoid as representing oral plates." This argument is not quite correct, in so far as the central piece is frequently surrounded not only by the proximals—his orals—but also by the radials and anal plate (see Pl. 7); contrary to the basals, which form a ring by themselves. Besides, his argument is based to a large extent, if not altogether, upon the hypothetical plate which he calls "oro-central."

Taking everything in consideration, is it not reasonable and more natural to regard the five orals of the Neocrinoidea, which in the larva are loosely folded together, and which in some of the Cystidea and also in *Stephanocrinus* were united by a close suture, as gradually becoming anchylosed in a group in which they were permanently closed, than it is to invoke the existence of a new element unknown in Echinoderm morphology, and even then have to assert that six plates take the place of five?! But not only that, we also have to admit that these so-called "orals" contain in their midst anal and radial plates contrary to the case of the orals of the Neocrinoidea, *Stephanocrinus* and the Cystidea, and contrary to the basals, the abactinal representatives of the orals as Carpenter admits.

As a further proof that the central piece is the representative of the orals, we refer to the Cystid genus *Caryocrinus*, which has three in place of five groups of arms, and which, according to our interpretation, has no proximals. The central piece which occupies the centre of figure, and which we think represents the oral pyramid, is surrounded by eight plates, by *five* (not four) large ones, and three smaller ones, the latter conforming jointly to one of the other five. Three of the plates have a strictly radial position, the three others, including the compound one which takes the azygous side, are interradial. We doubt if Carpenter will regard these six plates, wholly or partly, as the representatives of our proximals—his orals—or his theory will have to undergo further modifications, as he will find it difficult to restore five primitive pieces from an assemblage of plates as here exhibited.

STEPHANOCRINUS Conrad.

1842. Conrad, Journ. Acad. Nat. Sci. Phila., vol. 8, p. 278.
1851. Hall, Palæont. N. York, vol. ii, pp. 212 and 351.
1851. F. Roemer, Wiegmann's Archiv f. Naturgesch. Jahrg. xvi, vol. i, pp. 365–375.
1853. Joh. Müller, Verh. d. Berl. Acad. d. Wissensch., p. 211.
1855. Leth. Geogn. (Ausg. 3), p. 266.
1857. Pictét, Traité de Paléont., vol. iv, p. 304.
1862. Dujardin and Hupé, Hist. Natur. des Zooph., p. 266.
1879. Hall, 28th Rep. N. York St. Cab. Nat. Hist., p. 146.
1881. Hall, 11th Ann. Rep. of Indiana, p. 279.
1879. Zittel, Handb. d. Palæont. i, p. 436.
1883. Carpenter, Ann. and Mag. Nat. Hist , Apr., p. 237.

Stephanocrinus resembles in many respects certain forms of the Blastoidea, but has true brachial appendages. The calyx is subpyramidal, or deeply cup-shaped, with five spiniform interradial processes.

The basals form a large semicircular or subturbinate cup, more or less truncate at the bottom, with a trigonal distal face, which is slightly excavated for the reception of a column. They consist of three pieces, almost coequal as to size but not as to form, one of them being quadrangular, the two others pentangular. The quadrangular piece takes the position of the smaller basal in the Blastoidea, to the right of the anterior radial; contrary to other Palæocrinoidea in which it occupies the left side. In one specimen, however, exceptionally, it is placed posteriorly, supporting the greater half of two postero-lateral radials.

The first radials are large and resemble to a large extent the forked plates of certain species of *Codaster* and *Phænoschisma*, in which the limbs—the prongs of the fork—of two contiguous radials extend up between the arms in an almost vertical direction, but instead of forming, as there, a sort of pyramid, they are extended in *Stephanocrinus* frequently into long thornlike processes, which sometimes attain more than one-half the height of the calyx up to the arm bases. These processes form radially a deep gutter, containing the ambulacral groove which leads to the arms.

The second radials rest within a horseshoe-like depression near the outer end of the gutter. The plates are reniform, small, short, axillary, with three conspicuous prong-like projections extending inward. The outer ones of these projections are wing-like, resting against, and partly upon, the interradials; the inner one sword-shaped, their sharp point extended deeply into the ambulacral groove, so as to divide it, and to form a branch groove for each main division of the rays. *Stephanocrinus angulatus* evidently had ten arms to the ray, but the mode of branching beyond the second radials is not well known. We found, however, in one instance the second radial succeeded by two other axillaries. The arms are biserial, thin, short, pinnule-like, and they cover the whole ventral surface. In length they do not extend beyond the interradial processes, which apparently were to protect these delicate organs.

The interradials are comparatively large. They resemble in form and position the deltoids of *Codaster*, *Troostocrinus* and other Blastoids, in which, like here, no part of the plates is visible in a side view. They extend to the top of the projections and rest against the inner faces of two limbs, the suture running downwards so as to divide the processes into an inner and outer part. The plates are connected laterally with one another, but not centrally. They leave in the centre a moderately large open space, which in perfect specimens is filled by oral plates. The lateral edges of the interradials are deflected, curving downward, so as to form a wide and deep ambulacral groove, which on approaching the inner end becomes deeper and narrower, and toward the arm bases divides as stated above. The ambulacral grooves are readily distinguished from the general gutter formed by the protuberances. They contain neither hydrospires, nor pores, nor other openings, but there seem to be small axial canals at the arm bases. At each side of the ambulacral groove there is a sort of depression, which forms a place of attachment for two series of small, subquadrangular covering pieces, which form a vault over the groove, leaving underneath a circular, comparatively large passage, which at one end communicates with the arms, at the other enters the calyx beneath the edge of the oral pyramid. The covering plates of the same series are so closely anchylosed that they appear in the best specimens, even under a magnifier, as two single plates, one at each side, as which they were figured by Hall. Their composite nature and alternate arrangement, however, was ascertained in places where portions of this integument had been weathered.

The oral pyramid, which occupies the centre of figure, is placed on a level with the covering pieces to which it is closely attached. It rests against the truncated margins of the interradials, which for its reception are slightly excavated. It is composed of five subequal pieces, which are so closely united by suture laterally and centrally, that the suture lines are rarely visible, and the plates appear as if forming a single piece.

The anal aperture is located ventrally, near the top of one of the interradial processes, at the place where two of the limbs meet with the interradial. In its usual preservation it consists of a rather large circular opening, which, however, in perfect specimens is closed by a valve of from four to six small pieces.

The *Stephanocrinus* which Hall described and figured in the 28th Rep. of the N. York St. Cab. Nat. Hist. (Second Edition), p. 146, Pl. 14, figs. 15–20, is in our opinion specifically distinct from *S. gemmiformis*, and even generically unless the small interradial plates are very incorrectly outlined.

S. osgoodensis S. A. Miller (*Codaster osgoodensis*), Cincin. Journ. Nat. Hist., vol. ii, Pl. 10, figs. 7 and 7 *a*, which the author in his Catalogue of the Palæoz. Fossils (Second Edition) referred to *Stephanocrinus* is described from internal casts, and too incompletely known for identification. *St. pulchellus*, S. A. Miller, is a *Codaster*.

The column is small, and composed of comparatively long joints.

Geological Position, etc.—The genus has been found exclusively in the Niagara group of America.

The following species have been described :—

1842. **Stephanocrinus angulatus** Conrad. (Type of the genus). Journ. Acad. Nat. Sci. Phila., vol. viii, p. 279, Pl, 15, fig. 8.—Pictet, 1857, Traité de Paleont., vol. iv, Pl. 99, fig. 23.—F. Roemer, 1851, Wiegmann's Archiv., Jahrgang xvi, pp. 365–375, Pl. 5.—Hall, 1851, Palæont. N. York, vol. ii, pp. 213 and 351, Pl. 48, fis. 1 *a–m*, and Pl. 85, figs. 1–4.—Niagara group. Lockport, N. York.

1851. **St. gemmiformis** Hall, Palæont. N. York, vol. ii, p. 215, Pl. 48, figs. 2 *a–i*; also 1879, 28th Rep. New York St. Cab. Nat. Hist., p. 146, Pl. 14, figs. 15–20; also, 1881, 11th Ann. Geol. Rep. Indiana by Collett, p. 279, Pl. 13, figs. 15–20.—Rochester, N. Y., and Waldron, Indiana (?).

Notes on the Underbasals and Top Stemjoint of Neocrinoidea and Palæocrinoidea.

On p. 8 we stated that probably many Neocrinoids, heretofore supposed to be monocyclic, either have small underbasals concealed beneath the column, or that these plates had been represented in the early larva. We referred to the genera *Pentacrinus*, *Millericrinus* and *Apiocrinus*, which, according to our generalizations on p. 7, are built decidedly on the plan of dicyclic Palæocrinoids. Our investigation, unfortunately, could be extended only to comparatively few species, as the column and axial canal of the Neocrinoidea very frequently, and even among the genera to which we alluded, are not angular, and *Pentacrinus* among the three is the only genus that has lateral cirrhi.

Rudimentary underbasals are known to exist in the Pentacrinoid genus *Extracrinus*, and similar plates have been discovered in the Apiocrinidæ by Mr. De Loriol in two species of *Millericrinus*. In these species, as in the case of *Extracrinus*, the angles of the column, when this is pentangular, are interradial, the canals radial, exactly as in species in which underbasals are supposed to be wanting, but contrary to the conditions of monocyclic Palæocrinoids in which the angles of the column are radial, the axial canals interradial.

Millericrinus polydactylus, according to Mr. De Loriol (Monograph of the French Crinoids, p. 553, Pl. 110, figs. 1 *a* and 2 *a*)[2], has five minute plates within the basal ring, which were regarded by him as "infrabasalia," the term which he applies to underbasals. De Loriol describes these plates as follows: "Je distingue très nettement, sur deux individus, cinq pièces extrêmement petites, à peine distinctes à l'œil nu, qui son logées au centre de l'article basal, chacune reposant sur le sommet de l'une des carènes, dans une direction radiale; au centre se trouve une petite dépression qui forme le fond de la cavité. Ces petites pièces, que je n'avais jamais encore observées, jouent évidemment le rôle de pièces infrabasales, mais à l'état tout à fait rudimen-

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[1] By an error it was stated on p. 7 in Rule 2: the five sections of the column are "*radial*," the longitudinal sutures "*inter*radial," which should read: the five sections of the column are "*inter*radial," the longitudinal sutures "radial."

[2] This and the succeeding quotations are made from the Paléontologie Française, 1re Serie, Animaux Invertébrés, Terrain Jurassique, Tome xi, Première Partie, Crinoides, par M. P. De Loriol, Paris, 1882–1884.

taire." Similar pièces were discovered by him in his *Millericrinus Orbignyi* (Pl. 116, figs. 1 *b*, *c*, *d*), upon which he says on p. 566: "Elles ne peuvent absolument se voir que lorsque, par un hasard heureux, l'article basal peut se dégager du calice. Il me paraît indubitable que ce sont là de petites pièces infrabasales rudimentaires semblables à celles que j'ai signalées dans le *Mill. polydactylus.*"

We fully agree with the distinguished Swiss palæontologist that the plates in question in both cases are rudimentary underbasals, from the very fact that the plates are disposed radially, the outer angles of the column interradially, as seen in *Mill. Orbignyi*, in which the stem is pentangular.

Admitting these plates to be underbasals, we doubt if all other species of *Millericrinus*, which have an interradial pentangular stem, and those with a round stem, and the species of *Apiocrinus*, a genus which, according to De Loriol, is closely allied to *Millericrinus*, should be devoid of underbasals. In that case the two species should be separated from the others, and be placed by themselves under a very distinct genus.

That small underbasals at least temporarily were represented in other species of *Millericrinus* and in *Apiocrinus*, is indicated by the fact that the open space within the basal ring, which in *Millericrinus Orbignyi* is occupied by the underbasals, is radial, contrary to the axial canals of monocyclic Palæocrinoids, which are interradial. Moreover, the space is not in proportion to the axial canal in the stem, which in both genera is small and circular. The space in these species is large enough to have contained, in addition to the axial canal, such small plates as De Loriol figured in *Millericrinus Orbigny*, and these, if present, would take the same position as the underbasals in that species.

In all dicyclic Crinoids, the column rests either exclusively against the underbasals, or, when these are very small, also partly against the basals. The latter is the case in the two species of *Millericrinus* where underbasals are known to be present. In these species they form together with the basals a deep concavity for the reception of the top stem joint, which occupies the whole concavity, as beautifully shown by De Loriol in *Mill. polydactylus* (Pl. 110, fig. 1 *a*). In other species of *Millericrinus* in which no underbasals have been observed, and in the genus *Apiocrinus*, the structure is fundamentally the same, except that the columnar concavity is formed exclusively by the basals, the underbasals being here absent, and the space which they should fill left vacant in the fossil. In all these species the top stem joint occupies the same position toward the basals that it does in the two species in which the underbasals are in place, although the plate varies considerably in form. In some of them it appears as if forming a part of the calyx, in others as an ordinary stem joint. In some species it is much wider than the succeeding joints, in others of the same width; but there are all possible gradations between the extremes. In all of them, however, the plate rests against the outer walls of the basals as in *Mill. polydactylus*, not within the basal ring, and in all of them the basal concavity, whether large or small, is completely filled by the top stem joint.

It is very interesting that in the two cases in which De Loriol accidentally discovered underbasals, these were separated from the basals, and are closely attached to the column, which goes to prove that probably already a partial resorption of the plates took place. It suggests further that the union with the underbasals was tighter than with the basals, that probably the former was effected by common suture, the other by syzygy or some other loose way, the apposed faces being either striated or showing traces of fossæ.

A near approach to the structure of *Millericrinus polydactylus* we find in *Mill. Piletti* (Pl. 63), in which no underbasals were observed, but the lateral faces of the basals (fig. 8 *a*) show clearly that underbasals were once present. The column also here, from the first joint down, is strictly interradial, the axial canal small and round, and not in proportion to the large open space between the basals. The basal concavity is funnel-shaped, very deep, wide at the outer end. The upper stem joint is large, and extends in width considerably beyond all succeeding joints.

A similar base exists in *Mill. Milleri* (Pl. 96), in which again the upper columnar joint is laterally extended and strictly interradial, the columnar canal round, and much smaller than the open space within the basal ring, which is star-shaped, the rays directed radially.

A very different base is figured by De Loriol in *Apiocrinus magnificus* (Pts. 46–48), in which the top stem joint takes the form of the anchylosed underbasal disk of the Palæocrinoid genus *Stemmatocrinus*. A comparison, however, with other species proves very clearly, that it is a top stem joint of a very extreme form, and that the plate actually rests *against the outer faces* of the basals, and not *between* the basals as in the case of the inner plate in *Stemmatocrinus* and *Cupressocrinus*, which Carpenter (Chall. Rep., p. 152), as we think, erroneously took to be a stem joint. The plate in *Apiocrinus magnificus* is not, as should be supposed from appearances, disposed radially, but interradially, as shown by comparison with species having a pentangular stem. It attained its radial angles accidentally by adapting its form to the basal concavity which is naturally angular. The case is parallel to that of *Eucalyptocrinus* and *Barrandeocrinus*, in which the angles of the upper column are shaped so as to conform with surrounding plates, which are in that genus the radials.

In *Apiocrinus Parkinsoni* (Pts. 27 and 28) and in *A. roissyanus* (Pts. 41–45), the basal structure is similar to that of *Ichthyocrinus*, but, while in the latter the underbasals are persistent through life, they may have disappeared in the other. The basal concavity is shallow, and in both species the upper portions of the column taper abruptly in a downward direction. The same is the case frequently among the Ichthyocrinidæ.

The base of *Guettardicrinus* and *Rhizocrinus* is in a similar condition, but less concave. For *Rhizocrinus* we refer to the Challenger Report, Pl. x, figs. 5 and 9. The top stem joint resembles closely that of *Apiocrinus*, and also the basal concavity, which also here is filled completely by the top joint. The columnar canal is circular or ovoid, and much smaller than the pentangular space within the basal ring, which, contrary to monocyclic Crinoids, is directed radially. The same is the case in *Guettardicrinus*. Both genera are built on the same plan as *Apiocrinus*, and if the latter possessed underbasals, these plates were also present in *Rhizocrinus* and *Guettardicrinus*.

In the Pentracrinidæ, and not only in *Extracrinus*, in which underbasals have been observed, but also in *Pentracrinus* and *Metacrinus* in which they are said to be absent, the angles of the column, without exception, are interradial, the lateral cirrhi radial, but, while the axial canals of *Metacrinus*, and probably *Extracrinus*, are radial [1] in conformity with dicyclic Palæocrinoids, they are interradial in *Pentacrinus*,[2] as in all monocy-

[1] Challenger Report, Pl. 12, figs. 1 and 2, and Pl. 41, figs. 6 and 7.

[2] Pl. 12, figs. 15 and 16 ; Pl. 20, figs. 1 and 2 ; Pl. 22, figs. 1, 2, 7 ; Pl. 23, figs. 1 and 2 ; Pl. 26, fig. 11 ; Pl. 27, figs. 2, 3 ; Pl. 30, fig. 4 ; Pl. 34, figs. 8 and 9 ; Pl. 37, figs. 14 and 15.

clic older Crinoids. This departure from what we discovered to be the rule in the Palæocrinoidea induced us not to mention the axial canals in suggesting on p. 71 that perhaps "all Neocrinoids, or at least many of them, may have possessed in their larval state rudimentary underbasals hidden by the column," basing our arguments mainly upon the interradial angles of the column and the radial position of the columnar cirrhi. This forms at present an objection to our view that the two genera, and especially *Pentacrinus*, are dicyclic. On the other hand it must not be overlooked that the position of the column, whether radial or interradial, apparently is governed by laws similar to those by which the underbasals are radial, the basals interradial. The pentapartite stem—and this is found in quite a number of palæozoic genera, especially Silurian—alternates always with the proximal ring of plates, the segments are radial when there are basals only, interradial when also underbasals are present. In Palæocrinoids in which the column is undivided and pentangular, its position, whether radial or interradial, is ascertained from its lateral angles, and hence their direction morphologically important. In species in which the underbasals are small, and completely covered by the column, as sometimes in *Barycrinus*, the angles of the column occupy the same relative position toward the basals, as the upper stem joint of *Metacrinus*, *Pentacrinus*, *Millericrinus* and the centrodorsal of all Comatulæ does toward their basals. This led us to the conclusion that either the rules, which meet with no exception among Palæocrinoidea, as far as we know, either do not hold good for the Neocrinoidea, or the genera to which we alluded, and which are built otherwise upon the plan of dicyclic Crinoids, really possessed rudimentary underbasals during life as *Extracrinus* and certain species of *Millericrinus*, or that perhaps underbasals were present in their larva.

The ventral surface of the centrodorsal in some species of *Antedon* is almost identical with that of the top stem joint of *Millericrinus*, the plate is also interradial (Pl. 6, fig. 11), and rests, as in the Apiocrinidæ, against the outer face of the basals, not within the basal ring. It is similar in other Comatulæ, in all of which the centrodorsal is interradial, and upon this mainly, we base the opinion that perhaps also the Comatulæ in their early larva had rudimentary underbasals. That these plates, if present, were not observed, is not surprising, as they may have been very minute and been covered entirely by the column.

Zittel suggested (Handb. d. Palæont., i, p. 390), that the plate which connects with the basals in *Apiocrinus* probably represented an anchylosed underbasal disk, composed of five pieces. That this is impossible is shown by the case of *Mill. polydactylus*, which in that case would have two rings of underbasals. We fully agree with De Loriol and Carpenter that it is an enlarged stem joint, and believe that the plate represents morphologically the top joint (the first one beneath the basals) of all Crinoids, recent or fossil. The plate forms no integral part of the calyx, but rests in all cases either against the dorsal (outer) face of the basals, against the underbasals, or against both of them. It is disposed interradially in the Apiocrinidæ, Pentacrinidæ and Comatulæ, similar to dicyclic Palæocrinoids, and undivided; while in other groups it is sometimes compound (tripartite or quinquepartite). The underbasals, however, form an integral part of the calyx, they rest within the basal ring, against the lateral faces of the plates, and they are composed primarily of five pieces, which occasionally are reduced by anchylosis to three, or coalesced into a solid disk. If this is correct, it follows that the inner plate of *Stemmatocrinus*, *Cupressocrinus* and allied genera is not a stem joint, as suggested by Carpenter (Chall. Rep. 153) and others, but an anchylosed underbasal disk, as seen by examining the inner side of the calyx, which shows that the plate forms a part of the calyx, and rests against the lateral faces of the basals, within the basal ring, and not against their outer faces.

ADDITIONS AND CORRECTIONS.

Owing to peculiar circumstances preventing a sufficiently careful supervision of publication (although the proofs were carefully examined by one of the authors), a number of errors have been detected, especially in the first section of Pt. III. Two or three of these are exceedingly annoying, entirely changing our meaning. We request our readers to make the changes at once in their copies as indicated below.

Part I.

On p. 239 (Ex. Ed., p. 16), 6th line from bottom, for "Palæocrinoids" read "*Pentacrinoids.*"

On p. 251 (Ex. Ed., p. 28), 16th line from top, for "first radials" read "*basals*" (although the interpretation thus indicated has been modified by us).

On p. 324 (Ex. Ed., p. 101), 11th and 10th line from bottom, change twice: "radial" into "*interradial,*" and "interradial" into "*radial.*"

Part II.

On p. 207 (Ex. Ed., p. 33), 4th line from bottom, for "inverted" read "*recumbent.*"

On p. 247 (Ex. Ed., p. 73), 19th line from bottom, for "ornigranules" read "*ornigranulus.*"

On p. 250 (Ex. Ed., p. 76), 4th line from top, for "vesiculus" read "*vesiculosus.*"

On p. 281 (Ex. Ed., p. 107), 20th line from top, for "elongatulus" read "*elegantulus.*"

On p. 281 (Ex. Ed., p. 107), 16th line from top, for "comptus" read "*comtus*;" and 20th line from bottom, for "Harbrocrinus" read "*Habrocrinus.*"

On p. 298 (Ex. Ed., p. 124), 2d line from top, for "posterior" read "*superior.*"

On p. 299 (Ex. Ed., p. 125), 7th line from top, for "first" read "*second.*"

On p. 319 (Ex. Ed., p. 145), 2d line from bottom, for "tennuis" read "*tenuis.*"

On p. 320 (Ex. Ed., p. 146), 1st line from top, for "tennuisculptus" read "*tenuisculptus.*"

On p. 356 (Ex. Ed., p. 182), 12th line from top, for "basals" read "*underbasals.*"

On p. 389 (Ex. Ed., p. 215), 4th and 11th lines from top, for "pendant" read "*pendent.*"

On p. 393 (Ex. Ed., p. 219), 14th line from top, for "mammilaris" read "*mammillaris.*"

Part III, Sect. I.

On p. 228 (Ex. Ed., p. 6), top line, insert after "and" the words "*we think.*"

On p. 229 (Ex. Ed., p. 7), 5th line from bottom, for "radials" read "*interradials,*" and 4th line from bottom, for "interradials" read "*radials.*"

On p. 230 (Ex. Ed., p. 8), 15th line from top, after the word "cirrhi" insert "*when present.*"

On p. 232 (Ex. Ed., p. 10), 10th and 11th lines from top, for "postero-lateral" read "*antero-lateral.*"

On p. 235 (Ex. Ed., p. 13), 8th and 10th lines from top, for "Pl. 6" read "*Pl. 5;*" also 4th line from bottom, for "Hoplocrinus" read "*Haplocrinus.*"

On p. 241 (Ex. Ed., p. 19): Our statement in the 16th and 17th lines from bottom has been made the basis of a criticism by Dr. P. H. Carpenter, which is well founded. It did not properly express our meaning, and we change it as follows: Strike out all after the word "present" to the end of the sentence, and insert: "*in others apparently absent externally, either as a rule or occasionally, but in these cases we believe them to be represented on the ventral side, as in the Crotalocrinidæ.*" In the same connection, on p. 295 (Ex. Ed., p. 73), in the 12th line from the top, strike out "*all,*" and after the word "are" insert "*generally.*"

On p. 245 (Ex. Ed., p. 23), 3d line from top, for "Palæocrinidæ" read "*Palæocrinoidea.*"

On p. 249 (Ex. Ed., p. 27), 6th line from bottom of text, for "Pl. 2" read "*Pl. 5.*"

On p. 253 (Ex. Ed., p. 31), 8th line from top, for "stellatus" read "*stellaris.*"

On p. 254 (Ex. Ed., p. 32), 18th line from top, before "alone" insert "*perhaps.*"

On p. 255 (Ex. Ed., p. 33), 14th line from bottom, for "multiradiatus" read "*multibrachiatus,*" and for "fig. 2" read "fig. 6;" also 11th line from bottom for "Norwordi" read "*Norwoodii;*" also 5th line from bottom, for "to each plate" read "*or more.*"

On p. 263 (Ex. Ed., p. 41), 5th line from bottom, for "radials" read "*interradials.*"

On p. 277 (Ex. Ed., p. 55), 14th line from bottom, for "Pl. 8" read "*Pl. 9.*"

On p. 285 (Ex. Ed., p. 63), 9th line from top, for "Pl. 1" read "*Pl. 4.*"

On p. 287 (Ex. Ed., p. 65), 5th line from bottom, for "Iovensis" read "*iowensis.*"

On p. 291 (Ex. Ed., p. 69), 12th line from top, for "anal" read "*oral.*"

On p. 292 (Ex. Ed., p. 70), 14th line from top, read "*Palæocrinoidea.*"

On. p. 294 (Ex. Ed., p. 72), last line, for "as a rule" read "*always.*"

On p. 295 (Ex. Ed., p. 73), top line, for "Palæozic" read "*Palæozoic.*"

On p. 300 (Ex. Ed., p. 78), at top, for "Stellerites" read "*Stellerids.*"

On p. 303 (Ex. Ed., p. 81), 16th line from bottom, for "Palæocrinoidæ" read "*Palæocrinoidea.*"

On p. 307 (Ed. Ed., p. 85), 15th line from top, for "Beteocrinus" read "*Reteocrinus.*"

On p. 312 (Ex. Ed., p. 90), 6th line from bottom, for "Platynicridæ" read "*Platycrinidæ.*"

On p. 321 (Ex. Ed., p. 99), under Thylacocrinus, for "Vanniosti" read "*Vannioti.*"

On p. 327 (Ex. Ed., p. 105), top line, for "mespiliformes" read "*mespiliformis.*"

On p. 336 (Ex. Ed., p. 114), 12th line from bottom, for "simple" read "*single.*"

On p. 349 (Ex. Ed., p. 127), 18th line from bottom, for "Nebergangsgeb.," read "*Uebergangsgeb.;*" and on the 11th line, for "Dupé" read "*Hupé.*"

On p. 359 (Ex. Ed., p. 137), 9th line from top, for "peristomeal" read "*peristomial;*" and 12th line, for "were" read "*was.*"

Mr. W. R. Billings discovered underbasals in *Glyptocrinus priscus*, and we therefore refer the species to "*Ptychocrinus.*" He also did send a diagram of *Rhodocrinus* (?) *asperatus*, which leaves but little doubt that it is a somewhat aberrant form of "*Archæocrinus.*"

PART III, SECT. II.

On p. 71 (Ex. Ed., p. 147), 13th line from bottom, strike out the word "*constructed.*"

On p. 79 (Ex. Ed., p. 155), 2d line from bottom, read "*Myrtillocrinus*" without an "*h.*"

On p. 89 (Ex. Ed., p. 165), 10th line from top, for "Austini" read "*Austinii.*"

On p. 90 (Ex. Ed., p. 166), 3d line from bottom, for "Scytalocrinus" read "*Stylocrinus.*"

On p. 99 (Ex. Ed., p. 175), 11th line from top, for "T. granulatus" read "*T. pyriformis.*"

On p. 105 (Ex. Ed., p. 181), 14th line from bottom, for "pyrimidalis" read "*pyramidalis.*"

On p. 115 (Ex. Ed., p. 191), 15th line from top, for "Streblocrinus" read "*Streptocrinus.*"

On p. 150 (Ex. Ed., p. 228), 22d line from top, for "subuminus" read "*subtumidus.*"

On p. 157 (Ex. Ed., p. 233), 18th line from top, strike out the brackets and insert "commas" in their place.

On p. 161 (Ex. Ed., p. 237), 5th line from bottom, for "Dactilocrinus" read "*Dactylocrinus.*"

On p. 162 (Ex. Ed., p. 238), 13th line from top, for "single" read "*simple.*"

On p. 163 (Ex. Ed., p. 239), 16th line from bottom, for "Parisocrinus" read "*Pachylocrinus.*"

On p. 166 (Ex. Ed., p. 242), 11th line from bottom, insert: "**Woodocrinus coxanus, Worthen (Zeacrinus coxanus), Geol. Rep. Illinois, vii, p. 302, Pl. 28, fig. 1. Keokuk gr.—Hamilton, Ill. Syn. Zeacrinus Keokuk, ibid., p. 303, fig. 3.*"

On p. 167 (Ex. Ed., p. 243), 10th line from bottom, for "Pl. 6, fig. 3," read "*Pl. 6, fig. 9 and Pl. 9, fig. 8.*"

On page 169 (Ex. Ed., p. 245), 5th line from bottom, for "orbicularis" read "*globularis.*"

On p. 171 (Ex. Ed., p. 247), 12th line from bottom, for "Epachycrinus" read "*Eupachycrinus.*"

On p. 173 (Ex. Ed., p. 249), 17th line from bottom, for "platybasilis" read "*platybasalis.*"

On p. 175 (Ex. Ed., p. 251), 15th line from top, add the word "*right*" before postero-lateral.

On 177 (Ex. Ed., p. 253), 18th line from bottom, for "Eriocrinus" read "*Erisocrinus.*"

On p. 197 (Ex. Ed., p. 273), 21st line from top, leave out the word "*axial*" before "canal."

APRIL 6.

Mr. JOHN H. REDFIELD in the chair.

Twenty-five persons present.

Permission having been given, Prof. Heilprin withdrew his paper entitled "On a Giant Conorbis from the Oligocene of Florida."

The death of Charles Wilt, a member, was announced.

Fresh-water Sponges from Newfoundland: A new Species.—Mr. EDWARD POTTS stated that in the latter part of August, 1885, Mr. A. H. MacKay, of Pictou, Nova Scotia, whose success as a collector of fresh-water sponges in his own neighborhood has been already recorded (Proc. Acad. Nat. Sci. Phila., 1884, p. 215, etc.), made a scientific visit to the island of Newfoundland. His explorations were mainly limited to the irregular peninsula of Avalon, the southeasterly extremity of the island, and the record of his collections beside mentioning the neighborhood of the city of St. Johns, embraces such familiar names as Trinity Bay, Harbor Grace, and Heart's Content, the landing place of the Atlantic cable.

He writes "I was extremely sorry that owing to my limited time and the impenetrability of the interior to any ordinary effort, I could not gain access to the great lakes in the heart and the western portion of the island. I have merely made a dip into a few of the ponds on the N. (?) E. coast." These are more particularly mentioned as Virginia and Ouidi Vidi Lakes, near St. Johns; Lady Lake, Bannerman Lake, Rocky Lake and Carbonear Lake, small bodies of water near Harbor Grace; and other lakelets and brooks upon the rocky ridges and near the sea level between Harbor Grace and Heart's Content. All this region is described as "the Canadian Huronian, the equivalent of the English Cambrian," and the collections were generally limited to the shallow margins of the ponds, where the sponges were found upon the under sides of splinters of hard slaty quartzites, in numbers very plentiful, but generally small; "from mere points to an inch or more in diameter."

It is to be regretted that the date of Mr. MacKay's visit was necessarily so early in the year, as the specimens collected were either immature or contained only the degenerate statoblasts of the preceding season. The information gathered as to the range of temperature upon this island, is valuable as indicating so far the conditions of the growth of these and other organisms.

He says: "The Island is not extreme in its temperature, and the frost does not go very deep into the soil. The lakes freeze in November or December with ice at least a foot in thickness, and remain closed until the end of April. The average temperature during eight years, from 1857 to 1864, was 41·2° Fahr. Average maximum thermometer during the same time 83°, minimum 7°. In the year 1879, the mean temperature was 40·2° Fahr.; highest record August 3, 82°; lowest December 22, +4°. In Nova Scotia, though that is so much further south, the range is far greater, from +96° to —20° or —24° Fahr., with an annual average of 44°."

The specimens of sponges so kindly forwarded by Mr. MacKay for examination and report, were more or less minute incrustations upon small stones, gathered as above indicated, and belonged to the species *Spongilla lacustris*, Auct.; *S. fragilis*, Leidy; *S. mackayi*, Carter; *Meyenia fluviatilis*, Auct., and *Heteromeyenia pictovensis* and *Tubella pennsylvanica*, Potts. Of these, *Spongilla fragilis* was by far the most abundant, and our knowledge of its range is thus extended along the Eastern coast of North America from Florida to Newfoundland; whereas it had previously been traced westwardly to British Columbia near the Pacific Ocean, and more recently has been discovered in Russia, Bohemia and England. Beside the familiar species, *S. lacustris*, *S. fragilis* and *M. fluviatilis*, *Tubella pennsylvanica* has been rapidly enlarging its borders beyond the narrow limits of its original territorial designation; while *S. mackayi* and *H. pictovensis* had previously been known only from the discoveries of Mr. MacKay in Nova Scotia.

One other form remains to be described, and at the suggestion of its discoverer it is hereby designated—

SPONGILLA NOVÆ TERRÆ, n. sp.

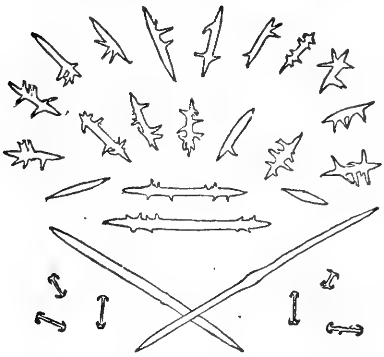
Sponge incrusting; sarcode of the young growth, a dense mass of minute spherical cells, embedding slender curving lines of fasciculated skeleton spicules, developing later into a very loose, open tissue, with few connecting spicules.

Gemmules rather numerous, unusually large, spherical; chitinous coat thin; "crust" apparently wanting.

Skeleton spicules relatively few, slender, cylindrical, smooth or sparsely microspined; gradually pointed.

Dermal or flesh spicules very abundant, minute *birotulates* of unequal size; shafts slender, cylindrical, occasionally spined; outer surface of rotules dome shaped; rays prolonged, terminations acute; malformations frequent. Mixed with occasional linear, spined spicules.

Spicules upon the gemmulæ abundant, crossing each other upon the crustless, chitinous body. Their shape when smooth is robust-fusiform, with pointed terminations; the great majority, however, have from one to six or more long spines, non-symmetrically placed, but with an evident tendency to group themselves at points about one-fourth the length of the spicule from one or both of its extremities.



Measurements: Diameter of gemmules 0·036 inches; skeleton spicules, 0·0068 by 0·0002 inches; length of average dermal spicule, 0·00066 inches; of gemmula spicule, 0·00145 inches.

Habitat.—Encrusting stones in shallow water.

Locality.—Lakes or ponds in the vicinity of Heart's Content, Newfoundland; collected by Mr. A. H. MacKay.

All the specimens of this sponge came from the neighborhood of Heart's Content, but whether they were gathered from a lake upon the heights or from a brook mentioned by Mr. MacKay near the sea level, does not seem entirely clear. The accompanying illustration (magnified 225 diameters) will suggest the peculiarities of its skeleton, dermal and gemmular spiculation. The striking resemblance of the dermal spicules to the minute birotulates, heretofore only known in a corresponding position, in the case of *Meyenia everetti*, will at once impress the student. These are however more variable in size, are occasionally spined, and have their rays more prolonged and more delicately terminated.

It is in the singular character of the spicules surrounding the gemmulæ that this sponge must attract peculiar attention. By the system of H. J. Carter, Esq., the fresh-water sponges are now classified into six genera, beside some conditional designations of forms in which the typical features are as yet undiscovered. These six, *Spongilla*, *Meyenia*, *Heteromeyenia*, *Tubella*, *Parmula* and *Carterius*, may again be associated into two groups, one of them including only the genus *Spongilla*, characterized by the *linear acerate* spicules surrounding the gemmulæ; and the other comprising all the other genera, where the spicule of corresponding significance is a *birotulate* or some easily recognized derivative of that type. Within this latter and larger group intermediate forms, connecting the defined genera, are frequent, and the location of species upon one side or other of the distinctive line comparatively unimportant. Heretofore, between the genus *Spongilla* and those genera comprising the other group, there has been "a great gulf fixed." One only case in the past has suggested their possible association, or the development of one group from the other.

In *Meyenia acuminata*, Potts (Proc. Acad. Nat. Sci. Phila., 1882, p. 69), since regarded as a variety of *M. fluviatilis*, the shafts of the birotulates are prolonged at each extremity, forming acuminate terminations some distance beyond the surface of the rotules. In position, also, these spicules are abnormal, lying flat upon the chitinous coat, instead of resting upon one rotule, their shafts taking the position of radii, as is usual in this form. In fact we have the spicules of a Meyenia occupying the ordinary positions, and in degree approximating the forms of those peculiar to the Spongillæ.

In the present instance their intermediate character is still more striking, and while their form and position probably more closely associate them with the genus *Spongilla* in which the species has now been placed, the grouping of the ray-like species clearly suggests *Meyenia.* It has been an altogether unprecedented experience with the author to hesitate between these two genera, and it will be no cause of surprise if the future teacher shall shift it from its present position.

It must not escape notice that in both of these instances the gemmulæ are without "crust;"—that it is difficult to understand how birotulates could be supported in their ordinary positions *without* these embedding granules; and that we may not unreasonably infer that the change in position has induced the modification of type that we here find.

This collection of sponges, including the new species, has been examined coincidently by H. J. Carter, Esq., F. R. S., and their identification and this description are believed to meet his approval.

April 13.

Mr. John H. Redfield in the chair.

Nineteen persons present.

The death of the Hon. John Welsh, a member, was announced.

April 20.

Mr. Geo. W. Tryon, Jr., in the chair.

Fifteen persons present.

The death of Andrew Nebinger, M.D., a member, was announced.

APRIL 27.

The President, Dr. JOS. LEIDY, in the chair.

On Anthracomartus Trilobitus Scud.—Prof. F. L. HARVEY remarked that the coal field of North Arkansas belongs to the western interior coal area, which covers the greater part of Missouri, and extends into Iowa, Kansas, Nebraska, Indian Territory, Arkansas and Texas. This vast field covers 78,000 square miles, of which about 10,000 are in Arkansas and 12,000 in the Indian Territory. It belongs to the lowest, the *subconglomerate.* The veins occur in the shales of the millstone grit, less than 100 feet above the Archimedes limestone. There is only one vein in the northern limit, which is from eight to eighteen inches thick. In the Arkansas River valley there are three veins which often have an aggregate thickness of over six feet. The veins lie high in the hills in the Boston Mountains, but the southward dip brings them in the Arkansas River valley, beneath the drainage of the country.

The veins in north Arkansas are worked in a limited way by scalping and drifting, but shaft mining is done at Coal Hill, Spadra and other points and there is at present considerable coal exported to New Orleans down the Arkansas valley route.

The conditions were most favorable for the preservation of plant remains. Beautifully preserved plants occur in the shales above the coal vein of northwest Arkansas and limited research in Washington County alone yielded the speaker over 100 species new to the State and fifteen new to science.

While searching for fossil plants in the brash shale near the coal, a specimen of fossil spider was found. By carefully working over a few tons of shale several more specimens were procured. The material was sent to Prof. Scudder for examination and he named the form *Anthracomartus trilobitus*, sp. nov. It is believed to be the only species of the genus found in the coal measures of the United States. The genus was founded upon a single European species. It is interesting that a second species should be found so far separated. Fossil insects are scarce in the subconglomerate, and the three known from Arkansas are, a wing of *Blattina venusta*, discovered by Prof. Lesquereux and figured in Owen's Report of Arkansas, vol. ii, p. 312; the species of spider under consideration and an undescribed Neuropterous larva in the cabinet of the speaker. The description and figure of this *Anthracomartus*, so far as we know, has not been published, but is enumerated in Mr. R. D. Lacoe's "Check List of Palæozoic Insects." Less than a dozen specimens are known and they are in the cabinets of Prof. Scudder, Mr. R. D. Lacoe and the speaker, besides the specimen presented to the Academy this evening. The specimens are all imperfect, showing only the abdomen and a part of the cephalothorax. The most of them were compressed vertically and give a transverse view. The compressed abdomen reminds one of the pygidium of a trilobite, hence the specific name. A single specimen compressed laterally shows well the elevated and rounded abdomen characteristic of our modern spiders. The cephalothorax is minutely punctate. The species is interesting as occurring at the base of the coal measures. The locality is no longer worked and the species may be considered scarce.

Messrs. Calvin McCormick and Samuel Wagner were elected members.

The following was ordered to be printed :—

A REVIEW OF THE AMERICAN GASTEROSTEIDÆ.

BY CARL H. EIGENMANN.

In this paper I have attempted to give the synonymy of the American species of *Gasterosteidæ* with analytical keys for their identification, and such notes as my studies of the group seem to justify. The specimens examined all belong to the Museum of the Indiana University.

I am indebted to Dr. David S. Jordan for the use of his library and for many suggestions.

Analysis of Genera of Gasterosteidæ.

a. Snout not prolonged; dorsal spines 3 to 11.

b. Innominate bones joined, forming a median plate on belly behind ventral fins.

c. Gill membranes joined; their posterior border free from the isthmus; spines small, mostly feeble.

d. Dorsal spines 7 to 11, weak, divergent; innominate bones with the outer edge stout and thick; the median part scarcely ossified; pubic bones long, weak, widely divergent, leaving a ◁-shaped naked area in front of ventral spines; body slender. PYGOSTEUS. 1.

dd. Dorsal spines 5, non-divergent, of moderate size; innominate bones united, forming a short, narrow but strong ventral plate; pubic bones weak, short, widely divergent, leaving a subcircular space in front of ventral spines; body rather stout; skin smooth. EUCALIA. 2.

cc. Gill membranes narrowly joined to the isthmus; innominate bones large and strong; spines of fins mostly strong; divergent; dorsal spines 3 or 4 in number; pubic bones very broad, long and little divergent, leaving a lanceolate-shaped, naked area in front of the ventrals; form robust; skin mailed or naked. GASTEROSTEUS. 3.

bb. Innominate bones not joined, but each extending as a strong process under the skin on outside of insertion of ventrals; the area between them flat and not ossified; pubic bones short and weak, not visible externally; dorsal spines strong, divergent, 4 in number; gill membrane broadly joined to the isthmus; body rather stout; the caudal peduncle very slender; skin smooth. APELTES. 4, *aa.* Snout projecting, subtubiform; dorsal spines small, about 15; innominate bones joined only at base; body elongate; sides mailed. SPINACHIA. 5.

1. PYGOSTEUS.

Pygosteus (Brevoort MSS.) Gill, Cat. Fish. East Coast N. A., 39, 1861. (Not characterized); Canadian Naturalist, ii, 8; August, 1865 (*occidentalis*).

Gasterostea Sauvage, Revision des Epinoches, 29, 1874 (*pungitius*).

This genus is characterized by the presence of 7 to 11 divergent dorsal spines and by the weakness of the innominate bones. It differs from *Gasterosteus* also, in having the posterior margin of the gill membrane free and by the less development of the spinous armature.

But a single species, variable in its characters, seems to be known. It is widely distributed in the fresh and brackish waters of northern regions.

Analysis of Species of Pygosteus.

a. Body extremely elongate and slender, deepest at ventral spines, decreasing in height towards head and tail. Head long, 4 in length to base of caudal. Mouth large, very oblique; maxillary not reaching to anterior margin of orbit. Teeth small, in a single series. Eye large, its diameter greater than snout. Caudal peduncle keeled, slender and long, about 5 in length to base of caudal. No bony plates along side; small plates extending along the bases of the anal and soft dorsal. Post pectoral plate present, large and faintly granulate. Scapula forming a triangular post opercular plate; operculum striate. All the surface bones very weak, bones of scull granulate; innominate bones weak, translucent, thin in the median part. Gill openings extending to below posterior edge of preopercle. Vertebræ (*pungitius*) 14 + 18. Caudal fin lunate, long and narrow.

b. Ventral spines more than one-third of head. D. VII. to IX–1, 9; A. 1, 8. PUNGITIUS. 1.

bb. Ventral spines less than one-third length of head. D. X–I. 10; A. I, 10. *Brachypoda.* 1 (*a.*)

1. PYGOSTEUS.

1. **P. pungitius.**

Gasterosteus aculeis in dorso decem Artedi, Gen. Pisc., 52, 1738.

Gasterosteus pungitius Linnæus, Syst. Nat., Edit. x, L. 296, 1758 (based on Artedi) (and of European authors generally); Storer, Rept. Fish. Mass., 32, 1839 (Salem); Bean, Proc. U. S. Nat. Mus., 1879, 10 (Boston); Goode & Bean, Fish. Essex Co. and Mass. Bay, 5, 1879 (Salem Pond); Bean, Proc. U. S. Nat. Mus., 1880, 77 (Wood's Holl); Bean, Proc. U. S. Nat. Mus., 1881, 128 (Hudson Bay); Jordan and Gilbert, Syn. Fish. N. A., 393, 1883; Stearns, Proc. U. S. Nat. Mus., 1883, 124 (Labrador).

Pygosteus pungitius Forbes, Bull. Ill. Lab. Nat. Hist., iii, 69, 1880 (Calumet R.; Lake Michigan); Jordan, Ohio Geol. Rep., 999, 1882 (Name only); Jordan, Cat. Fish. N. A., 63, 1885.

Gasterosteus pungitivus Walbaum, Artedi Piscum, 446, 1792 (After Artedi).

Gasterosteus occidentalis Cuvier & Valenciennes, Hist. Nat. Poissons, iv, 509, 1829 (Newfoundland); Dekay, Nat. Hist. N. Y., 68, plate XLII, fig. 135, 1842 (New York); Jordan, Cat. Freshwater Fish. U. S., 441, 1878 (Name only).

Gasterosteus pungitius var. *occidentalis* Günther, Cat. Fish. Brit. Mus., i, 6, 1859 (North America).

Pygosteus occidentalis (Brevoort MSS.) Gill, Cat. Fish. East Coast N. A., 39, 1861 (East Coast); Gill, Cat. Fish. East Coast N. A., 16, 1873 (Name only); Jordan, Man. Vert., 248, 1876 (Great Lakes); Goode, Bull., xiv, U. S. Nat. Mus., 53, 1879 (Name only); Goode, Bull. xxi, U. S. Nat. Mus., 31, 1880 (Name only).

Gasterostea occidentalis Sauvage, Revision des Epinoches 30, plate i, fig. 18, 1874 (Newfoundland).

Gasterosteus concinnus Richardson, "Fauna Bor. America. iii, 57," 1836 (Saskatchawan and Mackenzie Rivers); Dekay, Nat. Hist. N. Y., 68, 1842 (Northern regions); Günther, Cat. Fish. Brit. Mus., i, 6, 1859 (copied).

Pygosteus concinnus Jordan & Copeland, Checklist N. A. Fresh Water Fish., 40, 1876; Jordan, Cat. Fresh Water Fish N. A., 441, 1878 (Name only).

Gasterostea concinna Sauvage, Revision des Epinoches, 35, 1874 (Name only).

Gasterosteus mainensis Storer, Boston Journal Nat. Sci., i, 465, 1837 (Kennebec Co., Maine); Dekay, Nat. Hist. N. Y., 68, 1842 (copied); Günther, Cat. Fish. Brit. Mus., i, 6, 1859 (copied); Sauvage, Revision des Epinoches, 33, 1874 (copied).

Pygosteus mainensis Jordan & Copeland, Checklist N. A. Fresh Water Fish, 140, 1876 (Name only); Jordan, Cat. Fresh Water Fish N. A., 441, 1878 (Name only).

Pygosteus occidentalis var. *mainensis* Jordan, Man. Vert., 248, 1876 (Kennebec Riv.).

Gasterosteus nebulosus Agassiz, Lake Superior, 310, plate iv, fig. 4, 1850 (Lake Superior).

Pygosteus nebulosus Jordan, Fish. Indiana, 31, 1874 (Lake Michigan); Jordan and Copeland, Checklist N. A. Fresh Water Fish., 140, 1876 (Name only); Nelson, Bull. Ill. Lab. Nat. Hist., i, 42, 1877 (Lake Michigan).

Pygosteus occidentalis var. *nebulosus* Jordan, Man. Vert., 248, 1874; Jordan, Bull. Ills. Lab. Nat. Hist., ii, 51, 1877 (Lake Michigan); Jordan, Cat. Fresh Water Fish. N. A., 441, 1878 (Name only).

Gasterosteus dekayi Agassiz, "Lake Superior, 311," 1850 (after Dekay); Putnam, "Proc. Essex Inst., 148, 155;" Putnam, Bull. Mus. Comp. Zool. i, 11, 1863; Storer, Hist. Fish. Mass., 91, plate viii, fig. 3, 1867 (Massachusetts).

Pygosteus dekayi Gill, Cat. Fish. East Coast N. A., 39, 1861 (Name only).

Gasterostea dekayi Sauvage, Revision des Epinoches, 31, 1874 (New York).

Gasterostea blanchardi Sauvage, Revision des Epinoches, 32, 1874 (New York); Bean, Proc. U. S. Nat. Mus., 1879, 31 (Boston).

1 *a*. **P. pungitius brachypoda.**

Gasterosteus pungitius brachypoda Bean, Bull. U. S. Nat. Mus., xv, 129, 1879 (Oosooadlin—Mountain Streams and Lakes); Bean, Proc. U. S. Nat. Mus., 1880, 77 (American Harbor); Bean, Arctic Cruise, 118, 1881 (Elephant Point, near Icy Cape); Bean, Proc. U. S. Nat. Mus., 1881, 240 (St. Paul, Kodiak; Unga Island, Shumagins; Iliuliuk Lake, Unalaska; St. Paul Island, Bering Sea; St. Michaels; Port Clarence; Elephant Point; Eschscholtz Bay; Icy Cape, Arctic Ocean; Alaska; Bean, Proc. U. S. Nat. Mus., 1881, 270 (Pacific South of Bering Strait); Jordan & Gilbert, Syn. N. A. Fish., 394, 1883; Bean, Bull. U. S. Nat. Mus., xxi, 19, 1883 (St. Michaels, Alaska).

Gasterosteus pungitius Stejneger, Proc. U. S. Nat. Mus., 1883, 65 (Commander Islands).

Habitat.—Shores of Northern Europe and Eastern America South to New York, also in the great Lakes and northward; var. *brachypoda* in the North Pacific, the specimens examined by me are from Calumet Lake, Ills., and from Massachusetts.

The synonomy of this species, as given above, needs a word of remark.

The *pungitivus* of Walbaum is of course identical with the *pungitius* of Linnæus.

I cannot see that east coast specimens, representing the *occidentalis* of Cuvier and Valenciennes, and that of Dekay, differ at all from descriptions of the European *pungitius*, but I have had no specimens of the latter for direct comparison. I cannot, therefore, regard *occidentalis* as a separate species or variety. The *dekayi* of Agassiz is based on the *occidentalis* of Dekay; I have therefore placed it also in the synonymy of *pungitius*.

The *mainensis* of Storer is said to differ from *pungitius* only in having a " bony serrated plate on the side." This probably refers to the plate behind the pectorals.

The *concinnus* of Richardson is said to differ in having seven dorsal spines, but as the number seems to vary from 7 to 11, this cannot be considered as a specific character. I have examined specimens from Calumet, R. Illinois (presumably representing the form called *nebulosus*). I can find no difference whatever between these and Massachusetts examples of *pungitius*.

The var. *brachypoda* seems to differ from *pungitius* only in the shorter ventral spines. It is known to me only from the description of Dr. Bean (above cited).

2. EUCALIA.

Eucalia Jordan, Man. Vert., ed. i, 248, 1876 (*inconstans*).

This genus is closely allied to *Pygosteus*, agreeing with it in the structure of the gill membranes, but differing in having the dorsal spines few and non-divergent, and in having the innominate bones more fully united. The species are the most feebly armed of the Sticklebacks.

Analysis of Species of Eucalia.

a. Body moderately robust, the caudal peduncle not very slender; depth 4 in length to base of caudal. Head pointed; mouth small, very oblique; maxillary reaching to anterior margin of eye; teeth small, stout, in a single series; eye large, much longer than snout. Caudal peduncle moderately compressed, $7\frac{1}{2}$ times in length to base of caudal. No bony dermal plates; skin naked; no post-opercular (suprascapular) plate; post-pectoral plate covered by skin; skin of head not ossified. Lateral line beginning at upper angle of preopercle and curved to below fourth dorsal spine, from where it goes straight to middle of tail; a second row of tubes is seen for a small distance along its origin. A patch of mucous pores at beginning of lateral line; a row along the edge of the preopercle and a ⊂-shaped row at nape. Dorsal spines about equal to one-half diameter of eye, the first just reaching base of second; these spines are recurved and slightly serrate on their edges; the fifth spine is more recurved and higher than the others. Soft dorsal very high in front, its longest ray about equal to snout and half the orbit; the last ray equals half the orbit; caudal short and broad; anal inserted below insertion of second dorsal, similar to and coterminous with it. Pectorals short and broad, their length equal to their breadth at tips. Vertebræ (*cayuga*), 14 + 18. Brownish with lighter blotches and black points. Males in spring black, tinged with red on the jaws and snout.

b. Ventral spines equal to $\frac{2}{3}$ length of innominate bones; post-pectoral plate large, variable, mostly ▽-shaped. D. IV–I, 10; A. I, 10. INCONSTANS. 2.

bb. Ventral spines short, but longer than innominate bones; post-pectoral smaller than in preceding, mostly ∩-shaped. D. IV–I, 10; A. I, 10. *cayuga.* 2 (*a*).

bbb. "D. III or IV–I, 6. A. I, 6." (?). *pygmæa.* 2 (*b*).

2. EUCALIA.

2. E. inconstans.

Gasterosteus inconstans Kirkland, Boston Journal Nat. Hist., iii, 273, 1841 (Trumbull Co., Ohio); Dekay, Nat. Hist. N. Y., 68, 1842 (Name only); Cope, Proc. Acad. Nat. Sci. Phila., 1865, 81 (Sukertoppen, Greenland); Jordan & Gilbert, Syn. Fish. N. A., 394, 1883.

Apeltes inconstans Jordan, Fish of Indiana, 31, 1874 (Northern Indiana).

Eucalia inconstans Jordan, Man. Vert., ed. i, 249, 1876 (Name only); Jordan & Copeland, Checklist N. A. Fresh-water Fish, 141, 1876 (Name only); Nelson, Bull. Ills. Tab. Nat. Hist., i, 42, 1876 (Copied); Jordan, Bull. Ills. Lab. Nat. Hist., ii, 58, 1877 (Small Streams of Northern Ills.); Jordan, Proc. Acad. Nat. Sci. Phila., 1877, 65; Jordan, Cat. Fresh-water Fish N. A., 441, 1878 (Name only); Forbes, Bull. Ills. Lab. Nat. Hist., iii, 68, 1880 (Northern Ills.).

Gasterosteus micropus Cope, Proc. Acad. Nat. Sci. Phila., 1865, 81 (Fort Riley, Kansas); Sauvage, Revision des Epinoches, 28, 1874 (Copied).

Eucalia micropus Jordan & Copeland, Checklist N. A. Fresh-water Fish, 141, 1876 (Kansas).

Gasterosteus globiceps Sauvage, Revision des Epinoches, 35, 1874 (North America).

Eucalia inconstans, var. *pygmæa* Jordan, Geol. Report Ohio, 998, 1882 (Central Ohio; Trib. of Great Lakes).

2 *a*. **E. inconstans cayuga.**

Eucalia inconstans, var. *cayuga* Jordan, Man. Vert., ed. i, 249, 1876 (Cayuga Lake); Jordan & Copeland, Checklist N. A. Fresh-water Fish, 141, 1876 (Name only); Jordan, Geol. Report Ohio, 998, 1882.

2 *b*. **E. inconstans pygmæa.**

Gasterosteus pygmæus Agassiz, Lake Superior, 314, 1850 (Lake Superior).

Eucalia inconstans, var. *pygmæa* Jordan, Man. Vert,, ed. i, 249, 1876 (Copied); Jordan & Copeland, Checklist N. A. Fresh-water Fish, 141, 1876 (Name only); Nelson, Bull. Ills. Lab. Nat. Hist., i, 42, 1876 (Lake Michigan).

Habitat.—Fresh waters of North America, from Kansas and Great Lake region northward to Greenland. Var. *cayuga* in tributaries of Lake Ontario. Var. *pygmæus* in Great Lakes.

The specimens of the typical *inconstans* examined by me are from Rock River, Illinois.

Those of the var. *cayuga* are from Syracuse, New York.

The *micropus* of Cope would seem to differ in its shape, being shorter and deeper, and in having a smaller post-pectoral plate and ventral spines. All of these characters are of doubtful permanence.

The *globiceps* of Sauvage offers no peculiar characters.

The var. *cayuga* seems to differ from *inconstans* in having longer ventral spines and smaller post-pectoral plates; it is perhaps identical with it.

The *pygmæa* of Agassiz is said to differ from *inconstans* in having the body shorter and deeper, and in the number of fin rays. The difference in form is of no importance, and it is not likely that the alleged difference in the fin rays is real.

3. GASTEROSTEUS.

Gasterosteus Artedi, Gen. Pisc., 52, 1738.

Gasterosteus Linnæus, Syst. Nat. Ed. x, i, 295, 1758 (*aculeatus*).

Gasteracanthus Pallas, "Zoogr. Rosso. Asiatica, iii, 228," 1811 (*cataphractus*).

Leiurus Swainson, Nat. Hist. Class Fishes, ii, 242, 1839 (*gymnurus*, etc.).

This genus is distinguished from *Pygosteus* and *eucalia* in having the posterior margin of the gill membrane joined to the isthmus. The body is more robust; the spines and innominate bones much stronger; the pubic bones very broad and little divergent. Its species are the strongest of the sticklebacks and the most fully armed. All of them are very variable and very closely related one to another. The species with the bony plates most developed are most marine in their habit, while the partly or wholly naked forms seem rather to inhabit the rivers. It may be that a complete gradation exists from the fully armed *aculeatus* to the naked *williamsoni*, in which case all these forms should be regarded as varieties of *aculeatus*. All northern regions seem to possess full mailed species (*aculeatus* and vars.) and half mailed species (allies of *gymnurus*). The former type seems identical on both sides of the Atlantic, but the latter type so far as our specimens can show seems to be different in America from any described in Europe.

Analysis of Species of Gasterosteus.

a. Sides entirely covered with (28 to 30) bony dermal plates. Caudal peduncle keeled; ventral spines each with a large cusp on outer edge of base. Bones of head striate, the skin ossified. Mouth large, little oblique; maxillary not reaching front of eye; teeth small, in a single series in lower and double series in upper jaw. The anterior plates are joined above to the large bony plates at base of spines; the posterior plates are separated from the small plates at bases of soft dorsal and anal by narrow naked strips. Lateral line high up, parallel with outline of back and along middle of caudal peduncle, which is strongly keeled. Dorsal spines serrate on their edges. Origin of soft dorsal far in advance of origin of anal. Caudal lunate; anal spine recurved, smaller than third dorsal spine, the fin similar to soft dorsal. Ventrals long and slender, serrate. Pectorals narrow. D. I–I–I, 11 to 13; A. I, 9 or 10.

b. Body moderately robust, the depth $4\frac{1}{2}$ in length. ACULEATUS. 3.

bb. Body deeper and stronger; caudal keel very strong. *cataphractus.* 3. (*a.*)

aa. Sides partly covered with (2 to 15) bony dermal plates, the posterior part of the body naked. Ventral spines with or without cusp at base.

c. Sides with 15 bony plates; caudal peduncle keeled; body slender; ventral spine long, almost or quite reaching vent; dorsal spines in a straight line. Head $3\frac{1}{3}$ in length to base of caudal; depth 5. D. I–I–I, 11; A. 1, 8. Silvery below with dark bands across the body (*Bean*). ATKINSII. 4.

cc. Sides with 2 to 6 bony dermal plates; caudal peduncle keeled or not.

d. Ventral spine without cusp at base.

e. Dermal plates 4 to 6; body stout, little compressed; head large, flat above, a small knob at occiput. Mouth large, maxillary almost reaching front of orbit. Teeth in broad bands in front. From occiput, two rows of mucous pores diverge to posterior borders of eye, extending thence parallel with the orbit to above nasal opening forming an arrow-shaped figure. Plates on sides imbedded, thin; striate; the last one immediately in front of second dorsal spine. Post-pectoral plate striate ∩-shaped. Scapula forming a striate post-opercular plate. Caudal peduncle very thick to a point immediately in front of caudal where it is much compressed. Innominate bones and ventrals varying much in relative length, so that in some specimens the one is the longer in others the other. Dorsal spines short, straight, broad at base, serrate on outer edges. First spine about $\frac{2}{3}$ in eye, third very small. Caudal slightly lunate. Anal inserted under fifth dorsal ray, coterminous with the dorsal. Ventrals coarsely serrate on outer and finely on inner edges. Pectorals broad and short, fan-shaped. D. I–I–I, 11 to 13; A. 1, 9. Olivaceous, silvery below, thickly punctulate. MICROCEPHALUS. 5.

ee. Dermal plates on side 2 or 3, strong, not imbedded. Mouth large, maxillary reaching to below front of orbit. Mucous pores none. Scapula forming a post-opercular plate. All bones thicker and stronger than in *microcephalus*. Caudal peduncle compressed for its whole length. D. I–I–I, 10 to 12; A. 1, 8. WHEATLANDI. 6.

dd. Ventral spines each with a distinct cusp at base. Lower jaw the longer. Teeth in lower jaw stronger than in upper. Diameter of orbit $3\frac{1}{2}$ in head. Sides with 7 plates. Innominate bones almost reaching vent. Caudal peduncle with a membranous carina. Caudal fin forked. Ventral $\frac{1}{3}$ in. finely serrate. Pectoral $\frac{1}{2}$ in. Length of specimen $2\frac{1}{2}$. D. I–I–I, 12; A. 1, 8. Uniformly grayish on back, head and posterior half of body; abdomen yellowish.

DIMIDIATUS. 7.

aaa. Sides entirely naked; no bony dermal plates; caudal peduncle not keeled. Tip of first dorsal spine not reaching second. Head 3 in length to base of caudal. Depth 5 in total length. D. I–I–I–1, 10; A. 1, 7. Olivaceous brown, darker above; sides spotted with black; belly yellowish. WILLIAMSONI. 8.

3. GASTEROSTEUS.

3. **G. aculeatus.**

Gasterosteus in dorso tribus. Artedi, Gen. Pisc., 52, 1738 (Europe); Pennant, Arctic Zool., ii, 385, 1792 (No description).

Gasterosteus aculeatus Linnæus, Syst. Nat. Ed. X, i, 295, 1758 (after Artedi); Fabricius, "Fauna Grœnlandica," 169, 1780 (Greenland); Bloch, Syst. Nat., plate 53, fig. 3; Richardson, Fauna Bor. America, 55, 1836; Gill, Cat. Fish. East Coast N. A., 39, 1861 (Name only); Gill, Cat. Fish. East Coast N. A., 16, 1873 (Name only); Sauvage, Revision des Epinoches, 9, 1874 (Bonneville, near Caen); Jordan, Cat. Fresh Water Fish. N. A., 442, 1878 (Name only); Goode & Bean, Fish. Essex Co. Mass. Bay, 5, 1879 (Essex Co.); Bean, Proc. U. S. Nat. Mus., 1880, 77 (Woods Holl, Wilmington, Del.); Jordan & Gilbert, Syn. Fish. N. A., 395, 1883 (East Coast); Stearns, Proc. U. S. Nat. Mus., 1883, 123 (Labrador).

Gasterosteus bispinosus Walbaum, Artedi Ichth., 450, 1792 (after Pennant).

Gasterosteus biaculeatus Shaw, Zool., iv, 608, 1839 (after Pennant); Mitchill, Trans. Lit. and Phil. Soc., 430, 1814 (Salt Water at New York); Dekay, Nat. Hist. N. Y., 65, plate iii, fig. 8, 1842 (New York); Storer, Syn. Fish. N. A., 63, 1846; H. R. Storer, Fish. Labrador, 260, 1849 (Brooks emptying into Gut of Canso); Gill, Cat. Fish. East Coast N. A., 39, 1861 (Name only); Putnam, Bull. Mus. Comp. Zool., 11, 1863; Storer, Hist. Fish. Mass., 87, plate viii, fig. 213, 1867.

Gasterosteus noveboracensis Cuvier & Valenciennes, Hist. Nat. Poissons, iv, 502, 1829 (New York); Storer, Rept. Fish. Mass., 30, 1839 (Massachusetts); Ayres, Fish. Brookhaven, Long Island, 259, 1842 (Old Man's Harbor, Storer, Syn. Fish. N. A., 63, 1846; Gill, Cat. Fish. East Coast N. A., 16, 1873 (Name only); Sauvage, Revision des Epinoches, 11, 1874 (New York, Newfoundland, Boston); Jordan, Man. Vert., Ed. i, 250, 1876 (Name only); Goode, Bull. U. S. Nat. Mus., xiv, 53, 1879 (Name only).

Gasterosteus aculeatus var. *noveboracensis* Günther, Cat. Fish. Brit. Mus., i, 4, 1859 (Greenland).

Gasterosteus niger Cuvier, Règne Animal, 76, 1829 (Based on *biaculeatus* of Mitchill); Cuvier & Valenciennes, Hist. Nat. Poissons, iv, 503, 1829 (Newfoundland); Dekay, Nat. Hist. N. Y., 68, 1842 (Newfoundland); Storer, Syn. Fish. N. A., 63, 1846; Gill, Cat. Fish.

East Coast N. A., 39, 1861 (Name only); Sauvage, Revision des Epinoches, 13, 1874 (Newfoundland); Jordan, Cat. Fresh Water Fish. N. A., 442, 1878 (Name only).

Gasterosteus trachurus Cuvier, Règne Animal, 76, 1829 (Based in part on Bloch); Storer, Syn. Fish. N. A., 62, 1846.

Gasterosteus loricatus Reinhardt, Grœn. Fauna, 37, 1837 (Greenland); Reinhardt, "Kong. Danske. Vidensk. Selsk. Nat. Math. Afh., vii, 114," 1838; Sauvage, Revision des Epinoches, 12, 1874 (Newfoundland).

Gasterosteus neoboracensis Dekay, Nat. Hist. N. Y., 66, plate vi, fig. 17, 1842 (New York).

Gasterosteus dekayi Ayres, Proc. Ac. Nat. Sci. Cal. (based on *biaculeatus* of Dekay).

Gasterosteus suppositus Sauvage, Revision des Epinoches, 11, 1884 (after Dekay).

3. **G. aculeatus cataphractus.**

Gasteracanthus cataphractus Pallas, "Mem. Acad. Petersb., iii, 325," 1811.

Gasterosteus cataphractus Bean, Proc. U. S. Nat. Mus. 1881, 239 (Kodiak, Cook's Inlet, Sitka, Port Mulgrave, Shumagins, Unalaska, Amchitka, Kyska Harbor, St. Paul, Bering Sea near Bering Isl.); Bean, Proc. U. S. Nat. Mus., 1881, 270 (Pacific South of Bering Strait, Puget Sound, San Francisco); Stejneger, Proc. U. S. Nat. Mus., 1883, 65 (Commander Island); Bean, Proc. U. S. Nat. Mus., 1883, 353 (Duncan's Bay, Brit. Col.); Bean, Cat. Fish. in Internat. Fish. Exhib. London, 19, 1883 (St. Paul Isl.).

Gasterosteus aculeatus var. *cataphractus* Jordan & Jouy, Proc. U. S. Nat. Mus., 1881, 1 (Puget Sound); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1881, 69 (San Francisco to Alaska).

Gasterosteus aculeatus subsp. *cataphractus* Jordan & Gilbert, Syn. Fish. N. A., 396, 1883 (West Coast).

Gasterosteus obolarius Cuvier & Valenciennes, Hist. Nat. Poissons, iv, 500, 1829 (Kamtschatka); Sauvage, Revision des Epinoches, 12, 1874 (Name only).

Gasterosteus insculptus Richardson, Last Arctic Voy., 10, plate xxv, fig. 1, 2, 3, 1854 (Northumberland and Puget Sound); Bean, Bull. U. S. Nat. Mus., xv, 129, 1879 (Northumberland Sound):

Gasterosteus serratus Ayres, Proc. Cal. Acad. Nat. Sci., 1855, 47 (San Francisco); Girard, Pacific R. R. Survey, 88, 1859 (Shoal Water Bay: San Francisco); Sauvage, Revision des Epinoches, 13, 1874 (San Francisco Bay); Jordan, Cat. Fresh Water Fish. N. A., 442, 1878 (Name only); Jordan & Gilbert, Proc. U. S. Nat. Mus. 1880, 452 (Puget Sound, San Francisco); Jordan & Jouy, Proc. U. S. Nat. Mus., 1881, 1 (Foot note).

Gasterosteus intermedius Girard, Proc. Acad. Nat. Sci. Phila., 1856, 135; Girard, Pacific R. R. Survey, 89, 1859 (Cape Flattery); Jordan, Cat. Fresh-water Fish N. A., 442, 1878 (Name only).

Habitat.—Northern Atlantic Coast of both Continents. Var. *cataphractus* is found on the West Coast of North America, from San Francisco to Alaska and Kamtschatka.

This species differs from the others in having the whole sides covered with (28–30) bony plates.

The *biaculeatus* of Mitchill possesses the (33) plates characizing the *aculeatus* and otherwise agrees with the latter; the slight variation in the number of lateral plates may perhaps arise from a different manner of counting them.

The *bispinosus* of Walbaum and *biaculeatus* of Shaw are alike based on Pennant. The description given by the latter author is of very little importance, but the probabilities all favor that the species he had in mind was *Gasterosteus aculeatus.*

The *noveboracensis* of Cuvier and Valenciennes is said to differ from *aculeatus* in the position of the lateral line and in the stronger caudal keel. Neither of these features is likely to be of specific value, and I therefore place it in the synonymy of *aculeatus.*

The *niger* of Cuvier is based on the *biaculeatus* of Mitchill, which is *aculeatus.* The *trachurus* of the same author has the sides completely covered with plates, and is, of course, the ordinary European form of *aculeatus.*

The *suppositus* of Sauvage is a supposed new species described by Dekay as *neoboracensis*, but the *neoboracensis* of Dekay is identical with the *noveboracensis* of Cuvier and Valenciennes, and *suppositus* is therefore a synonym of *aculeatus.* The figure of Dekay has lateral plates extending from the post-pectoral plate to the caudal, but as this differs from the nature of the armature of this group, and as Dekay does not mention the naked area about the ventral region and gives the number of the plates as 30 to 33, these discrepancies must be due to a mistake of the artist.

The *Gasterosteus texanus* of Sauvage is somewhat different. It has eleven plates extending to the second ray of the soft dorsal; thence to the last ray, the body is naked, the peduncle being again mailed and strongly keeled. As no sticklebacks are found much south of the Great Lake region, it is very probable that the type of *G. texanus* did not come from Texas. At present I place *texanus* in the synonymy of *aculeatus*, the peculiarities above mentioned being perhaps due to mutilation.

The many specimens examined by me are from Wilmington, Delaware, and from Woods Holl, Massachusetts.

The var. *cataphractus* differs from *aculeatus* in its deeper and shorter form. Northern specimens are larger and more robust than those found further south, and it is not likely that with a large series any tangible permanent differences could be maintained.

The names *cataphractus* and *obolarius* were given to Alaskan specimens; the *insculptus* from the Arctic is not essentially different, and the *serratus* of Ayres and *intermedius* of Girard, from further south, are also certainly the same.

The large collections made by Jordan and Gilbert of the West Coast of the U. S., show conclusively that not more than two distinct forms of Sticklebacks, *cataphractus* and *microcephalus*, exist on that coast.

4. **Gasterosteus atkinsii.**

Gasterosteus atkinsii Bean, Proc. U. S. Nat. Mus., 1879, 67 (Schoodic Lakes); Jordan & Gilbert, Syn. Fish. N. A., 395, 1882 (Copied).

Habitat.—Schoodic Lakes, Maine.

This species is characterized by the presence of 15 lateral plates; it is therefore intermediate between the full armed *aculeatus* and the partly mailed *gymnurus*, etc. The species is known to me from the description of Bean (*loc. cit.*). This description indicates some affinity with the European *Gasterosteus semiarmatus*, which has also 14 (12 to 15) plates.

5. **Gasterosteus microcephalus.**

Gasterosteus microcephalus Girard, Proc. Ac. Nat. Sci. Phila., 1854, 133; Girard, Pacific R. R. Survey, 91, 1859 (Tulare Valley); Sauvage, Revision des Epinoches, 22, 1874 (Tulare Valley); Jordan, Cat. Fresh-water Fish N. A., 442, 1878 (Name only); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1880, 453 (Puget Sound; San Francisco; Monterey Bay; San Pedro); Jordan & Jouy, Proc. U. S. Nat. Mus., 1881, 1 (San Francisco); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1881, 69 (Los Angeles to Puget Sound); Bean, Proc. U. S. Nat. Mus., 1881, 240 (Piseco Lake, Sitka; St. Paul, Kodiak; Chirikoff Isl.; Iliuliuk Unalaska); Bean, Proc. U. S. Nat. Mus., 1881, 270 (Pacific, south of Bering Strait; Puget Sound; San Francisco); Jordan & Gilbert, Syn. Fish. N. A., 395, 1882; Rosa Smith, Proc. U. S. Nat. Mus., 1883, 217 (Name only); Rosa Smith, Proc. U. S. Nat. Mus., 1883, 233 (Todos Santos Bay); Bean, Proc. U. S. Nat. Mus., 1883, 353 (Mountain Lake, Alaska); Bean, Cat. Fish. in Internat. Fish. Ex. London, 19, 1883 (St. Paul, Kodiak).

Gasterosteus plebeius Girard, "Proc. Ac. Nat. Sci. Phila., 1854, 147;" Girard, Pacific R. R. Survey, 86, 1859 (San Francisco; San José; Petaluma); Sauvage, Revision des Epinoches, 18, 1874 (Petaluma); Jordan, Cat. Fresh-water Fish. N. A., 442, 1878 (Name only).

Gasterosteus inopinatus Girard, "Proc. Ac. Nat. Sci. Phila., 1854, 147;" Girard, Pacific R. R. Survey, 90, 1859 (Presidio); Sauvage, Revision des Epinoches, 19, plate i, fig. 4, 1874 (Presidio Creek, Cal.); Jordan, Cat. Fresh-water Fish N. A., 442, 1878 (Name only).

Gasterosteus pugetti Girard, "Proc. Ac. Nat. Sci. Phila., 1856, 135;" Girard, Pacific R. R. Survey, 92 and 354, 1859 (Puget Sound); Jordan, Cat. Fresh-water Fish N. A., 442, 1878 (Name only).

Habitat.—Pacific Coast North America, from Bering Strait south to Todos Santos Bay. Ascends rivers.

This species differs from *dimidiatus* in having no cusp at base of ventrals and no caudal keel; it differs from *wheatlandi* in having all its bones much weaker and in the arrangement of the mucous pores about the head.

The collection of Jordan and Gilbert shows that all naked-tailed Sticklebacks (*microcephalus*, *plebeius*, *inopinatus* and *pugetti*) belong to one species.

It is possible, as several writers have affirmed, that all these naked-tailed Sticklebacks (*gymnurus*, *microcephalus*, *wheatlandi*, *williamsoni*) are simple varieties of the ordinary *G. aculeatus*. It seems to me that the peculiarities of the Californian form are so constant that we may regard this one at least as presenting a distinct species. Of *G. wheatlandi* and *gymnurus* I am not so certain, but I have not yet seen any distinctly intermediate forms, although all these types, like all other Sticklebacks, are subject to much individual variation. The characters given in the analysis above are to be regarded as simply provisional, as representing the differences shown by the material at my disposal.

The specimens examined by me are from San Diego, Cal.

6. **Gasterosteus wheatlandi.**

Gasterosteus wheatlandi Putnam, "Proc. Essex Inst., v. 4, 1867;" Storer, Hist. Fish. Mass., 254, 1867 (Nahant).

Gasterosteus trachurus Goode & Bean, Fishes of Essex Co. and Mass. Bay, 5, 1879 (Nahant, not *G. trachurus* of Cuvier).

Habitat.—East Coast United States, northward.

This species differs from *G. microcephalus* in having stronger surface bones, no mucous pores about the head, and the caudal peduncle compressed.

The specimens examined by me are from the coast of Massachusetts.

7. **Gasterosteus dimidiatus.**

Gasterosteus biaculeatus Cuvier & Valenciennes, Hist. Nat Poissons, iv, 503, 1829 (Newfoundland, not *G. biaculeatus* of Shaw); Günther, Cat. Fish. Brit. Mus., i, 5. 1859 (Coast Newfoundland and Labrador); Gill, Cat. Fish. East Coast N. A., 16, 1873 (Name only); Sauvage, Revision des Epinoches, 21, 1874 (Newfoundland); Jordan, Cat. Fish. N. A., 442, 1878 (Name only); Jordan & Gilbert, Syn. Fish. N. A., 395, 1883; Stearns, Proc. U. S. Nat. Mus., 1883, 123 (Labrador).

Gasterosteus dimidiatus Reinhardt, Grœn. Faun. 37, 1837 (Greenland); Reinhardt, "Kong. Dansk. Vidensk. Selsk. Nat. og. Math. Afhand. vii, 193," 1838; Sauvage, Revision des Epinoches, 28, 1874 (Name only).

Gasterosteus aculeatus var. *dimidiatus* Gill, Cat. Fish. East Coast N. A., 39, 1861 (Name only).

Gasterosteus cuvieri (Girard MSS.) Storer, H. R. Fish. Nova Scotia and Labrador, 254, plate vii, fig. 1, 1849 (Bras d'Or, Red Bay).

Habitat.—East Coast North America, northward.

This species differs from its nearest relations in having a cusp at the base of the ventrals and a fleshy caudal carina.

The name *biaculeatus* cannot be retained for this species, as it was originally based on a description of Pennant which apparently refers to *G. aculeatus.*

I have examined no specimens of this species, and I am not sure that it differs in any important respect from the naked tailed sticklebacks (*G. gymnurus* Cuvier = *G. leiurus* Cuv. and Val.) of Europe.

8. **Gasterosteus williamsoni.**

Gasterosteus williamsoni Girard, "Proc. Acad. Nat. Sci. Phila., 133," 1854 (Williamson Pass); Girard, Pacific R. R. Survey, 93, 1859 (Williamson Pass); Sauvage, Revision des Epinoches, 25, 1874; Jordan, Cat. Fresh Water Fish. N. A., 441, 1878; Jordan & Gilbert, Syn. Fish. N. A., 393, 1883; Rosa Smith, Proc. U. S. Nat. Mus., 1883, 217 (Artesian well at San Bernardino).

Eucalia williamsoni Jordan & Copeland, Checklist Fresh Water Fish. N. A., 141, 1876.

Habitat.—Streams of California.

This species differs from the other species of this genus in having no lateral plates. Miss Rosa Smith records one from an artesian well in California and pronounces it a true *Gasterosteus* and not a *Eucalia.*

The species is known to me from Girard's description in the Pacific R. R. Survey, and from the account given by Miss Smith.

4. APELTES.

Apeltes Dekay, Nat. Hist. N. Y., 67, 1842 (*quadracus* no description).
Apeltes Jordan, Man. Vert., 249, 1876 (Characterized).

This genus is distinguished by the form and position of the innominate bones, these being separated and forming subdermal spines on the outer edges of the abdomen. The pubic bones are small and weak, not visible on surface. It is a more sharply defined group than *Eucalia* or *Pygosteus* and its single species has shown no important variation.

Analysis of Species of Apeltes.

a. Trunk oblong; head pointed; caudal peduncle slender, not keeled. Mouth small, horizontal; maxillary not reaching to eye; teeth slender, in a single series. No bony dermal plates along sides. Scapula forming a small granulated post-opercular plate. Innominate bones wide apart; the area between them flat so that a section of the fish is triangular. Gill membrane broadly united to the isthmus. Free dorsal spines divergent. The spines slender, pointed, slightly serrate. Distance between first and third spine much less than that between third and fourth; the first extending beyond base of third. Caudal long, narrow; anal similar to soft dorsal and coterminous with it; its spine under third ray of dorsal. Ventral spines strong, subterete; serrate on both edges and covered by skin to near tip. When ventral spines are set they point almost sidewise, when depressed they lie along inside of innominate bones. QUADRACUS. 9.

9. **Apeltes quadracus.**

Gasterosteus quadracus Mitchill, Trans. Lit. and Phil. Soc., i, 430, 1814; Cuvier & Valenciennes, iv, 504. 1829 (Newfoundland); Storer, Rept. Fishes Mass., 31, 1839 (Salem); Dekay, Nat. Hist. N. Y., 67, plate vi, fig. 18, 1842 (New York); Storer, Syn., 63, 1846; Baird, Fish. of N. Jersey Coast, 14, 1855 (Salt Ponds of New Jersey); Storer, "Mem. Am. Ac. New Series, ii, 315;" Storer, Fish. Mass., 89, plate viii, fig. 4, 1867 (Massachusetts); Günther, Cat. Fish. Brit. Mus., i, 7, 1859 (copied); Sauvage, Revision des Epinoches, 27, 1874 (copied).

Apeltes quadracus Putnam, "Proc. Essex Inst., 1855, 148," Brevoort in Gill's Cat. Fish. East Coast N. A., 39, 1861 (Name only); Gill, Cat. Fish. East Coast N. A., 16, 1873 (Name only); Jordan, Man. Vert. Ed., i, 249, 1876 (copied); Jordan & Copeland, Checklist Fresh Water Fish. N. A., 141, 1876 (East Coast); Jordan, Cat. Fresh Water Fish. N. A., 441, 1878 (Name only); Goode & Bean, Fish. Essex Co. and Mass. Bay, 5, 1879 (Salem and vicinity); Goode, Bull, U. S. Nat. Mus., xiv, 54, 1879 (Name only); Goode, Bull. U. S. Nat. Mus., xxi, 31, 1880 (Name only); Bean. Proc. U. S. Nat. Mus., 1880, 77 (Woods Holl, Noank); Jordan & Gilbert, Syn. Fish. N. A., 396, 1883.

Gasterosteus apeltes Cuvier & Valenciennes, Hist. Nat. des Poiss., iv, 505, 1829 (No locality); Storer, Rept. Fish. Mass., 31, 1839 (Salem); Sauvage, Revision des Epinoches, 26, plate i, fig. 13, 1874 (New York).

Gasterosteus millepunctatus Ayres, Boston Journ. Nat. Hist., 259 and 294, 1842 (Old Man's Harbor); Brevoort in Gill's Cat. Fish., East Coast N. A., 39, 1861 (Name only); Sauvage, Revision des Epinoches, 27, 1874 (copied).

Habitat.—Atlantic Coast of North America; Northward.

This species is easily distinguished by the separation of the innominate bones and by the four divergent dorsal spines.

The *apeltes* of Cuvier and Valenciennes does not differ from the *quadracus* of Mitchill.

The *millipunctatus* of Ayres is also identical with the *quadracus* of Mitchill.

The numerous specimens examined by me are from Woods Holl, Massachusetts.

5. SPINACHIA.

Spinachia Fleming, "Hist. Brit. Animals, 219," 1828 (*spinachia*).
Polycanthus Swainson, Fishes 175 and 242, 1839 (*spinachia*).
Gastræa Sauvage, Revision des Epinoches, 7, 1876 (*spinachia*).

This genus differs from the others in the prolongation of the snout which approaches in form the snout of *Aulorhynchus* and *Fistularia.* The innominate bones are as in *Apeltes;* there are about 15 free dorsal spines.

Analysis of the Species of Spinachia.

a. Snout prolonged; dorsal spines about 15; dermal plates, 40; depth 10 in length; head about 4; a carina running entire length of lateral line; body five-sided; tail four-sided. Vertebræ 18 + 23; D. XV, 6 or 7; ventral, i, 2; A. I, 6 or 7. *Spinachia.* 10.

10. **Spinachia spinachia,**

Gasterosteus spinachia Linnæus, Syst. Nat. Ed. X., 296, 1758 (based on Artedi) (and of authors generally).

Gastræa spinachia Sauvage, Revision des Epinoches, 36, 1876 (Newfoundland).

Habitat.—North Atlantic on both continents.

This species has been but once ascribed to America. Sauvage notes a specimen in the Museum at Paris which he said to be from Newfoundland. This record needs verification, and is probably the result of an error in labeling.

Comparative Measurements in Hundreds of Length to Base of Caudal.

	Pungitius.	Inconstans.	Cayuga.	Aculeatus.	Microcephalus.	Wheatlandi.	Quadracus.
Depth of Body.	17	22	23	24	30	26	32
Caudal Peduncle,	18	16	16	12	10	14	20
Length of Head,	25	29	27	29	34	32	25
Interorbital space,	4	4·5	5			7	
Snout,		5	7				
Operculum,		10	8			11	
Orbit,	8	8	9	7	8	9	7
First Dorsal Spine from Snout,	27	32	29	36	42	40	30
Height,	6	6	4	9		9	11
Antecedent Spine,		7	6			3	
First ray,		11	11	13		14	
Last ray,		3	2				
Anal from Snout,	30	58	59	72	70	70	58
Height of Spine.		7	7	2		2	8
First ray,		13	13	12		12	
Last ray,		3	1				
Caudal,		13	15	middle 12 extern 16	15 17	15 17	16
Pectoral from Snout,		30	31	36	39	38	29
Length,		11	11	20	15	17	17
Ventral from Snout,		40	41	43	44	45	33
Length,		9	7	14	14	13	16
Innominate bones.		12	5	17			

List of Nominal Species of Gasterosteidæ, Arranged in Chronological Order, with Identification.

(Tenable Specific Names are in *Italics*.)

Nominal Species.	*Date.*	*Identification.*
Gasterosteus *aculeatus* Linnæus,	1758,	Gastrosteus aculeatus.
Gasterosteus *pungitius* Linnæus,	1758,	Pygosteus pungitius.
Gasterosteus *spinachia* Linnæus,	1758,	Spinachia spinachia.
Gasterosteus pungitius Walbaum,	1792,	Pygosteus pungitius.
Gasterosteus bispinosus Walbaum,	1792,	Gasterosteus aculeatus.
Gasterosteus *cataphractus* Pallas,	1811,	Gasterosteus cataphractus.

Nominal Species.	*Date.*	*Identification.*
Gasterosteus *quadracus* Mitchill,	1814,	Apeltes quadracus.
Gasterosteus niger Cuvier,	1829,	Gasterosteus aculeatus.
Gasterosteus trachurus Cuvier,	1829,	Gasterosteus aculeatus.
Gasterosteus obolarius Cuv. & Val.,	1829,	Gasterosteus cataphractus.
Gasterosteus noveboracensis Cuv. & Val.,	1829,	Gasterosteus aculeatus.
Gasterosteus biaculeatus Cuv. & Val.	1829,	Gasterosteus dimidiatus.
Gasterosteus apeltes Cuv. & Val.	1829,	Apeltes quadracus.
Gasterosteus occidentalis Cuv. & Val.	1829,	Pygosteus pungitius.
Gasterosteus concinnus Richardson,	1836,	Pygosteus pungitius.
Gasterosteus mainensis Storer,	1837,	Pygosteus pungitius.
Gasterosteus loricatus Reinhardt,	1837,	Gasterosteus aculeatus.
Gasterosteus *dimitiatus* Reinhardt,	1837,	Gasterosteus dimidiatus.
Gasterosteus biaculeatus Shaw,	1839,	Gasterosteus aculeatus.
Gasterosteus *inconstans* Kirtland,	1841,	Eucalia inconstans.
Gasterosteus millepunctatus Ayres,	1842,	Apeltes quadracus.
Gasterosteus cuvieri Girard,	1849,	Gasterosteus dimidiatus.
Gasterosteus nebulosus Agassiz,	1850,	Pygosteus pungitius.
Gasterosteus de kayi Agassiz,	1850,	Pygosteus pungitius.
Gasterosteus *pygmæus* Agassiz,	1850,	Eucalia inconstans.
Gasterosteus insculptus Richardson,	1854,	Gasterosteus cataphractus.
Gasterosteus *microcephalus* Girard,	1854,	Gasterosteus microcephalus.
Gasterosteus *williamsoni* Girard,	1854,	Gasterosteus williamsoni.
Gasterosteus plebeius Girard,	1854,	Gasterosteus microcephalus.
Gasterosteus inopinatus Girard,	1854,	Gasterosteus microcephalus.
Gasterosteus serratus Ayres,	1855,	Gasterosteus cataphractus.
Gasterosteus intermedius Girard,	1856,	Gasterosteus cataphractus.
Gasterosteus pugetti Girard,	1856,	Gasterosteus microcephalus.
Gasterosteus *atkinsii* Bean,	1859,	Gasterosteus atkinsii.
Gasterosteus micropus Cope,	1865,	Eucalia inconstans.
Gasterosteus *wheatlandi* Putnam,	1867,	Gasterosteus wheatlandi.
Gasterosteus suppositus Sauvage,	1874,	Gasterosteus aculeatus.
Gasterostea blanchardi Sauvage,	1874,	Pygosteus pungitius.
Gasterosteus globiceps Sauvage,	1874,	Eucalia inconstans.
Eucalia *cayuga* Jordan,	1876,	Eucalia cayuga.
Gasterosteus trachurus Goode & Bean,	1879,	Gasterosteus wheatlandi.
Gasterosteus *brachypoda* Bean,	1879,	Pygosteus brachypoda.

Recapitulation.

In this review I have admitted 10 species and 5 genera of *Gasterosteidæ* as valid. Below I give a list of the species. The general distribution of the species is indicated by the letters A. (America); E. (Europe); W. (West Coast of North America); P. (East Coast North America and Greenland); G. (Great Lake Region and Northward); U. (Western Slope of Rocky Mountains).

Family GASTEROSTEIDÆ.

Genus 1. **PYGOSTEUS** Brevoort.

1. *Pygosteus pungitius* Linnæus (E. A.). (P. G.).
1 *a*. *Pygosteus pungitius brachypoda* (W. U.). (Unknown to me).

Genus 2. **EUCALIA** Jordan.

2. *Eucalia inconstans* Kirtland (G. E).
2 *a*. *Eucalia inconstans cayuga* Jordan (G.). (Variety of doubtful value).
2 *b*. *Eucalia inconstans pygmæa* Agassiz (Unknown to me; characters assigned perhaps erroneous).

Genus 3. **GASTEROSTEUS** Linnæus.

3. *Gasterosteus aculeatus* (E. A.) (P.).
3 *a*. *Gasterosteus aculeatus cataphractus* Pallas (W.). (Variety of doubtful value).
4. *Gasterosteus atkinsii* Bean (P.). (Unknown to me; perhaps local var. of *aculeatus*).
5. *Gasterosteus microcephalus* Girard (W.). (Possibly variety of *aculeatus*).
6. *Gasterosteus wheatlandi* Putnam (P.). (Perhaps var. of *aculeatus*).
7. *Gasterosteus dimidiatus* Reinhardt (P.). (Unknown to me; perhaps identical with *G. gymnurus*).
8. *Gasterosteus williamsoni* Girard (U.). (Possibly an extreme variety of *microcephalus* or *aculeatus*).

Genus 4. **APELTES** DeKay.

9. *Apeltes quadracus* Mitchill (P.).

Genus 3. **SPINACHIA** Fleming.

10. *Spinachia spinachia* Linnæus (E. P.). (Probably not American).

May 4.

Mr. Geo. W. Tryon, Jr., in the chair.

Twenty-eight persons present.

The Railway Cutting at Gray's Ferry Road.—Mr. Aubrey H. Smith remarked that the Schuylkill River, as is well known, makes a curve to the westward just below the U. S. Arsenal grounds, returning to its southwardly course at Harmar's wharf, nearly a mile below. The new iron bridge of the Baltimore and Ohio R. R. Co. spans the river obliquely from the northern side of Bartram's Garden to Harmar's at the height of about 23 feet above tide. The tract of land half enclosed by the river is elevated about 50 feet above tide and is composed of the same diluvial gravels and clays which form the plain on which stands the old city of Philadelphia.

The railroad proceeds from the bridge by a deep cut of half a mile transversely to the streets on the city plan northeastwardly to the low grounds on the river below the arsenal, thus forming a chord to the arc of the river bend. The cut is a deep one, as the railroad company was required by its agreement with the city to construct its line beneath Wharton Street and the Gray's Ferry Road.

Soon after leaving the bridge the cutting enters the plateau and is soon twenty-five or more feet deep. The excavation is through yellow clays and river gravels to the depth of about twenty-five feet. It then discloses a compact bed of dark blue clay, sharply defined under the gravel, apparently a river deposit. Its thickness is not exactly known but it exceeds six feet. This bed of blue clay extends from just beyond the Harmar house to the Gray's Ferry Road, a distance of 500 or 600 yards.

It is apparently thickest near the Harmar house, but thins out at the Gray's Ferry Road, where the excavations show it to be only about four feet thick and to rest upon a bed of yellow gravel or sand. It does not appear at all northeast of the Gray's Ferry Road.

Some observations and inquiry in November, 1885, for organic remains resulted, so far as he was aware, only in showing that the blue clay contains numerous genera and species of diatoms and several species of recent woods. The observations on the diatoms are due to Professor Koenig. The gravels and clays above the blue clay were barren of all organic forms. The woods then obtained were apparently birch, maple or oak, and were neither mineralized or decomposed. They came from the dump heap where the excavated clay was deposited by the workmen, but are doubtless from the blue clay bed.

The specimen of wood exhibited to the Academy to-night is of some coniferous tree, probably a white cedar, *Cupressus thyoides*. This tree, until very recently, was common along the Schuylkill and Delaware, and isolated specimens may still exist there. The wood now shown is in no degree mineralized and but slightly decomposed. It came from a log which lies in the blue clay just north of the Wharton Street Bridge and is still to be seen there. No shells, so far as he knew, have been found in the excavation, but more careful search in this direction might be rewarded.

The blue clay bed appears to mark one of the periods of quiescence in the glacial action which, in its torrential course, scooped out the valleys of the Schuylkill and Delaware and afterwards filled them up again at the margin of tide-water. It harmonizes itself with similar beds which have been observed at several points along the shores of the rivers—notably at the Lazaretto and Printz Hall, Tinicum, and near Camden, N. J.

There were probably several of these periods of comparative rest in the course of the retirement of the ice from northern Pennsylvania.

The artesian well of Mr. Black, at Black's Island, below Fort Mifflin, which is 456 feet deep, disclosed at the depth of 100 feet a bed of white beach sand 47 feet in thickness, as well as many of gravel and clay. The decomposed gneiss rock was reached at the depth of 240 feet or thereabouts.

Section of the strata of Black's Island, Delaware River below Fort Mifflin, from the artesian well of E. N. Black, Esq.:

Blue alluvium,	45 feet.
Sand,	1 "
Blue alluvium,	33 "
Gravel,	6 "
White clay,	2 "
Beach sand,	47 "
Gravel,	10 "
Clay,	3 "
Red gravel,	6 "
White gravel and sand,	17 "
Beach sand and gravel,	38 "
Decomposed gneiss (mica),	20 "
Gneiss rock,	228 "
	456 feet.

MAY 11.

The President, Dr. LEIDY, in the chair.

Twenty-two persons present.

Fatal Cases of Trichiniasis.—The President read a letter from Mr. EUGENE A. RAU, of Bethlehem, Pennsylvania, giving an account of recent cases of fatal trichiniasis arising from imperfectly cooked, measly pork, which had been eaten for a week from January 6, 1886. The family consisted of a man and wife and two daughters, aged respectively five and thirteen years. The older daughter and the mother, aged 37 years, have died; the other members of the family, although affected, are recovering. In the mother, who died March 8, the deltoid muscle showed, under the microscope, three to nine; the rectus femoris, two to six, and the diaphragm, one to three trichinæ, in a field view about one-fifth of an inch in diameter. In the daughter, who died February 19, trichinæ were found imbedded in the deltoid muscle, in some portions as many as forty-two being counted on the field of view under the microscope. No other portions of the daughter were examined, but the lungs, heart, liver, spleen and kidneys of the mother were found to be unaffected.

The pork used was home-raised, and, according to the owner, the animal did not at any time show signs of ill health. An examination of two other hogs raised on the premises was made, but no trichinæ were found. As usual in such cases, the meat was imperfectly cooked or fried, the tenderloin, sausage meat, spare ribs, etc., all being freely used. For several days while in water the human trichinæ showed signs of life, coiling and uncoiling when freed from the muscular fibre, but the stage of development found in the pork showed no activity under the same conditions. The communication is accompanied by excellent photographs of portions of human muscle and of the affected pork, showing a number of the worms imbedded in the tissue.

MAY 18.

Mr. GEO. W. TRYON, JR., in the chair.

Seventeen persons present.

MAY 25.

The President, Dr. LEIDY, in the chair.

Nineteen persons present.

Charles P. Sherman was elected a member.

The following was ordered to be printed:—

A REVISION OF THE AMERICAN SPECIES OF THE GENUS GERRES.

BY BARTON W. EVERMANN AND SETH E. MEEK.

In the summer of 1883 we published in the Proceedings of the Academy of Natural Sciences of Philadelphia, pp. 116 to 124, a "Review of the Species of Gerres found in American Waters." In December of the same year, Dr. Jordan made a large collection of the Atlantic species of this genus at Cedar Keys, Key West and Havana. A large portion of this collection is now in the Museum of the Indiana University, and constitutes the material upon which the present paper is based.

The present collections contain numerous specimens of species not before examined by us, and, in the light of the new relationships which an examination of them discloses, we have thought it best to attempt an entire revision of the genus. We have therefore collected all the synonymy up to date, made an analytical key by which the species can be determined, and given a detailed description of all the species now before us. To the account of the Pacific Coast species, as given in the former paper, we have now nothing to add, as the very extensive collection of them studied by us has been since mostly destroyed by fire.

We take this opportunity of acknowledging our indebtedness to Dr. Jordan for the use of his library, and for other aids.

Genus **GERRES** Cuvier.

Gerres Cuvier. Règne Animal, ed. 2, ii, 104, 1829 (*rhombeus*, etc.).
Catochænum Cantor. Cat. Malayan Fishes, 55, 1850. (Proposed for *Gerres* Cuv., regarded by Cantor as preoccupied by *Gerris* Fabricius).
Diapterus Ranzani. Nov. Comment. Acad. Bonom., 1841 (*plumieri*, etc.).
Eucinostomus Baird and Girard. Ninth Smithsonian Report, 1855, 20 (*argenteus* = *gula*).
Synistius Gill. Proc. Acad. Nat. Sci. Phila., 1862, 238 (*longirostris*).
Mojarra Poey. Enum. Pisc. Cub., 50, 1875 (*rhombea* = *olisthostoma*).

Analysis of Species of Gerres.

a. Preorbital and preopercle entire; body elongate, the depth $2\frac{1}{3}$ to 4 in length to base of caudal (*Eucinostomus* Baird and Girard).

b. Premaxillary groove naked.

c. Anal rays II, 8; body very elongate, its depth $3\frac{3}{5}$ in its length; eye $2\frac{3}{4}$ in head. *Lefroyi.* 1.

cc. Anal rays III, 7.

d. Premaxillary groove narrow, linear.

e. Eye very large, its diameter much greater than length of snout, $2\frac{2}{3}$ in length of head. Exposed portion of maxillary small, triangular. *Dowi.* 2.

ee. Eye small, more than 3 in head, its diameter about equal to length of snout. Exposed portion of maxillary triangular in front, oblong behind.

f. Body elongate, the back little elevated; greatest depth $3\frac{1}{4}$ to $3\frac{1}{2}$ in length. Anal spines small, the second $4\frac{1}{2}$ in length of head. *Pseudogula.* 3.

ff. Body more compressed, deeper, the back more elevated; greatest depth $2\frac{2}{3}$ in length. Anal spines larger, the second $3\frac{1}{2}$ in length of head. *Gracilis.* 4.

dd. Premaxillary groove broad, oval, naked. Body elevated, compressed, its greatest depth $2\frac{1}{2}$ in its length.

g. Caudal fin shorter than head, sides without dark vertical bars. Second anal spine short, 3 to 4 in head; ventrals short, little more than half the length of head, their tips not reaching vent; dark punctulations on body few or none; upper part of spinous dorsal becoming gradually blackish; other fins nearly plain; axil faintly dusky. *Californiensis.* 5.

gg. Caudal fin longer than head. Sides with 7 to 9 dark bluish vertical bars, about as broad as pupil. Anal spines longer, the second $2\frac{2}{3}$ in length of head. Ventrals longer, $1\frac{2}{5}$ in length of head, scarcely reaching vent. *Cinereus.* 6.

bb. Premaxillary groove scaled in front, forming a naked pit behind. Depth $2\frac{2}{5}$ in length; head 3 to $3\frac{1}{5}$ in length of body. Second anal spine about $3\frac{1}{2}$ in head. *Gula.* 7.

aa. Preopercle distinctly entire.

h. Preorbital entire; body without distinct dark streaks along the rows of scales. (*Moharra* Poey).

i. Premaxillary groove broad, triangular or oval, and free from scales.

j. Body ovate, the outline somewhat regularly elliptical, depth $2\frac{1}{4}$ in length. Dorsal spines slender, but little flexible, the second scarcely stronger than the third, 2 in length of head. Second and third anal spines subequal, $2\frac{3}{5}$ in length of head; second stronger than third. *Aureolus*. 8.

jj. Body rhomboidal, short and deep, with angular outlines, the depth usually more than half the length; spines long and slender.

k. Anal rays III, 8; second dorsal spine $\frac{3}{4}$ or more length of head; second anal spine more than half length of head. *Peruvianus*. 9.

kk. Anal rays II, 9; second dorsal spine about $\frac{1}{3}$ length of head; second anal spine $1\frac{3}{4}$ in length of head. *Rhombeus*. 10.

ii. Premaxillary groove broad, oval, and covered with scales (these sometimes deciduous in poorly preserved specimens). Anal rays III, 8; second dorsal spine $1\frac{1}{4}$ in head; second anal spine $1\frac{3}{5}$ in head; teeth rather long and slender. *Olisthostoma*. 11.

hh. Preorbital serrate, a distinct dark streak along each row of scales on back and sides; body rhomboidal, with angular outlines; spines very strong; anal rays III, 8 or 9. (Gerres).

l. Ventrals blackish; upper margin of dorsal fin falcate; depth $2\frac{1}{5}$ in length; scales 5–38–9. *Brasilianus*. 12.

ll. Ventrals pale.

m. Spines moderate, the second dorsal spine $\frac{2}{3}$ to $\frac{3}{4}$ length of head.

n. Pectorals long, reaching to front of anal; caudal longer than head; lateral stripes numerous; depth nearly 2 in length. *Lineatus*. 13.

nn. Pectorals short, barely reaching vent; caudal shorter than head; lateral stripes few; depth about $2\frac{3}{5}$ in length. *Brevimanus*. 14.

mm. Spines very high, the second dorsal spine longer than head; second anal spine about equal to length of head; lateral stripes very distinct, about 12 in number; depth of body $2\frac{1}{6}$ in length. *Plumieri*. 15.

1. **Gerres lefroyi.**

Diapterus lefroyi Goode, Amer. Jour. Sci. and Arts, 123, 1874; Goode, Bull. U. S. Nat. Mus., 1876, 39 (Bermudas).

Gerres lefroyi Günther, Voyage Challenger, Fishes, 10, 1880 (name only); Evermann & Meek, Proc. Acad. Nat. Sci. Phila., 1883, 118; Jordan, Proc. U. S. Nat. Mus., 1884, 130 (Key West); Jordan and Swain, Proc. U. S. Nat. Mus., 1884, 233 (Cedar Keys); Jordan, Cat. Fish. N. A., 1885, 95.

Eucinostomus productus Poey, Enum. Pisc. Cub., 55, 1875 (Havana); Poey, Ann. Lyc. Nat. Hist. N. Y., 1876 (Havana).

Habitat.—Atlantic coast of tropical America; West Indies; Bermudas; Cedar Keys; Key West; Havana.

The specimens examined by us are from Havana (8 specimens), Key West (5 specimens), and Cedar Keys (1 specimen). In size they range from 2 to $8\frac{1}{2}$ inches in length.

Head $3\frac{1}{3}$ to $3\frac{1}{2}$; depth $3\frac{3}{5}$; scales 5–47–9. D. IX, 10. A. II, 8. Body elongate, elliptical, not very strongly compressed; back little elevated; snout conical, not much pointed; mouth small, end of maxillary reaching scarcely beyond vertical from anterior margin of orbit, its length 3 in length of head, exposed portion nearly triangular, its greatest width 2 in its length, which is 5 in length of head. Top of head flattish. Premaxillary groove long, linear and naked. Eye large, $2\frac{3}{4}$ in head; snout $3\frac{1}{2}$ in head, interorbital area 3 in head. Gill-rakers weak, small, 7 or 8 below the angle. Dorsal spines all weak and flexible, second and third subequal, $5\frac{1}{2}$ in length of head; upper margin of the fin concave. Second anal spine moderate, its length 4 in head. Least depth of caudal peduncle $3\frac{2}{3}$ in length of head.

Color silvery, darker above, everywhere with fine dusky punctulations and traces of crossbars. Top of spinous dorsal black, dorsal, anal, and caudal dusky. Ventrals and pectorals paler, but with dusky punctulations; axil dusky; a dark spot on supraorbital; snout dusky; no distinct stripes along rows of scales.

In form, size and color, this species resembles *G. dowi*, but is readily distinguished from the latter by the presence of two anal spines instead of three. This character is apparently a constant one, observed in many specimens.

2. **Gerres dowi.**

Diapterus dowi Gill, Proc. Acad. Nat. Sci. Phila., 1863, 162 (Panama).

Gerres dowi Günther, Fish. Centr. Amer., 448, 1866 (Description taken from Gill); Steindachner, Ichth. Beiträge, iv, 13, 1875 (No description), (Callao, Peru; Galapagos Islands); Jordan & Gilbert, Bull.

U. S. Fish Comm., 1881, 329 (Panama); Jordan & Gilbert, Bull. U. S. Fish Comm., 1882, 111 (Panama); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1882, 377 (Panama); Evermann & Meek, Proc. Acad. Nat. Sci. Phila., 1883, 120 (Panama).

Gerres aprion Günther, Fish. Centr. Amer., 391, 1866 (Name only) (Panama).

Habitat.—Atlantic and Pacific coasts of tropical America; Galapagos Islands, Peru; Panama; Havana; Key West.

The specimens examined by us are from Havana (2 specimens, $5\frac{1}{2}$ and 6 inches in length), and Key West (5 specimens, 3 to 6 inches in length).

Head $3\frac{2}{5}$; depth 3; scales 5–45–10.

Body rather slender, compressed, elliptical, back little elevated, head flat, with a slight depression above front of orbit. Maxillary triangular and small, the width at posterior end being $\frac{1}{2}$ the length, which is about $\frac{1}{2}$ diameter of eye, also $\frac{1}{2}$ length of second dorsal spine. Preorbital and preopercle entire. Eye large, $2\frac{2}{3}$ in head; snout $3\frac{1}{2}$, and interorbital, $3\frac{1}{6}$ in head.

Second and third dorsal spines about equal, the third perhaps slightly longest, $1\frac{3}{4}$ in head, all weak and flexible. Second anal spine relatively strong, third weaker but slightly longer, $2\frac{3}{4}$ in head; base of anal $1\frac{7}{8}$ to $2\frac{1}{8}$ in length of head. Least depth of caudal peduncle $2\frac{2}{3}$ in head. Pectorals about $\frac{7}{8}$ length of head, their tips reaching vent. Ventrals $1\frac{3}{5}$ in head, reaching about $\frac{4}{5}$ distance to vent. Premaxillary groove narrow, linear and naked, and not extending quite to the vertical of centre of pupil.

Color silvery with bluish reflections, darker above lateral line. Tips of spinous dorsal black, ventrals dusky (lighter in Key West specimens); a black supraorbital spot, caudal dusky, body covered with very fine dark punctulations.

This species has not been hitherto recorded from the Atlantic.

3. **Gerres pseudogula.**

Eucinostomus pseudogula Poey, Enum. Pisc. Cub., 53, pl. i, 1875 (Havana).

Gerres jonesi Günther, Ann. and Mag. Nat. Hist., iii, 1879, 150, 389 (Bermudas); Günther, Voyage Challenger, Fishes, i, 10, 1880 (Bermudas); Evermann & Meek, Proc. Acad. Nat. Sci. Phila., 1883, 120 (Bermudas); Jordan, Cat. Fish. N. A., 1885, 95.

Habitat.—West Indies; Bermudas; Cuba.

We have examined eight specimens of this species, all from Havana. They range from $2\frac{3}{4}$ to 7 inches in length.

Head $3\frac{1}{4}$ to $3\frac{1}{2}$; depth $3\frac{1}{4}$; scales 5–49–9; D. IX–10; A. III–7. Body elongate, elliptical, not much compressed; back little elevated; profile evenly convex; top of head little convex; mouth rather small, end of maxillary reaching slightly past vertical from front of orbit; length of maxillary $3\frac{1}{4}$ in length of head, its exposed portion nearly triangular and about $\frac{1}{5}$ length of head, its greatest width $\frac{1}{2}$ its greatest length. Preorbital and preopercle entire. Snout not much pointed, conical; cheeks each with three rows of scales; seven gill-rakers below the angle. Eye $3\frac{1}{5}$ in head, snout $3\frac{1}{4}$ in head; interorbital area $3\frac{2}{5}$ in head. Dorsal spines all weak and flexible. Second and third dorsal spines subequal, $1\frac{1}{3}$ in length of head. Base of anal 2 in length of head, spines small, the second the stronger, its length $4\frac{1}{2}$ in length of head, about equal in length to third spine or slightly the shorter. Least depth of caudal peduncle 3 in length of head.

Tips of pectoral fins reaching vent, their length about $3\frac{2}{5}$ in length of body. Ventrals $1\frac{1}{2}$ in head, their tips reaching $\frac{3}{4}$ distance to vent. Premaxillary grooves long, linear and free from scales.

Color greenish above, with bluish reflections, silvery below; snout blackish; tips of spinous dorsal black; pectorals pale, dusky in axil. Ventrals and anal pale. Caudal reddish.

This species has been sometimes confounded with *Gerres gracilis*. It can easily be distinguished from the latter by its more elongate form and its comparatively small anal spines.

There seems to be no room for doubt of the identity of *G. jonesi* with *G. pseudogula.*

4. **Gerres gracilis.**

Diapterus gracilis Gill, Proc. Acad. Nat. Sci. Phila., 1862, 246 (Cape San Lucas).

Gerres gracilis Jordan & Gilbert, Proc. U. S. Nat. Mus., 1881, 274 (Guaymas); Jordon & Gilbert, Bull. U. S. Fish Comm., 1881, 329 (Guaymas; Mazatlan; Panama); Jordan & Gilbert, Bull. U. S. Fish Comm., 1882, 108 (Mazatlan; Panama); Jordan, Proc. U. S. Nat. Mus., 1884, 130 (Key West); Jordan, Cat. Fish. N. A., 1885, 95.

Gerres aprion Günther, Cat. Fish. Brit. Mus., i, 352, 1859 (San Domingo; Jamaica; West Indies; South America); Günther, Cat. Fish. Brit. Mus., iv, 255, 1862 (San Domingo; Jamaica; Bahia); Bean & Dresel, Proc. U. S. Nat. Mus., 1884, 154 (Jamaica) (not of Cuv. & Val.).

Eucinostomus harengulus Goode & Bean, Proc. U. S. Nat. Mus., 1879, 132 (Western Florida).

Diapterus harengulus Goode & Bean, Proc. U. S. Nat. Mus., 1879, 339 (Clear Water Harbor, Florida).

Gerres harengulus Jordan & Gilbert, Syn. Fish. N. A., 584, 1883 (Pensacola, Florida); Bean & Dresel, Proc. U. S. Nat. Mus., 1884, 154 (Jamaica).

Habitat.—Atlantic and Pacific coasts of tropical America, and the West Indies (Cape San Lucas; San Domingo; Jamaica; Havana; Bahia; Western Florida; Panama; Guaymas; Mazatlan; Key West).

The numerous specimens examined by us are from Havana and Key West, and range from 1 to $7\frac{1}{2}$ inches in length. Head $3\frac{1}{3}$; depth $2\frac{2}{3}$ to $2\frac{4}{5}$; scales 5–45–9; Dorsal IX–10; A. III–7.

Body elliptical, compressed, back moderately elevated; anterior profile little convex, not very steep; snout rather pointed, mouth moderate, maxillary reaching almost to vertical from front of orbit, its length 3 in length of head; exposed portion of maxillary triangular in front, oblong behind, its width 2 in its length, which is $4\frac{3}{4}$ in length of head. Preorbital and preopercle entire. Eye not very large, its diameter $3\frac{1}{5}$ in length of head, snout $3\frac{1}{2}$ in head. Premaxillary groove long, linear, and naked. Gill-rakers small and weak, 7 below the angle.

Dorsal spines weak and flexible, the longest $4\frac{3}{4}$ to $2\frac{1}{10}$ in head; anal spines rather short, the second the stronger, its length $3\frac{1}{2}$ in length of head; ventral fins short, their tips reaching about halfway to anal, their length $1\frac{2}{3}$ in head.

Pectorals slender, their tips reaching about to vent; length of pectorals about equal to head; ventrals and caudal mostly covered with small scales; other fins naked, color in life silvery, greenish above; snout and upper part of caudal dusky; spinous dorsal punctate at base, usually abruptly black at tip; the dark areas are separated by a transparent horizontal bar (these markings wanting in some specimens, perhaps females); soft dorsal punctate; caudal with a faint dusky margin; ventrals pale.

This species is very common at Key West and Havana. There seems to be no difference between the "*harengulus*" of the East Coast and the West Coast "*gracilis*."

5. **Gerres californiensis.**

Diapterus californiensis Gill, Proc. Acad. Nat. Sci. Phila., 1862, 245 (Cape San Lucas).

Gerres californiensis Jordan & Gilbert, Proc. U. S. Nat. Mus., 1881, 274 (Guaymas); Jordan & Gilbert, Bull. U. S. Fish. Comm., 1881, 319 (Guaymas); Jordan & Gilbert, Bull. U. S. Fish Comm., 1882, 108 (Mazatlan); Evermann & Meek, Proc. Acad. Nat. Sci. Phila., 1883, 120 (Guaymas; Mazatlan); Jordan, Cat. Fishes N. A., 1885, 95.

? *Gerres gula* Steindachner, Ichth. Beiträge, iii, 60, 1875 (name only; *nec* Cuv. & Val.); (Magdalena Bay).

Habitat.—Pacific Coast of Mexico (Mazatlan; Guaymas; Cape San Lucas).

This species is certainly close to *G. cinereus*, and it may eventually prove to be a variety of the latter.

6. **Gerres cinereus.**

Turdus cinereus peltatus Catesby, Nat. Hist., pl. ii, fig. 2, 1750 (Florida Keys; Bahamas).

Mugil cinereus Walbaum, Artedi Piscium, 228, 1792 (After Catesby).

Gerres cinereus Jordan & Gilbert, Bull. U. S. Fish Comm., 1882, 108 (Mazatlan); Jordan & Gilbert, Syn. Fish. N. A., 935, 1883; Evermann & Meek, Proc. Acad. Nat. Sci. Phila., 1883, 120; Jordan, Proc. U. S. Nat. Mus., 1884, 130, 148 (Key West); Jordan, Proc. U. S. Nat. Mus., 1884, 194 (identification of Catesby's figure); Jordan, Cat. Fishes N. A., 1885, 95.

Gerres zebra Müller & Troschel, Schomburgk Hist. Barbadoes, 668, 1848 (Barbadoes); Günther, Cat. Fish. Brit. Mus., i, 349, 1859 (copied); Günther, Cat. Fish. Brit. Mus., iv, 254, 1862 (copied); Steindachner, Ichthyol. Notizen, iv, ii, 1867 (Surinam); Steindachner, Zur Fisch-Fauna des Magdalenen-Stromes, 9, 1878 (Rio Magdalena. Identified with *Gerres squamipinnis* Günther); Jordan & Gilbert, Bull. U. S. Fish. Comm., 1881, 329 (Mazatlan); Bean & Dresel, Proc. U. S. Nat. Mus., 1884, 154 (Jamaica).

Gerres aprion Cuvier, Règne Animal, ed. 2, 104, 1829 (Based on Catesby); Cuvier & Valenciennes, Hist. Nat. Poiss., 461, 1830 (Martinique).

Diapterus aprion Poey, Enum. Pisc. Cuba, 51, 1875 (Havana).

Eucinostomus aprion Poey, Enum. Pisc. Cuba, 328, 1877 (Havana).

Gerres squamipinnis Günther, Cat. Fish. Brit. Mus., i, 349, 1859 (Jamaica; Guatemala); Günther, Cat. Fish. Brit. Mus., iv, 254, 1862 (Jamaica; Guatemala); Steindachner, Ichthyol. Notizen, iv, 12, 1867 (Surinam); Günther, Fish. Centr. Amer., 39, 1869 (Jamaica; Chiapam; Panama).

Eucinostomus zebra Poey, Enum. Pisc. Cuba, 51, 1875 (Havana).

Habitat.—Both coasts of Tropical America, and the West Indies (Havana; Jamaica; Chiapam; Panama; Guatemala; Martinique; Bahamas; Florida Keys; Barbadoes; Mazatlan.)

The specimens before us are from Key West and Havana. They range from $6\frac{1}{2}$ to 13 inches in length. This species seems to reach a larger size than any of the others here mentioned.

Head $3\frac{1}{3}$; depth $2\frac{1}{3}$ to $2\frac{3}{5}$; scales 6–45–10.

Body compressed, elongate, back moderately elevated, the dorsal profile being evenly convex. Mouth moderate, the maxillary extending but slightly beyond the vertical at anterior margin of orbit, its exposed portion triangular in form, and twice as long as wide, its length being contained five times in that of the head.

Preorbital and preopercle entire; premaxillary groove broad and free from scales; gill-rakers weak, 7 below the angle. Eye moderate, about $3\frac{1}{5}$ in head; snout $3\frac{1}{4}$, and interorbital space $3\frac{1}{5}$, in head. Distance from end of snout to dorsal fin $2\frac{1}{5}$ in length of body. Second dorsal spine longest, about $1\frac{1}{2}$ in head, and not much stronger than the others; all the dorsal spines are weak and flexible; general outline of the upper margin of the spinous dorsal falcate. Second and third anal spines subequal, second $2\frac{2}{3}$ to $2\frac{3}{4}$ in length of head, the pectorals scarcely reaching anal, their length being contained three times in that of the body. Ventrals contained $1\frac{2}{5}$ times in head, and scarcely reaching the vent.

Color silvery with bluish reflections above. Sides with 7 or 8 broken, bluish vertical bars, about equaling pupil in width. No dark stripes along the scales. Dorsal and caudal fins dusky, and slightly so; other fins pale, ventrals with a few dark punctulations; axil dark.

7. **Gerres gula.**

Gerres gula Cuvier & Valenciennes, Hist. Nat. Poiss., vi, 464, 1830 (Martinique; Brazil); Jenyns, Zöol. Beagle, Fishes, 58, 1842; Günther, Cat. Fish. Brit. Mus., i, 346, 1859 (Bahia; San Domingo; Jamaica); Günther, Cat. Fish. Brit. Mus., iv, 255, 1862 (Bahia; San Domingo; Jamaica); Poey, Rep. Pisc. Cub., 316, 1865 (Havana); Goode, Bull. U. S. Nat. Mus., v, 1876, 39 (Bermudas); Jordan & Gilbert, Syn. Fish. N. A., 934, 1883; Evermann & Meek, Proc. Acad. Nat. Sci. Phila., 1883, 122 (Bermudas; Beaufort, N. C.; Charleston, S. C.; Aspinwall; Pensacola); Jordan, Proc. Acad. Nat. Sci. Phila., 1883, 289 (Notes on original type); Jordan, Proc. U. S. Nat. Mus., 1884, 130 (Key West); Jordan & Swain, Proc. U. S. Nat. Mus., 1884, 233 (Cedar Keys); Jordan, Cat. Fish. N. A., 1885, 95.

Diapterus gula Poey, Syn. Pisc. Cub., 323, 1868 (Havana).

Eucinostomus argenteus Baird & Girard, Ninth Smith. Rept., 1855, 345 (New Jersey Coast); Girard, U. S. and Mex. Bd. Survey, Fishes, 17, Pl. ix, figs. 9–12, 1859 (Brazos Santiago, Indianola, and St. Joseph's Island, Texas).

? *Gerres argenteus* Günther, Cat. Fish. Brit. Mus., 256, 1862 (Texas).
Eucinostomus gulula Poey, Enum. Pisc. Cub., 54, Pl. 2, 1875 (Havana).
Diapterus homonymus Goode & Bean, Proc. U. S. Nat. Mus., 1879, 340, (Clear Water Harbor, Fla.).

Habitat.—Atlantic coast of America from New Jersey to Brazil, and the West Indies.

(New Jersey; Beaufort, N. C.; Charleston, S. C.; Clear Water Harbor, Fla.; Cedar Keys; Key West; Brazos, Indianola, and St. Joseph's Island, Texas; Aspinwall; Brazil; Bahia; Martinique; Jamaica, San Domingo; Havana; Bermudas.)

We have examined numerous specimens of this species from Cedar Keys, Key West, and Havana, varying in size from $1\frac{1}{2}$ to $6\frac{1}{2}$ inches in length.

Head $3\frac{1}{3}$; depth $2\frac{2}{5}$; D. IX, 10; A. III, 8; scales 5–42–9.

Body elliptical, compressed, back moderately elevated, mouth small; end of maxillary reaching slightly past vertical from front margin of orbit; exposed portion of maxillary nearly oblong, its width about 2 in its length, which is from 4 to 5 in the length of the head.

Preorbital and preopercle entire. Gill-rakers small and weak, 7 below the angle. Eye 3 in length of head, snout $3\frac{1}{2}$ in head. Interorbital area 3 in head. Premaxillary groove scaled in front, the posterior part naked, forming a sort of pit; longest dorsal spine $1\frac{1}{2}$ in head; second anal spine shorter and stronger than third, its length about $3\frac{1}{3}$ in head; ventrals reaching nearly to vent; their length $1\frac{2}{5}$ in length of head. Pectorals reaching front of anal, their length about 3 in length of body.

Color silvery, greenish, darker above; no distinct longitudinal lines except in very young; upper margin of spinous dorsal more or less black.

Dorsal and anal fins dusky, other fins pale.

The form of this species resembles that of *G. gracilis*, but the body is always less elongate than in the latter. The form of its premaxillary groove differing from that of any other species, affords the best character for distinction.

The many specimens of this species which we have examined present no marked differences or variations. They also agree very well with the description and drawing of *Encinostomus gulula* of Poey.

We have no doubt of the identity of *gula*, *argenteus*, *gulula* and *homonymus*.

8. **Gerres aureolus.**

Gerres aureolus Jordan & Gilbert, Bull. U. S. Fish. Comm., 1881, 328 (Panama); Jordan & Gilbert, Bull. U. S. Fish. Comm., 1882, 111 (Panama); Everman & Meek, Proc. Acad. Nat. Sci. Phila., 1883, 123 (Panama).

Habitat.—Bay of Panama. Only the original type of this strongly marked species is yet known.

9. **Gerres peruvianus.**

Gerres peruvianus Cuvier & Valenciennes, Hist. Nat. Poiss., vi, 467, 1830 (Payta, Northern Peru); Lesson, Voyage Coquille, Poiss., 180, 1828 ; Jordan & Gilbert, Bull. U. S. Fish Comm., 1881, 330 (Mazatlan ; Panama); Jordan & Gilbert, Bull. U. S. Fish Comm., 1882, 108, 111, 112 (Panama ; Mazatlan ; Punta Arenas); Evermann & Meek, Proc. Acad. Nat. Sci. Phila., 1883, 123 ; Jordan, Proc. Acad. Nat. Sci. Phila., 1883, 289 (Notes on original type); Jordan, Cat. Fish. N. A., 1885, 95.

Gerres rhombeus Günther, Fish Centr. Amer., 391, 1866 (Name only), (Chiapam); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1881, 232 (Salina Cruz), (not of Cuv. & Val.).

Habitat.—West Coast of Tropical America (Mazatlan ; Salina Cruz ; Chiapam ; Panama ; Peru).

Dr. Jordan has examined the type of this species, of which he says : " The type of this species is apparently identical with the common west-coast species called by this name by Jordan and Gilbert (Bull. U. S. Fish Comm., 188, 330), and later by Evermann and Meek (Proc. Acad. Nat. Sci. Phila., 1883, 123)."

10. **Gerres rhombeus.**

Stone bass Sloane, Nat. Hist. Jamaica, ii, pl. 253, fig. 1, 1727 (Jamaica).

Gerres rhombeus Cuvier & Valenciennes, Hist. Nat. Poiss., vi, 459, 1830 (Martinique ; San Domingo); Günther, Cat. Fish. Brit. Mus., i, 341, 1859 (Cuba ; Jamaica ; Puerto Capello ; South America ; in part *G. olisthostoma* Goode & Bean); Günther, Cat. Fish. Brit. Mus., iv, 253, 1862 (Cuba ; Jamaica ; Puerto Capello); Steindachner, Zur Fisch-Fauna Magdalenen-Stromes, 9, 1878 (Rio Magdalena); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1883, 383 (Aspinwall); Evermann & Meek, Proc. Acad. Nat. Sci. Phila., 1883, 123; Jordan, Proc. Acad. Nat. Sci. Phila., 1883, 290 (Notes on original type); Bean & Dresel, Proc. U. S. Nat. Mus., 1884, 154 (Jamaica).

Habitat.—West Indies and Atlantic Coast of Tropical America (Jamaica ; San Domingo ; Martinique ; Puerto Capello ; Havana ; Aspinwall ; Rio Magdalena).

We have examined a number of specimens from Havana, ranging from $2\frac{3}{4}$ to 10 inches in length.

Head $3\frac{1}{4}$; depth $1\frac{5}{6}$; scales 5–38–10. D. IX, 10; A. II, 9.

Body much compressed, rhomboidal in form, the back much elevated; profile evenly convex to supraorbital where there is a slight depression; snout somewhat pointed; mouth rather large; end of maxillary reaching to vertical from centre of pupil, its length 3 in head. Exposed portion of the maxillary oblong, its width about $2\frac{3}{4}$ in its length, which is $4\frac{1}{4}$ in head. Eye $3\frac{1}{4}$ in head; snout 4 in head; interorbital area $3\frac{1}{4}$ in head. Gill-rakers stronger than in *gula* or *olisthostoma* 18 below the angle. Premaxillary groove broad, oval and free from scales. Pectoral fins reaching to front of anal, their length 3 in length of body; ventral fins reaching beyond vent, their length $4\frac{1}{4}$ in length of body. Second dorsal spine stronger, but shorter than third and fourth, its length about $4\frac{1}{4}$ in length of body; margin of fin falcate. Suborbital entire; preopercle entire. Caudal peduncle $2\frac{2}{3}$ in length of head. Anal spine constantly *two* in number. Second anal spine $1\frac{3}{4}$ in length of head.

Color silvery, with bluish reflections, darker above; margin of dorsal fin black; fins rather pale; ventrals and anal with dusky punctulations; snout dusky; no distinct dark lines along the rows of scales.

11. **Gerres olisthostoma.**

> *Gerres rhombeus* Poey, Rep. Pisc. Cub., 316, 1865 (Havana); Poey, Syn. Pisc. Cub., 321, 1868 (Havana).
>
> *Mojarra rhombea* Poey, Enum. Pisc. Cub., 51, 1875 (Havana); Poey, Enum. Pisc. Cub., 327, 1877 (Havana) (not *Gerres rhombeus* C. & V.).
>
> *Gerres olisthostoma* Goode & Bean, Proc. U. S. Nat. Mus., 1882, 423 (Indian River, Florida); Jordan & Gilbert, Syn. Fish. N. A., 934, 1883; Evermann & Meek, Proc. Acad. Nat. Sci. Phila., 1883, 123; Jordan, Proc. U. S. Nat. Mus.. 1884, 130 (Key West); Jordan, Cat. Fish. N. A., 1885, 95.

Habitat.—Coast of Florida and Cuba (Key West; Indian River, Fla.; Havana; San Matheos).

We have examined specimens from Key West, Havana and San Matheos. They range from 5 inches to a foot in length.

Head $3\frac{1}{3}$; depth $2\frac{1}{6}$; scales 5–38–9. D. IX, 10; A. III, 8.

Body compressed, rhomboidal in form, back very much elevated. Mouth large, maxillary extending to vertical from anterior portion of pupil, its length $2\frac{3}{4}$ in head; exposed portion oblong, its width $2\frac{1}{2}$ in its length, which is 4 to $4\frac{1}{4}$ in head.

Preorbital entire; preopercle serrate; premaxillary groove broad, closely covered with small scales (an important diagnostic character); gill-rakers weak, 11 below the angle. Eye $3\frac{1}{2}$ in head; interorbital space $3\frac{1}{4}$, and snout about $3\frac{1}{3}$ in head. Distance from snout to dorsal fin about $2\frac{1}{4}$ in length. Second dorsal spine $1\frac{1}{5}$ to $1\frac{1}{3}$ in head; third about equal to second, the others decreasing in length, the sixth being but one-half length of second—the general outline of upper margin of spinous dorsal being sickle-shaped. Pectorals reaching slightly beyond front of anal, and equal a little less than one-third length of body. Ventrals reaching just beyond vent and are one-fourth length of body. Anal spines always 3. Second anal spine stout, about $1\frac{3}{5}$ in head. Least depth of caudal peduncle about $2\frac{1}{2}$ in head.

Color silvery with bluish reflections, darker above. No distinct dark lines along rows of scales. Dorsal, ventrals and anal dusky, other fins paler. A dark supraorbital spot; snout dusky.

This species has, until lately, been confounded with *G. rhombeus*.

12. **Gerres brasilianus.**

Gerres brasilianus Cuvier & Valenciennes, Hist. Nat. Poiss., vi, 458, 1830 (Brazil; Porto Rico); Poey, Rep. Pisc. Cub., i, 315, 1865 (Havana); Poey, Syn. Pisc. Cub., 320, 1868 (Havana); Poey, Enum. Pisc. Cub., 50, 1875 (Havana); Poey, Enum. Pisc. Cub., 327, 1877 (Havana); Evermann & Meek, Proc. Acad. Nat. Sci. Phila., 1883, 124; Jordan, Proc. Acad. Nat. Sci. Phila., 1883, 289 (Notes on type).

Gerres patao Poey, Memorias Cuba, ii, 192, 1858 (Havana); Poey, Syn. Pisc. Cub., 320, 1868 (Havana); Poey, Enum. Pisc. Cub., 50, 1875 (Havana); Günther, Cat. Fish. Brit. Mus., iv, 253, 1862 (Copied); Evermann & Meek, Proc. Acad. Nat. Sci. Phila., 1883, 123.

We have examined a very large specimen of this species collected at Charleston, South Carolina, by Mr. Charles C. Leslie, as well as numerous smaller ones from Havana.

Head $3\frac{3}{7}$; depth $2\frac{1}{5}$; scales 5–38–9; D. IX–10; A. III–7 or 8.

Body compressed, rhomboidal; back very much elevated; profile nearly straight from spinous dorsal to premaxillary groove, where there is a slight depression. Snout conical, bluntish; mouth rather large; maxillary reaching slightly beyond the vertical from anterior margin of pupil, its length $2\frac{4}{5}$ in length of head. Exposed portion of maxillary oblong, its width $2\frac{1}{2}$ in its length, its length $4\frac{1}{2}$ in length of head.

Preorbital and preopercle serrate; premaxillary groove broad, narrowed posteriorly, entirely free from scales. Gill-rakers short and weak, 11 below the angle; eye small, $3\frac{2}{3}$ in length of head; snout $3\frac{1}{2}$ in length of head. Dorsal spines rather strong and stiff, second and third subequal in length, the second much the stronger, its length $1\frac{2}{3}$ in length of head, upper margin of dorsal fin falcate. Second and third anal spines subequal, the second much the stronger, its length $1\frac{2}{3}$ in length of head. Least depth of caudal peduncle $2\frac{1}{5}$ in length of head.

Color silvery gray, with bluish reflections, darker above, a dark streak along each row of scales, most conspicuous on upper part of body; fins all dusky except pectorals, which are pale; dorsal and anal blackish on their margins. A dark supraorbital spot; axil dusky.

The description of *Gerres brasilianus* Cuv. and Val. is very poor indeed. Dr. Jordan has examined the type, and we here give a copy of his notes: "The type of this species is in very bad condition, unfit for detailed description. Sides apparently with dark stripes along the rows of scales. Preorbital and preopercle serrate. Frontal groove broad, naked. Longest dorsal spine 5 in body. Second anal spine $5\frac{1}{4}$. Anal spines 3 in number. Caudal fin long. This species is allied to *G. plumieri*, but the back is less elevated and the spines smaller than in the latter."

The above agrees very well with our specimens from Charleston and Havana, the latter being evidently identical with the *Gerres patao* of Poey.

13. **Gerres lineatus.**

Smaris lineatus Humboldt, Observ. Zool., ii, 185, Pl. 46, 1807–1834 (Acapulco).

Gerres lineatus Cuvier and Valenciennes, Hist. Nat. Poiss., vi, 470, 1830 (Description from Humboldt); Jordan & Gilbert, Bull. U. S. Fish Comm., 1881, 330 (Mazatlan; San Blas); Jordan & Gilbert, Bull. U. S. Fish Comm., 1882, 108 (Mazatlan); Jordan & Gilbert, Bull. U. S. Nat. Mus., 1882, 377 (Fresh-water Lake at Acapulco); Evermann & Meek, Proc. Acad. Nat. Sci. Phila., 1883, 123; Jordan, Cat. Fish. N. A., 1885, 95.

Gerres axillaris Günther, Proc. Zool. Soc. London, 1864, 102; Günther, Fish. Cent. Amer., 448, 1866 (Chiapam); Jordan & Gilbert, Proc. U. S. Nat. Mus., 1881, 232 (Name only) (San Blas).

Habitat.—West Coast of Mexico (Acapulco; Mazatlan; San Blas; Chiapam).

14. **Gerres brevimanus.**

Gerres brevimanus Günther, Proc. Zöol. Soc. London, 1864, 152; Günther, Fish. Centr. Amer., 448, 1869 (Chiapam); Evermann and Meek, Proc. Acad. Nat. Sci. Phila., 1883, 124; Jordan. Proc. Acad. Nat. Sci. Phila., 1883, 290 (Notes on type).

Habitat.—Pacific Coast of Tropical America.

Concerning this species, Dr. Jordan observes: "This species is distinct from *G. lineatus* (Humboldt), although closely allied to it. Only the original type is yet known. On this I have the following notes:—

"Head $3\frac{1}{4}$ in length; depth $2\frac{1}{3}$; eye $3\frac{1}{3}$ in head. Coloration of *Gerres lineatus*. Back much lower than in the latter, and pectoral fins very much shorter; their length $1\frac{1}{4}$ in head; their tips not reaching nearly to tips of ventrals, which are $1\frac{1}{4}$ in head; caudal 3 in body. Preorbital very little serrate, almost entire. Preopercle weakly serrate. Second dorsal spine $1\frac{2}{5}$ in head; second anal spine $1\frac{2}{3}$. Teeth small and short. No black on base of pectoral, or on lower fins. Spinous dorsal dusky above. Frontal groove broad and naked, as in *G. lineatus*."

15. **Gerres plumieri.**

Gerres plumieri Cuvier & Valenciennes, Hist. Nat. Poiss., vi, 452, 1830, (Antilles; Porto Rico); Günther, Cat. Fish. Brit. Mus., i, 340, 1859 (San Domingo; Guatemala; Pernambuco; Bahia); Cat. Fish. Brit. Mus., iv, 253, 1862 (San Domingo; Guatemala; Pernambuco; Bahia); Poey, Rep. Pisc. Cub., 315, 1865 (Havana); Poey, Syn. Pisc. Cub., 321, 1868 (Havana); Poey, Enum. Pisc. Cub., 49, 1875 (Havana); Poey, Enum. Pisc. Cub., 327, 1877 (Havana); Steindachner, Zur Fisch-Fauna des Magdalenen-Stromes, 9, 1878 (Rio Magdalena); Jordan & Gilbert, Syn. Fish. N. A., 583, 1883; Evermann & Meek, Proc. Acad. Nat. Sci. Phil.. 1883, 124 (Aspinwall; Indian River, Florida); Jordan, Proc. Acad. Nat. Sci. Phila., 1883, 290 (Notes on type); Bean & Dresel, Proc. U. S. Nat. Mus., 1884, 153 (Jamaica); Jordan, Cat. Fish. N. A., 1885, 95.

Habitat.—West Indies and Atlantic Coast of Tropical America (Antilles; Havana; Porto Rico; San Domingo; Jamaica; Indian River, Fla.; Pernambuco; Bahia; Aspinwall; Guatemala).

We have examined six specimens from Havana. They range from $5\frac{1}{4}$ to 6 inches in length.

Head 3; depth $2\frac{1}{6}$; scales 5–37–11. D. IV, 10; A. III, 8.

Body compressed, rhomboidal in form, back very much elevated. Mouth rather large, maxillary extending slightly beyond vertical from anterior margin of pupil, its length $2\frac{5}{6}$ in head; exposed portion of maxillary oblong, its width $2\frac{1}{2}$ in its length, which is $4\frac{3}{4}$ in length of head.

Preorbital and preopercle serrate; premaxillary groove broad and entirely free from scales. Gill-rakers small, weak, 13 below the angle. Eye rather large, 3 in head; snout 4 in head. Distance from tip of snout to dorsal fin equals the greatest depth of fish. Upper margin of dorsal fin is sickle-shaped. Second dorsal spine very strong and long, its length $2\frac{3}{5}$ in length of body; the other spines rather weak and flexible. Second anal spine very long and strong, its length equals length of head; third anal spine shorter and much weaker than second. Pectoral fins reaching beyond the front of anal, their length $2\frac{2}{3}$ in length of body; ventral fins reaching past vent, almost to front of anal, their length $3\frac{2}{5}$ in length of body.

Color bluish-silvery above, silvery below; distinct dark longitudinal lines along each row of scales. Dorsal caudal and anal fins dusky; margin of dorsal fin black; a dark supraorbital spot. Pectoral and ventral fins pale.

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.*
Mugil *cinereus* Walbaum,	1792,	Gerres cinereus.
Smaris *lineatus* Humboldt,	1830,	Gerres lineatus.
Gerres *plumieri* Cuvier and Valenciennes,	1830,	Gerres plumieri.
Gerres *brasilianus* Cuv. and Val.,	1830,	Gerres brasilianas.
Gerres *rhombeus* Cuv. and Val.,	1830,	Gerres rhombeus.
Gerres aprion Cuv. and Val.,	1830,	Gerres cinereus.
Gerres *gula* Cuv. and Val.,	1830,	Gerres gula.
Gerres *peruvianus* Cuv. and Val.,	1830,	Gerres peruvianus.
Gerres zebra Müller and Troschel,	1848,	Gerres cinereus.
Eucinostomus argenteus Baird & Girard,	1855,	Gerres gula.
Gerres patao Poey,	1858,	Gerres brasilianus.
Gerres squamipinnis Günther,	1859,	Gerres cinereus.
Diapterus *californiensis* Gill,	1862,	Gerres californiensis.
Diapterus *gracilis* Gill,	1862,	Gerres gracilis.
Diapterus *dowi* Gill,	1863,	Gerres dowi.
Gerres axillaris Günther,	1864,	Gerres lineatus.
Gerres *brevimanus* Günther,	1864,	Gerres brevimanus.
Gerres *lefroyi* Goode,	1874,	Gerres lefroyi.
Eucinostomus *pseudo-gula* Poey,	1875,	Gerres pseudo-gula.
Eucinostomus gulula Poey,	1875,	Gerres gula.

Nominal Species.	*Year.*	*Identification.*
Eucinostomus productus Poey,	1876,	Gerres lefroyi.
Gerres jonesi Günther,	1879,	Gerres pseudogula.
Eucinostomus harengulus Goode and Bean,	1879,	Gerres gracilis.
Diapterus homonymus Goode and Bean,	1879,	Gerres gula.
Gerres *aureolus* Jordan and Gilbert,	1881,	Gerres aureolus.
Gerres *olisthostoma* Goode and Bean,	1882,	Gerres olisthostoma.

Recapitulation.

We have in this paper admitted 15 species of the American Gerridæ, and repeat here the list of species. The distribution of the species is indicated by the letters W. (West Indies and adjacent coasts), U. (Southern Atlantic coast of the United States), and P. (Pacific coast of Tropical America).

1. Genus **GERRES** Cuvier.

1. *Gerres lefroyi* Goode (W.).
2. *Gerres dowi* Gill (U.; W.; P.).
3. *Gerres pseudogula* Poey (W.).
4. *Gerres gracilis* Gill (U.; W.; P.).
5. *Gerres californiensis* Gill (P.).
6. *Gerres cinereus* Walbaum (U.; W.; P.).
7. *Gerres gula* Cuv. and Val. (U.; W.).
8. *Gerres aureolus* Jordan & Gilbert (Panama).
9. *Gerres peruvianus* Cuv. & Val. (P.).
10. *Gerres rhombeus* Cuv. & Val. (W.).
11. *Gerres olisthostoma* Goode & Bean (W.; U.).
12. *Gerres brasilianus* Cuv. & Val. (W.; U.).
13. *Gerres lineatus* Humboldt (P.).
14. *Gerres brevimanus* Günther (P.).
15. *Gerres plumieri* Cuv. & Val. (W.; U.).

JUNE 1.

The President, Dr. LEIDY, in the chair.

Twenty-five persons present.

The deaths of C. J. Hoffman, a member, and of C. U. Shepherd, a correspondent, were announced.

Trapa bicornis, L.—Mr. MEEHAN called attention to the Ling nut of the Chinese, of which a specimen on the table was four-horned, as in the European species *T. natans*, and another with three. It showed that the calycine horns were little more than bracts, and that the European species was one more highly developed than the Asiatic species.

Formation of Crow's Nest Branches in the Cherry Tree.—In regard to fasciated branches, or as they were familiarly called "crow's nests," in trees, Mr. MEEHAN remarked that they might be classed as different species, and perhaps each species might have its own peculiar law of development. In former contributions to the Academy, he had explained some of the phenomena attendant on fasciation in trees and plants, which gave clues as to their origin. In the cherry there was a species of fasciation distinct from that prevailing in most trees. In a portion of the mass of branches cut from the main mass, very little of an abnormal character could be noted. But on the tree itself a huge mass of small branches proceeding from one common branch might be noted, in striking contrast with the prevailing character. The specimens exhibited were from a mass of about four feet in diameter. In this there were about two hundred branchlets. In one of the thickest growths of a normal character, only about twenty branchlets could be counted in a similar space. The weight of these fasciations was so great that the masses hung like pendulums from the trees. The garden cherry had for more than a century been naturalized near Philadelphia, and he knew of three of these fasciations, one on each wild tree, within a half mile of each other. He had not seen any on cultivated trees. They had been under his observation for years. They might be said to never flower. On one he had seen two weak flowers last year. There were none this. The leaves are attacked by a species of fungus, which Professor Farlow, of Cambridge, had kindly worked out for him, and found to be *Exoascus Wilsneri*, an European species closely allied to *E. deformans*, the species well known as causing the disease called the "curl" in the peach. Prof. Farlow states that the specimens sent by Mr. Meehan gave him the first knowledge of the existence of the species in America.

As in the peach leaf-curl, the first leaves that push in the spring are attacked, and are soon destroyed, the blistered and browned leaves all falling by the first of June. New leaves, free from the fungus, and weak shoots follow the attack. The absence of flowers led to the discovery of the method by which the fasciation is formed. In the normal condition of the cherry tree, the weak shoots become fruit-bearing spurs. From these spurs leaves annually appear, leaving an axillary bud, which becomes the flower bud of the next season. The leaf continues healthy throughout the growing season, and the parts that, morphologically speaking, might make a weak growth of wood, remain in a kind of microcosm as sepals, petals, stamens, and carpels, fed by the leaf for another year. But when this leaf is injured or destroyed, instead of the bud remaining quiescent, or the theoretical leaves changing into floral parts in the bud, a new growth of leaves and the weak shoot are produced instead. It is indeed so clear when once observed that the fasciation is simply the development to weak branches of what would normally be blossom spurs, that it was provoking to reflect that it had taken so many years to discover it.

An interesting observation was that the fungus should confine itself to the fasciated mass for so many years, and show no disposition whatever to spread to any other part of the tree. In practical gardening we were taught when these fungus pests appeared on orchard trees it was highly important to cut off the branches or leaves, and burn them, in order to check the spread. In the absence of actual demonstration in this case, one might with good reason assume that the mycelium of the parasite had obtained an entrance into the tissue and propagated itself continuously as the branches grew, and that a crop of spores in myriads must be produced annually. Only in rare instances were the circumstances favorable to their germination. The careful cutting away and burning of a few thousand spores would be a matter of small importance in comparison with the immense number that must escape the effort of the cultivator for their destruction. Safety lies evidently rather in the difficulty these minute bodies experience in finding the exact conditions necessary for their growth and development, than from the destruction of the germs themselves.

Distribution of Modiola tulipa.—Mr. John Ford reported the finding by him of a half-grown specimen of *Modiola tulipa* Lam., near Cape May, N. J., on the 16th ult. As the species is essentially a southern one, it was at first supposed that the specimen had been carried north on the bottom of a vessel, or in some other artificial manner. The discovery two weeks later, by Mr. Ford, of a dozen or more adult specimens, at Anglesea, ten miles further north, seems to prove that the species has entered upon its new conditions in large numbers, and with the purpose of making its new home a permanent one.

There is no record of the species having been found north of South Carolina before.

Toxodon and other Remains from Nicaragua, C. A.—Prof. LEIDY directed attention to some fossils, and remarked that they were part of a collection which he had been invited to examine by Mrs. Dr. B. F. Guerrero, now residing in this city. The collection was obtained from the northern part of Nicaragua, but nothing further had been learned about it. It mostly consisted of uncharacteristic fragments of bones, but among them were many interesting specimens referable to Megatherium, Elephant, Mastodon, Horse, Ox, Toxodon, and Capybara. The association of these animals is another illustration of the extension of the early South American quaternary fauna into North America. Among the remains of *Megatherium* there is the greater part of the distal extremity of a femur and a fragment of the mandible with two teeth. Of the Elephant there is a portion of a molar tooth. Of the Mastodon there is a molar tooth and portions of several others apparently of the *M. andium.* Of the Horse there are two upper molar teeth, with no well-marked difference distinguishing them from those of ordinary varieties of the Domestic Horse. Perhaps they may pertain to one or other of the species indicated by Prof. Owen with the names of *Equus curvidens* or *E. tau.* Of the Ox, the collection contains several horn-cores of different sizes; one, double the size of that of the Domestic Ox.

The Capybara is indicated by a fragment of the left ramus of a mandible with the first molar alveolus containing the greater part of the tooth. The specimen conforms to the corresponding portion of the jaw of the living Capybara, but indicates a considerably larger and more robust animal. Considering the difference in size and age of the fossil, it was probably a different species from the Capybara, and regarding it as such he proposes for it the name of *Hydrochoerus robustus.* The first molar tooth complete would have the appearance represented in figure 1, and, except in size, does not differ from that of the Capybara. Comparative measurements of the fossil are as follows:—

1.

	H. robustus.	Capybara.
Depth of mandible at first molar,	56 mm.	33 mm.
Length of first molar, . .	55 "	36 "
Fore and aft diameter, . .	25 "	17 "
Transverse diameter of last dental plate, ...	13 "	9 "
Diameter of incisive alveolus, .	20 "	10 "

Dr. Lund, in his Fossil Fauna of Brazil (An. Sc. Nat., 1839,

214) refers to remains of *Hydrochoerus*, which he refers to two species, one as *H. affine Capybaræ*, not different from the living Capybara, and another which he calls *H. sulcidens*, of a size intermediate to the latter and the Tapir, and having the incisors deeply grooved in front. He remarks the former differs in having the incisors smooth in front as in the living species, which saying is obscure, for in the living Capybara the incisors are conspicuously grooved in front.

Prof. Owen (Voyage of the Beagle 110), speaks of a decomposed molar tooth of *Hydrochoerus*, found with remains of *Megatherium*, *Toxodon*, etc., by Mr. Darwin at Bahia Blanca, S. A. He remarks that the fossil differs from the corresponding tooth of the Capybara, in the greater relative breadth of the component laminæ.

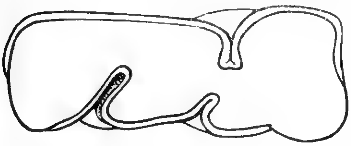
Prof. Gervais (Rech. Mam. Fos. de l'Amerique Meredionale, 1855, 12), describes remains of Hydrochoerus, found with those of Megatherium, Toxodon, etc., at Tarija, Bolivia. They consisted of portions of upper jaws, which are regarded as pertaining to a species but little different in size and in the form of the teeth from the recent Capybara. They are referred to the *H. affinis Capybaræ* of Dr. Lund. A specimen of a maxilla with the last two molar teeth, figured in Plate xiii, fig. 3, of the work, indicates a more robust animal than the living Capybara, and the last molar tooth is composed of fourteen plates, a greater number than exists in the recent animal. In four skulls of the latter he found the last upper molar to have twelve plates, while in the fossil described by Gervais there are fourteen plates. Comparative measurements of the latter fossil with the recent animal are as follows:—

	Capybara.	Tarija fossil.
Last molar, fore and aft diameter,	33 to 34 mm.	50 mm.
Last molar, transverse diameter,	12 to 13 "	20 "
Penultimate molar, fore and aft,	9 to 10 "	14 "

He thought it probable that the remains of *Hydrochoerus*, referred by Lund and Gervais to *H. affinis Capybaræ*, and those mentioned by Owen, as above noted, probably also belong to the species he had named *H. robustus*. He formerly described some remains of *Hydrochoerus*, which were found in association with those of *Megatherium*, etc., in the Ashley Phosphate Beds of South Carolina (Post-pleiocene Fossils of South Carolina, 1860, 112, pl. xxi, figs. 3–6). These consist of teeth, which agree in size with those of the recent Capybara, and were referred to a probably extinct species, with the name of *H. Æsopi*.

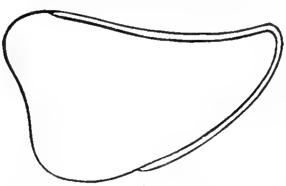
The most interesting fossils of the collection are those of *Toxodon*, as being evidence of the former existence of this remarkable animal in North America. The best preserved and best marked specimens consist of a nearly complete lower molar tooth, and two portions of a lower incisor. These in their form and size best agree with the corresponding teeth of *Toxodon Burmeisteri*, described and figured by Dr. Burmeister, in the Annals of the Museum of Buenos Aires, 1869, 256, pl. xi.

The molar tooth is the penultimate of the left side. Its length, when complete, has approximated five inches, and it measures 43 mm. fore and aft, and 18 mm. transversely at its fore part. An outline of the triturating surface is represented in figure 2. Enamel invests the outer surface extending about half way round the corners in front and behind. On the inner surface enamel invests the middle extending furthest behind. The inner angles of the tooth are both destitute of enamel. The outer enamel layer forms a single inflection about the anterior third of the tooth; the inner enamel layer forms two inflections nearly equidistant behind the position of the outer one; the posterior inflection being the deepest.



2.

The incisor, apparently the second lower of the right side, is broken into two about the middle, and when complete has been over six inches long. The transverse section, as seen in figure 3, viewed from below, is triangular, with the apex directed outward, and the base inward or mesially. The front surface is transversely convex, and the back surface in the same direction concave. The inner surface, extending around the corners, further in front than behind, is destitute of enamel. The triturating surface is worn away in a slope from the outer border inward and backward. The measurement of the section in front and behind is 37 mm., and internally fore and aft 23 mm.



3.

JUNE 8.

The President, Dr. LEIDY, in the chair.

Twenty-one persons present.

A paper entitled "On the Histology of Salpa (S. runcinata-fusiformis)," by Dr. Chas. S. Dolley, was presented for publication.

On the Expansion of the Crystalline lens.—Dr. BENJAMIN SHARP remarked that it is well known that accommodation in the eye, for distance, is effected by the contraction of the ciliary muscle, drawing on the point of attachment of the capsular ligament of the lens, the lens widening its optical axis as soon as the tension of the ligament is released. The lens is flattened, or its optical axis is shortened, as soon as the ciliary muscle is relaxed; the ligament being drawn upon by the elasticity of the sclera, and perhaps it is somewhat aided by the intraocular pressure. Dr. Sharp stated that as far as he knew the mechanism of the "lenticular expansion" had not been described. This action is easily seen on turning to the development of the lens. The lens is formed by an invagination of the external octoderm soon closing, and as a result we have a spherical vesicle, soon enclosed in the mouth of the secondary optic vesicle. When this has taken place, the posterior wall of the lens-vesicle thickens, that is, the posterior cells commence to elongate, and grow toward the anterior wall of the vesicle, the cells of which remain, generally speaking, of the same size, and later form the so-called epithelium of the lens. Keeping this structure in view, we see that when pressure is brought to bear on the lens, these elongated cells of the posterior wall are compressed in their longitudinal axis, so that as soon as the pressure is removed, they simply straighten out. This will also account for the fact, that the anterior face of the lens is the only portion that moves in the act of accommodation for distance. In the adult lens this structure is to a certain extent lost, and the lens is generally described as being made up of layers concentrically arranged. This is true, but the embryonic "impression" still remains. If we supposed that the lens were made up of layers concentrically arranged and *so formed*, when the capsular ligament "slacked up" the tendency of the lens would be to shorten its optical axis instead of lengthening it.

The Opal Mines of Queretaro, Mexico.—Dr. A. E. FOOTE remarked that the locality referred to is particularly interesting as being the only one in North America that is being worked solely for the production of gems.

The opals of Mexico have been celebrated since 1820, when Karsten and Del Rio referred to the opals of Zimapan and that neighborhood as being in many respects equal and in some respects superior to the Hungarian. There are quite a number of fine localities from which considerable quantities have been exported to Europe, so that among the lovers of the beautiful, Mexico is as well known for its brilliant opals as for the soft and exquisite tints of the tecali or Mexican onyx.

As in the case of diamonds from Brazil and Africa, there is a jeweler's prejudice against the new locality, and they are considered even more unlucky and liable to break than those of Hungary. I have, however, seen in the possession of Senor Cosio magnificent specimens that had been taken out over ten years, and were without a flaw.

The locality in Queretaro is the only one in Mexico that is being worked to any extent now.

The principal mines are on the hacienda of Esperanza, where the opal was discovered, by a servant, ten years ago. No mines were taken up until 1870, when Dr. Jose Maria Siurob located the mine of Santa Maria Iris. The fine specimens secured during the next few years created so much excitement that a large number of mines were located, most of which are now abandoned. The district is quite extensive, having been traced over a region about twenty leagues long by thirty-one leagues wide. At Ciervo, fourteen leagues from Esperanza, the opal is quite abundant, though none of the precious variety of good quality has been found.

The mines of Esperanza can only be reached on horseback, and the ride from Queretaro is a very hard one. San Juan del Rio, said to be the nearest large town where one can get accommodations for the night, is ten leagues to the S. E.

Leaving the Mexican Central Railroad and crossing a rich alluvial plain, covered with fields of corn and the so-called century plant, surrounded by fences of *Cereus giganteus*, we came to the foot hills. Here at once abundant evidences of volcanic action were seen. Round nodules of obsidian, large masses of agate, milk opal, and other siliceous products, were mixed with the cacti on every side. The rough trail soon led into the dry bed of a barranca, where porphyritic trachyte carrying the common varieties of opal were quite abundant; the trend of these porphyritic banks was from S. E. to N. W. The color of the rock is reddish gray. As the barranca terminated in a narrow valley, on the mountains on each side were seen the red dumps standing out conspicuously upon the gray surface.

Of the mines that he visited only one, the Jurado, was being worked. The deposits of opal-bearing trachyte are so irregular that the mines are soon exhausted.

The Jurado is an immense excavation about 150 feet deep, several hundred feet long, and about 100 feet wide. At the bottom, the porphyritic rock seemed to be thoroughly impregnated with hydrated silica, even occasionally being converted into common opal.

The general appearance of the rock furnishes a very good clue to the character of the opals that it may contain. Thus if the rock is less red in color and close and compact in texture, fire opals and related forms abound, while if the rock is deep red in color or clayey and pockety, the Hungarian, harlequin, and milky opals are much more abundant.

There is no locality of which he had ever heard where such an extraordinary variety of opals can be found in a single matrix. The same small piece of rock will show fire opal, fire opal showing green and blue reflections, the Hungarian, harlequin, girasol, hyalite, milk, and almost every variety. The harlequins showing a mosaic of brilliant minute spangles of color in a milky base, vie with the broad sheets of dazzling blue, red and green. Perhaps, like Ruskin, we should give the palm to the "Milky opals that gleam and shine like sullen fires in a pallid mist."[1]

Vitality of Mollusca.—Prof. HEILPRIN called attention to a remarkable case of vitality among certain members of the fauna of the New Jersey coast. Specimens of *Nassa obsoleta* collected by Miss Emma Walter, at Atlantic City just one year ago, and retained dry during the entire year of their accidental captivity, were stated to be still alive, although subjected for several months to the abnormal temperature occasioned by proximity to a heated wall surface. This, the speaker contended, was perhaps the most extraordinary instance of vitality known among the marine mollusca, although among the terrestrial and freshwater forms, especially among those which undergo a partial hibernation, longer periods of semi-adaptation to imposed conditions have been noted. Instances of such survivals were cited by the speaker and Prof. Leidy.

JUNE 15.

Mr. JOHN H. REDFIELD in the chair.

Twenty-two persons present.

JUNE 22.

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

Thirteen persons present.

A paper, entitled "Notes on the Paspali of Le Conte's Monograph," by Geo. Vasey, was presented for publication.

Note on Quercus dentata.—Mr. THOMAS MEEHAN exhibited specimens of *Quercus dentata* with female flowers, from a specimen raised from an acorn received from Japan ten years ago. It is of very rapid growth, being now eighteen feet high, and six inches in circumference. So recently as the issue of the volume of *De Candolle's Prodromus*, it was noted that the fruit was unknown. Some account of these female flowers might have an interest. Like our annual fruited oaks the flowers appear at the end of the young growth, in pairs on peduncles about half an

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[1] The speaker had collected at the opal mines a number of specimens of minute bright white rhombohedrons showing the basal planes; these have been examined by Prof. E. S. Dana, who pronounces them alunite. Well crystallized alunite is not common, and he believed this is the first time its appearance has been noted in North America.

inch long, the peduncles of course springing from the axils of the upper leaves. Early in June a second growth occurs, on which are also female flowers. On many of the stronger a third growth is made before autumn. The several growths during the season on this tree, have no doubt had much to do with its great size in so short a time. The involucre is a mass of loose scales, in the centre of which the four blackish ligulate stigmas are seen. Bisecting the flower vertically, the usually minute calyx segments, immediately beneath the stigmas are represented here by numerous brown scale-like hairs, which simulate the scales of the involucre, and are at the apex of a slender stipe or beak four lines long, that seems to spring from the true ovarium as if it were a true style, and the real pistils represent a four-cleft stigma at the apex. He did not remember any American species that had so long a beak in this early stage of growth, though there were some species that he had not had an opportunity of dissecting. From those that he had had the opportunity of examining the differences in this feature were striking, and the character could certainly be made more useful than it had been in enabling us to discriminate species in this very difficult genus. A horizontal section of the ovarium shows it to be four-celled, with each cell two-ovuled.

1. Peduncle with flowers, *Quercus dentata*, natural size.
2. Beak of the ovarium with stigmas enlarged.
3. Beak of the ovarium with stigmas enlarged, *Quercus macrocarpa*.

June 29.

The President, Dr. Leidy, in the chair.

Eighteen persons present.

A paper entitled "Notices of Nematoid Worms," by Dr. Joseph Leidy, was presented for publication.

Mineralogical Notes.—Composition of Stromeyerite.—Professor George A. Kœnig placed on record the identification of Stromeyerite from Zacatecas, Mexico. At this locality the miners designate the various silver minerals by their colors as black silver, red silver, green silver, and blue silver. Under the latter name—plata azul—several minerals are undoubtedly comprehended, but probably the most prevalent is the mineral here identified as Stromeyerite. One large specimen is composed of numerous prismatic crystals, the terminations broken off—sitting on well-crystallized quartz, and from several smaller specimens it would appear that quartz is the ordinary companion of Stromeyerite at Zacatecas, whilst the other silver minerals—Proustite, Polybasite, Stephanite, Argentite—are more commonly associated with Calcite. The faces of the crystals are rough, not admitting close measurements; the prismatic angle is near 120°–119°. The mineral has no cleavage. Its fracture is uneven to flat subchonchoidal and very splintery. The lustre is brilliantly metallic and the color iron-gray with a strong bluish purple admixture. The color of the powder is nearly the same. It is not sectile, but mild, and has a hardness of 3, 5.

Spec. gravity = 6·2303, made upon 1·623 grams of fragments from several crystals. Before the blowpipe it melts very readily to a globule, emitting sulfurdioxide, and changing to a gray globule of silver-copper. Gives no sublimate on charcoal, nor in open or closed tube, and dissolves in nitric acid to a blue solution, in which hydrochloric acid precipitates flocculent silver chloride.

A preliminary analysis made with a fragment from one crystal (0·2346 gram) gave the result I; a second analysis made upon the mixed fragments used in the determination of specific gravity (0·5 gr.) gave the result II.

I. $AgCl = 0·1615$; $Cu_2S = 0·0958$; $BaSO_4 = 0·2837$.
II. $AgCl = 0·2509$; $Cu_2S = 0·2105$; $BaSO_4 = 0·5758$.

From this we calculate:

	I.	II.
Insoluble	—	0·26
Ag	51·66	50·18
Cu	32·67	33·69
S	16·64	15·81
	100·97	99·94

Analysis having been made with twice the quantity of substance and with greater care, deserves alone to be taken as basis for the atomic ratio. Dividing the percentages by the atomic weights, we obtain:

$$Ag : Cu : S = 0·4661 : 0·5322 : 0·4975$$
$$Ag + Cu : S = 0·9983 : 0·4975$$
$$= 2·007 : 1$$
Hence, $47\ Ag_2S + 53\ Cu_2S$

It is seen that Ag and Cu are not exactly in the ratio 1 : 1, but very near. Undoubted Stromeyerite has been described heretofore only from two localities, Schlangenberg, in Siberia, and Rudelstadt, in Silesia, and from the latter place only in crystals. The analyses of the mineral from these places do not give the ratio of 1 : 1 for Ag and Cu either, but a little closer than the present locality of Zacatecas. Since Ag_2S and Cu_2S may replace each other isomorphically in all proportions without question, we may look upon such a ratio as Stromeyerite demands, 1 : 1, as quite an exception, owing no doubt to peculiar conditions present at the time of crystallization.

The material for this investigation was obtained from Dr. A. E. Foote, who collected it during his recent visit to Zacatecas and other mineral localities in Mexico.

Christian E. Metzler and Charles H. Marot were elected members.

The following was ordered to be published :—

NOTES ON THE PASPALI OF LE CONTE'S MONOGRAPH.

BY GEORGE VASEY.

The monograph of U. S. species of the genus *Paspalum*, by Capt. (since Major) Le Conte, was published in the Journal de Physique, Paris, vol. 91 (1820). It contains descriptions of eighteen species.

Through the kindness of Mr. J. H. Redfield, all the Lecontean specimens of *Paspalum* in the Herbarium of the Philadelphia Academy of Natural Sciences, have been placed in my hands for examination, and I have given them as careful a revision as I find possible. The result is expressed in the following notes. I have to premise that autograph specimens of some of these species are wanting, and of some others are mixed in the sheet with other species, making it doubtful which was the typical plant. But in most cases the specimens and descriptions enable us satisfactorily to determine the species indicated.

1. **Paspalum præcox**, Walter.

The specimen to which Le Conte's ticket is attached is a form of *P. læve*, Mich., not answering, however, to all the characters given, as the sheaths and leaves are not "*vilosissimus*" and the number of spikes is four instead of three. In the same sheet, however, is another specimen which has hairy leaves and sheaths. Le Conte evidently thought he was describing the plant of Walter, but the description does not answer for the plant which is now accepted as the *P. præcox* of Walter, nor does it agree with the description either of Michaux or Elliott.

2. **P. setaceum**, Michx.

The ticket bearing this name is in a sheet with another bearing the name of the next species, and the plants are all the common erect hairy form of *P. setaceum*, Michx., except one specimen, ticketed *P. ciliatifolium*, from Georgia, and marked "Baldwin." Mr. Le Conte's description answers well to the commonly accepted plant of Michaux, and he gives after his description this reference, "*P. setaceum* et *debile* Michaux, Nova Cesarea ad Floridam," with the mark O for annual, which latter point is open to doubt.

3. **P. ciliatifolium**, Michx.

As above stated, the ticket for this is in the same sheet with the preceding, and if it has not been changed, must apply to the same plant, as the description does not at all apply to the smooth long-leaved specimen of *P. ciliatifolium* from Georgia. Some of the specimens have "spica unica," and some have "spicis 1 sive 2," and some with the usual lateral peduncled ones.

4. **P. longepedunculatum**, Le Conte.

The specimen to which this name is attached is commonly referred to *P. setaceum*, Michx., but is a different form from Nos. 2 and 3, more like the southern *P. ciliatifolium*, but having the leaves shorter and narrower. There are several long peduncled lateral spikes which are not mentioned in the description, the name being based on the "very long peduncled common spike." In Herb. Scribner is a specimen, collected by Mr. Isaac Burk, on the ballast grounds of Philadelphia, which is almost exactly like the Le Contean one, and if *P. ciliatifolium* is considered a species this might be called variety *brevifolia*. At the close of his description Le Conte says "*P. debile*, Muhl. Gram."

5. **P. Floridanum**, Michx.

There are two tickets with this name, one of which is attached to a specimen of *P. racemulosum*, Nutt., which specimen does not agree with Le Conte's description; the other is attached to a much smaller plant, very well answering the description of Le Conte but not of Michaux. The specimen is not different apparently from the one to which Le Conte's ticket "*P. præcox*" is attached, which we take to be *Paspalum læve*, Michx., the short broad-leaved form which is perhaps the typical one.

In Herb. Torrey is a specimen of *Paspalum Floridanum* with a note, "not of Le Conte, which is *P. læve*. Ell. i, p. 106, non Michx.?" We see from this note not only that Dr. Torrey referred Le Conte's *P. Floridanum* to *P. læve*, Ell., but also that he had doubt if Elliott's plant was the same as Michaux's.

6. **P. læve**, Michx.

Le Conte's ticket with this name is loose in a sheet with the preceding, the three specimens being apparently all alike except as to the pubescence of the leaves. There is also in another sheet a specimen with the ticket attached, which specimen is the form of *P. læve*, with long, smooth leaves, not as No. 6 is described with "foliis latiusculis, brevibus."

7. **P. difforme,** Le Conte.

The name as printed is "clifforme," evidently a typographical error. The specimen is intermediate between *P. læve* and *P. Floridanum*, and different from either. Le Conte says, "Refert *P. Floridanum* sed spicis erectis, glumisque majoribus facile distinguitur." This comparison was evidently made with his No. 5, which was not the *P. Floridanum*, Mx. He also refers *Paspalum* No. 7 of Muhlenberg's Gram. to this plant, but the description is too obscure to be of any value. We have specimens in the U. S. Herbarium from N. C., and from Florida, which are apparently the same as Le Conte's plant. They have been referred to *P. Floridanum*, but are clearly different in the smaller size of the plant, in the shorter spikes, and in the much shorter leaves. We have the same plant, also, from Dr. Charles Mohr, Mobile, Ala., who noted that it differed from the *P. Floridanum*. He says *P. Floridanum* blooms from the middle of June to the middle of July, while the other kind begins to flower six or eight weeks later. Altogether it seems that for these specimens Le Conte's name should be recognized and added to our list.

8. **P. undulosum,** Le Conte.

The specimen over this name is apparently a form of *P. læve*, Michx., with wider and smoother leaves, more numerous and shorter spikes than in the common form. I have seen no other specimens quite matching it, and it may very well be called *P. læve*, variety *undulosum*. The undulate margin of the leaves is also shared by other species. Schultes subsequently published this as *P. Leconteanum* (Mant. 2, 168), probably because Le Conte's name was too much like *P. undulatum*, Poir.

9. **P. latifolium,** Le Conte.

The specimen with this name looks like a very exuberant *P. ciliatifolium*, with equally small spikelets, but in three or four series. The leaves are about an inch wide, and eight to ten inches long. I have seen no other such specimens, but the general appearance and habit is that of *P. ciliatifolium*, of which it is probably a luxuriant form.

10. **P. virgatum**, Walt.

The ticket bearing this name is loose in a sheet which contains two specimens of *P. plicatulum*, Michx., and two specimens of *P. præcox*, Walt., one of which is ticketed, " Herb. Schw., *P. plicatulum*, Georgia, Hermann." The description seems to refer to what we call *P. præcox*, Walt., "spicis 5–6, alternis, erectis, glumis biseriatis, rachi latiuscula, non flexuosa, dentibus bifloris." Le Conte apparently mistook his No. 1 for *P. præcox*, Walt., and this for *P. virgatum*, Walt. The true *P. virgatum*, Walt., is probably *P. purpurascens*, Ell. Le Conte adds to his description this note, " Calicis valvulæ omnium paspalorum, cuve semina maturescent juxta margines transversæ plicatæ fiunt." If this means that the glumes of all Paspalums when mature have transverse plications such as mark the *P. plicatulum*, Michx., it is a great error.

11. **P. angustifolium**, Le Conte.

The specimen bearing this name is evidently one of the forms commonly called *P. læve*, Michx., having long, narrow and smooth leaves, and three slender spikes three to four inches long. It is quite different from No. 5, which represents a form with much shorter and wider leaves, and which is possibly the typical plant, as Michaux says " foliis breviusculis." No subsequent writer except Elliott, however, quotes these words of Michaux. Gray says " the pretty large and long leaves;" Chapman says " leaves and sheaths smooth or the latter hairy;" Elliott quotes Michaux's words, " leaves short," but does not recognize the plant. It is, therefore, difficult to say precisely what was Michaux's type, and some botanists will prefer to consider this species of Le Conte as a distinct one. Otherwise, it may be distinguished as variety *angustifolium.*

12. **P. gracile**, Le Conte.

The two specimens bearing this name, one ticket marked " Paspalum gracile mihi, *P. læve*, Schweinitz," the other " *Paspalum tenue*, Kth., *P. gracile*, Le Conte, 'Durand,' " are clearly what is commonly understood as *P. plicatulum*, Michx., or *P. undulatum*, Poir. Kunth published *P. tenue*, evidently based either on Le Conte's specimens or on the description to which he refers. If Kunth saw the specimens, and they were the same as these in the Herb. Acad. Phil., it is not easy to understand how he should make a new species of them, unless, as may be the fact, Michaux's plant is the *P. purpurascens*, Elliott, in which case indeed another name would be needed for Le Conte's plant, and as the name *P. gracile* had been earlier appropriated by Rudge for a S. American plant, Kunth distinguished this by the name of *P. tenue.* An inspection of the Le Contean specimens in the Herb. Mus. Paris will probably settle this question. Kunth, however, refers Michaux's *P. plicatulum* not only to *P. purpurascens*, Ell., but also to *P. undulatum*, Poir, as if Michaux had confused two species, which is very likely to be the case. On the other hand, if Kunth saw Le Conte's specimens, and they were like these of the Herb. Acad. Phila., he should have recognized them as the *P. undulatum*, Poir.

Le Conte, at the end of his description of this species, says, "Muhlenberg Gram. sub Paspalo, No. 8," with the description of which Le Conte's does not agree. Furthermore, there is in Herb. Torrey a specimen of *Paspalum setaceum*, Michx., which is also referred to "Pasp. No. 8, Muhl. Gram.," and which agrees sufficiently well with the description.

13. **P. altissimum,** Le Conte.

The single specimen to which this name is attached is evidently what is commonly called *P. Floridanum*, Michx., for which, according to Kunth, the earlier name of *P. macrospermum*, Flugge, must be adopted. Le Conte's specimen has only two spikes, although his description says "spicis 4–5." The species, however, or some forms of it, often have 4 to 5 spikes. One form has pubescent leaves or sheathes, and one form is quite glabrous. Le Conte mistook his No. 5 for *P. Floridanum*, Michx.

14. **P. confertum,** Le Conte.

The specimen to which this name is attached is evidently *P. purpurascens*, Ell. Mr. Durand recognized this and attached a ticket marked "resembling *P. purpurascens*, and I believe identical, E. D." On the same sheet is another specimen of the same species, ticketed "*P. purpurascens*, Ell., Georgia, Dr. Baldwin." Kunth gives both *P. purpurascens*, Ell., and *P. confertum*, Le Conte, as if they were distinct plants. Probably he did not see Le Conte's specimens.

15. **P. distichum,** Linn.

I find no specimens with a ticket in Le Conte's writing, but there are in a sheet marked *P. distichum*, specimens noted as coming from Le Conte, and others, Georgia, Baldwin. The description of Le Conte seems to refer to *P. distichum*, Linn., but at the end he gives, as a synonym, *Digitaria paspalodes*, Michx., which is understood by Elliott and by Dr. Chapman as applying to *Paspalum Digitaria*, Poir, which seems not to have been known to Le Conte, unless he agreed with Elliott in referring it to the genus *Milium*, in which case it would not appear in a revision of *Paspalum*.

16. **P. tristachyum,** Le Conte.

The specimen bearing this name is apparently a three-spiked form of *P. vaginatum*, Swz. The description also conforms to that species, and Mr. Le Conte adds the remark, " Refert prius sed primo obtuto facile distinguitur, foliis angustis glaberrimus. Habitat in subsalsis, Georgia."

Mr. Bentham considers *P. vaginatum*, Swz., as synonymous with *P. distichum*, Linn., but the two are well defined by Le Conte, and I think are clearly distinct, although with poor or imperfect specimens it is not always easy to discriminate. Although this species commonly has but two spikes, it sometimes occurs with three.

17. **P. membranaceum,** Walt.

I find no specimen of this species with Le Conte's ticket, but from the description, and the reference to *P. vaginatum*, Ell., it is pretty clearly the *P. Walterianum*, Schultes.

18. **P. natans,** Le Conte.

I find no specimen with Le Conte's ticket, but from the description and reference to *P. mucronatum*, Muhl., and the additional notes, it can hardly be doubted that this is the *P. fluitans*, Walt. (*Ceresia fluitans*, Ell.).

Mr. Le Conte undoubtedly observed and collected many of the species of *Paspalum* in Georgia, where he spent many years of his early life ; he was also acquainted with Baldwin and Elliott. The latter had already published the earlier numbers of his " Sketch of the Botany of S. Carolina " before the appearance of Le Conte's Monograph, and Elliott is referred to in Le Conte's *Paspalum*, No. 17. Reference is several times made to Pursh and Muhlenberg, whose works had been published but a short time. Michaux described seven species of *Paspalum*, all of which are referred to by Le Conte. Muhlenberg describes ten species, including two to which he gave numbers without specific names, and to these Le Conte makes reference, No. 7 under his *P. difforme*, and No. 8 under his *P. gracile*, but a comparison of the descriptions does not afford much satisfaction. Elliott described eleven species of *Paspalum*, or thirteen, if we include his *Milium paspalodes* and *Ceresia fluitans*. The monograph of Le Conte enumerates eighteen species, of which four or five had not been previously described and may be counted new species or varieties. All these are indigenous to the Atlantic States; the additional ones of the Southwest had not, probably, been collected at the time of this monograph.

JULY 6.

Mr. USELMA C. SMITH in the chair.

Seven persons present.

JULY 13.

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

Ten persons present.

On Torsion in the Hollyhock, with some observations on cross-fertilization.—Mr. MEEHAN observed that the torsion of the opening flowers of the hollyhock was towards the sun; but after the expanded flower had become fertilized, and the flower closed for fading, the torsion was in the contrary direction. The same thing occurred in *Hibiscus rosa-sinensis.* He had no opportunity to this date to note the facts in other *Malvaceæ.*[1] As a general rule the spiral revolutions of plants are uniform through every stage of growth, at least this is the general teaching of botanists. Prof. Goodale notes ("Bot. Text Book," vol. ii, p. 407), that in the Tropics, some plants twine indifferently from right to left. If we had given thought to the manner in which secund inflorescence is arranged, we might have seen that the torsion is anything but uniform throughout the same plant, for a secund raceme could only be formed by the twisting of each succeeding flower in an opposite direction. This alternation of convolution is indeed necessary in a branch with a horizontal direction in order that each flower along the spiral should assume an erect attitude. When a horizontal or geotropic branch assumed an upright position, the inflorescence was necessarily secund. One might almost infer that secund inflorescence had its origin in geotropic plants which had retained the power of alternate torsion after assuming the erect form. So little is known of the laws operating in connection with the turning habits of plants and flowers, that every fact is of value, and this one relating to the reversal of the direction in these two malvaceous plants, and probably in others of the same order, must be worth placing on record.

Mr. Meehan further noted that the hollyhock, notwithstanding its gaudy coloring and general attractions to insects, is a self-fertilizer, and that insects rather aided than otherwise in this

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[1] The author has since noted that in *Palava flexuosa* the flower twists also in the direction of the sun, and in the contrary direction when fading, but in *Callirhœa involucrata* the flower is twisted against the sun, when fading as when opening.

self-fertilization. The flower is strongly proterandrous. The stamens are mature and shed their pollen co-incident with the expansion of the corolla. The fasciculus of pistils at this time, have not reached half their growth, and is completely covered by the stamens, which form a dense mass in the centre of the flower. During the day, and the one succeeding, humble and honey bees make this crown of stamens their resting-place. During these two days the pistils have not yet thrust their stigmas above the stamens that crown them. If now we cut a flower through longitudinally, we shall find that a very large quantity of pollen has fallen down within the bundle of pistils—this gathering of pollen being evidently aided by the feet of insects that made a landing-place of the staminal crown. Up to this time, however, the pistils not having come to maturity, the pollen thrust in among them would have no physiological significance. But on the morning of the third day, the pistils protrude and are in receptive condition, and they bring up with them large quantities of pollen, so completely covering the surface of each pistil that it would seem almost impossible for any grains of foreign pollen to find any lodgment for effective use; and though a grain of foreign pollen should get an opportunity to perform its function, it must be evident that the flower's own pollen has the earliest opportunities for usefulness, and must in almost every case be the fertilizing agent. An interesting note may be here recorded in reference to the power of own-pollen over fertility. Mr. Darwin in his "Cross- and Self-Fertilization," page 141, referring to his single experiment among malvaceous plants, *Hibiscus Africanus*, found a larger number of crossed flowers produced capsules than among the self-fertilizing ones; but in the case of these evidently self-fertilized flowers, no one seemed to fail in producing seed—every pistil, indeed, producing a perfectly fertile carpel. At the end of the third day the flowers closed, twisting in the opposite direction, as already noted.

On Projection of Pollen in the Flowers of Indigofera.—Exhibiting some flowers of *Indigofera Dosua*, Mr. MEEHAN remarked that the peculiar bending back of the carina in the flowers of Indigofera has been long known. Referring to the whole genus, Don, in the *General History of Dichlamydeous Plants*, published in 1837, says, "Keel furnished with a subulate spur on both sides, at length usually bending back elastically." In 1863 Decandolle and Treviranus, in *Botanische Zeitung*, page 3, refer to this bending back of the keel and say it is not an elastic motion, but simply a falling down on the full development of the flower; and the latter remarks, as quoted by Henslow, that "all these movements occur in the natural development of the parts, and only after self-fecundation takes place." Dr. Hildebrand, in the same magazine for 1866, seems to admit that finally the keel will fall dow from sheer maturity, but thinks insects in the search for honey may anticipate this natural development. The Rev. Geo. Henslow, in the ix vol. (1868) of the *Journal of the Linnæan Society*, page 357, commenting on these statements, suggests that though self-impregnation may be possible, the jerkings of the stamens when the carina falls away, causes the pollen to scatter over the insects, which then carry the pollen to other flowers. In the x vol. (1869), p. 468, he notes that when the carina is liberated it falls back with a jerk, as noted by Don, and that the stamens fly up and closely press the vexillum. But no opportunity occurred to him of observing what insects effected this process which he accomplished artificially. In Mr. Meehan's grounds the East Indian *Indigofera Dosua* is a hardy shrub, and for the past two years, he said, he had watched the behavior of the flowers, and the insects that visited them. The carina is arched and hooded, and extends so far over the apex of the stigma, against which it presses, that both the stigma and column of stamens are borne down to a right angle with the vexillum. The effort of the stamens and pistil to rise, and of the carina to recurve, keeps these portions in an exactly horizontal position. The anthers burst while thus enclosed in the carina, but the pollen does not escape, nor does it reach the stigma, for the pistil extends beyond the anthers, and its apex is pressed strongly against the carina, and no pollen can possibly reach the apex. The two wings of the flower are caught in the subulate spurs, and are borne down to the horizontal plane with the carina, and together form a level platform on which insects in search of honey alight. Humble-bees, honey-bees, and numerous species of sand wasps visit the flowers, but in no instance was an insect's visit found to be effectual in liberating the stamens and pistil from the grasp of the carina. This was only accomplished by slitting the upper portion of the carina with a penknife. Then the divided carina would instantaneously fall back, and the stamens and pistil jerk upwards, scattering a little cloud of pollen in every direction. In some cases pollen so scattered would light on a stigma, but in many cases the pollen would be so completely projected that none could be traced to the stigma, and these probably received pollen from the upper flowers where they in turn projected their pollen. Possibly many were by this time too mature to profit by the pollen they received, at any rate only a very small proportion of the flowers matured seed vessels. In the older flowers, the carina evidently became separated from the stamens and pistil only when withering away.

Mr. Meehan remarked in conclusion, that, as noted by authors quoted, so far as his observations in this part of the world (Philadelphia) with this single species goes, the behavior of the flowers were neither favorable to self-fertilization nor cross-fertilization. If insects had pollen scattered on them, there is no way by which it could be communicated to the pistils of other flowers. The stamens were not liberated naturally till the flower had lost all attractions for insects, and the act of liberating and scattering the pollen gave the pistil its first chance for pollinization. The great probability is that in the majority of instances the flowers are self-fertilized.

On Parallelism in Distinct Lines of Evolution.—Exhibiting some oak and chestnut leaves, Mr. MEEHAN remarked that the fact and the theory of evolution are distinct lines of thought. There seems no difficulty about the fact. That one form may and has been born of a pre-existing, and often very distinct form, cannot be disputed. What induces this change is another matter. It is here that science desires more light. A popular belief is that change of circumstances leads to change of form. This theory is embodied under the word "environment." In other words, plants, in their changes, are the "creatures of circumstances." In some sense this must be true. A seed will not sprout unless there be a necessary "environment" of heat and moisture, but this is not the sense in which "environment," as the term is here used, is generally understood. If one were to say that under a torrid temperature, endured for ages, a light-skinned, fair-haired Caucasian, might have descendents that were like woolly-headed, dark-skinned negroes, it would come nearer the general understanding of the term "environment," than some would limit it to. The speaker's observations and studies had led him to what might, perhaps, be regarded as the minority view. Circumstances—"environment"—seemed to have no further influence than to incite to action a change already ripe for development. In a paper read before the *American Association for the Advancement of Science*, 1874 (*See Proceedings Hartford Meeting*, p. 6, *Natural History*), he presented a number of facts to show that "change by gradual modification is not the universal law." New forms "jumped" into existence, and frequently these new forms were diverse from each other, under precisely the same "environment" so far as human knowledge had yet reached, as had been the surrounding circumstances of the parent form. Since that time he had contributed numerous observations to the *Proceedings of the Academy* and elsewhere, confirming these views.

To-night he would offer to the Academy some thoughts in a new line, but confirmatory of the same views. He exhibited some different forms of the American *Quercus Prinus*—the chestnut oaks, and a dwarf species from China, *Quercus Chinensis* of Bunge. Also some specimens of various forms of *Castanea Vesca*—the chestnut, and of *Castanea pumila, Mx.*, the chinquapin. It would be conceded by any evolutionist conversant with plant forms, that the chestnut and the oak are not remotely descended from the same parent. We may suppose, for the sake of argument, that "use or disuse," or some other item in the general catalogue of "environment" had affected some portion of the structure of the original parent, and resulted in a slight modification, leading towards an ultimate oak or a chestnut, as the case may have been. But when we take the subsequent changes—the evolution of the species of oak, and the species of chestnut, each class from its primordial oak or chestnut, and observe the same parallel lines of change in each, it is difficult to conceive how this exact parallelism could have come about except under a fixed law of change, which provides that when changes occur they shall be in strict accordance with a prior plan by which nature herself is bound—laws by which, if we could only ascertain them, we could ourselves foresee and define the forms that are yet to be a thousand years beyond our time, and which no mere accidents of environment could alter or delay.

The oaks exhibited, though when we have the fruit we can see they are oaks, have the foliage so like the chestnut that it is difficult to determine them. The dwarf species from China is so nearly like a chestnut, that only by the absence of the setaceous teeth that edge the chestnut leaf, can we see any difference. But the leaves are of a thicker texture than the other chestnut oaks—the serratures are finer and closer together, and the undersurface of the leaf is cinereous, while the chestnut oaks exhibited in comparison are of the same tint on both sides.

Now we take the chestnuts. We have the larger growing species as we have the larger growing chestnut oaks—the leaves are light green on both sides, and vary in the toothing, just as the chestnut oaks do—variation in each class is exactly parallel. The parallelism extends to the formation of a dwarf species. We have a dwarf chestnut, *Castanea pumila*, just as we have a dwarf chestnut oak, *Quercus chinensis*, and the parallelism extends to the sub-characters, for the dwarf chestnut, the chinquapin, has leaves of a thicker texture, the serratures are finer, and the undersurface of the leaf is cinereous, while the chestnuts exhibited are of the same tint on both sides.

Mr. Meehan finally remarked that the facts seemed to him stronger arguments in favor of evolution than many usually offered. That the changes in two very distinct genera that we only assumed to be syngenital, should be so nearly of a parallel character in each, is proof they were carrying out a plan originally common to both. While the fact that these original provisions, as we must regard them, for these special forms have been so faithfully carried out—the one on the American continent, the other in Eastern Asia—despite the varying conditions of mere "environment," shows how light a factor external circumstances are in the evolution of forms.

JULY 20.

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

Thirteen persons present.

JULY 27.

Dr. J. BERNARD BRINTON in the chair.

Thirteen persons present.

A paper entitled "History and Biology of Pear Blight," by J. C. Arthur, was presented for publication.

AUGUST 3.

Mr. THOS. MEEHAN, Vice-President, in the Chair.

Eleven persons present.

Oriskany Sandstone in Lycoming Co., Pa.—Mr. LEWIS WOOLMAN remarked that, accompanied by a resident of Lycoming Co., Pa., he had recently made a tour through that and the adjoining county of Sullivan, with an eye to the geological features of the region, using as a guide the most recent publications of the Second Survey. In Hand Atlas X, the Oriskany formation is omitted from the map of Lycoming County, while the text speaks of it as "being absent." It is also omitted from the larger map accompanying the Second Survey. He was, therefore, surprised to find on the roadside, at the village of Pennsville, Muncy Township, blocks of the sandstone, containing its characteristic fossils.

Further examination resulted in finding a belt of this formation; not, however, making the bold, elevated ridge it so often does elsewhere in the State, but existing as a prominence upon the lower slope of the hill that rises from the north side of the village, the ascent beyond being over the lower members of the Hamilton group. Time at command being limited, the formation was traced only about a mile, but without finding it to disappear. The Friends' meeting house at one end of the village, and the schoolhouse at the other end, both stand upon this ridge. The former has its corners pointed with this sandstone, from an old quarry in sight, while all around the latter are strewn weather-worn fragments, beautifully exhibiting the fossils. Several of the houses and barns intermediate are also situated upon this formation, and for some of these it has furnished building material.

The location of the belt is within the area shown on the maps as Hamilton, and a few hundred feet from the division there marked as separating that group from the Lower Helderberg. Along the lawn leading to the country residence of William Ellicott, the rock was seen in place, pointing upward over the anticlinal forming Bald Eagle Mountain. A letter from his companion states that he has since found this rock upon the other side of the mountain, in Clinton township.

Upon careful comparison of fossils in fragments brought home, the following were identified as exactly agreeing with those figured by Hall, from the Oriskany of New York, viz.: *Spirifer arenosus*, *Spirifer arrectus* and *Rensselaeria ovoides*.

AUGUST 10.

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

Fifteen persons present.

Notes on Lilium tigrinum, Gaul.—Mr. MEEHAN remarked that on the 7th of August he was attracted by the large number of honey bees (Italian) among the flowers of *Lilium tigrinum*. There were hundreds of flowers, and every flower had from one to six bees in them. They were not coming and going with the usual expedition of honey-seeking or pollen-collecting workers, but were taking things leisurely, as when feasting on a ripe peach, or some other soft, sweet, and spongy fruit. It was found that they were feeding or sucking the juices from the papillæ that form a ridge at the base of each division of the perianth. These papillæ are very numerous, minute and transparent, under a lens resembling ice crystals. They are formed in two lines, but approximate till they resemble a single gray line, extending from the base upwards for an inch in the centre of the segment. Several species of butterflies—notably some large Papilios, and some smaller Eudasmias, were sharing the repast with the bees. An examination showed that the papillæ had been pretty well "chewed" up—the term "chewing" being used notwithstanding the seeming impossibility from the structure of the bee's mouth, that it can chew in the ordinary acceptation of the term. A quantity of this papillose matter, gathered together on the point of a penknife, did not indicate any sweetness, or anything beyond moisture that would be popularly supposed to prove attractive to bees. Inside a flower just ready to expand, a considerable amount of moisture is excreted from the surface of the perianth. In this liquid no sweetness, but some slight astringency could be detected. Not even at the base, where in flowers nectar is usually secreted, could any sweetness be detected. It has been broadly stated that color and fragrance are of use to flowers only as they may serve to attract insects for purposes of pollinization; and that gaudy flowers have no fragrance. But some gaudy lilies are very sweet, and here we have a gaudy flowered species that seems to have nothing in the way of sweets after an insect has been attracted. Though feasting on the cellular matter, the bees in no way assist in pollination. It is difficult to imagine what relation the bees can have to any good economy in plant life in this instance. The plant produces no fruit in this part of the world; but this is evidently from some failure of nutrition, for when it is served with its own pollen, or the pollen of other plants or other species, it is alike barren.

At pages 412, 413 in the *Proceedings of the Academy* for 1875, he had called attention to the fact that in many species of lily, where the flower is cernuous, the point of bending straightened after fertilization; and the ovarium, pendulous in flower, became erect. There are some in which the flowers are always erect, and they seem to be just as successful in their several economies, as those that are at first cernuous, and afterward erect. At that time, with this reflection, it seemed to him reasonable to suppose that the bending down of the flowers in some species was not a matter of choice with the flower—if one might metaphorically use this expression—but was the result of a curving of the stem made for some other reason in plant economy than for good to the flower or its special objects alone. But here were some specimens of *Lilium tigrinum* that had blown over when young. The pedicles from these stems went straight down towards the earth and bore the expanded flower without the slightest curve. The flowers on the erect stems are all on recurved pedicels. Though we are still without light as to what advantage the recurved forms gain over the erect ones, this little incident teaches us, at least, that it is the flower that demands the curve, and not a case of a curve demanding a pendulous flower.

Fishing Lines and Ligatures from the Silk-glands of Lepidopterous Larvæ.—A communication was received from Miss Adele M. Fielde, stating that in the locality from which she wrote, Swatow, China, the silk-glands are taken from the larvæ of several species of large lepidopterous insects just before they enter the pupa stage, and are made into fishing lines. At this period in the life-history of the insect, the glands are full of the viscid white substance from which the cocoon is to be spun. The silk-glands of a species of *Atlas* were found to be one yard long, a tenth of an inch in diameter at the free, posterior end, and a hundredth of an inch in diameter at its anterior end. The two glands extend nearly the whole length of the body cavity, on either side of the alimentary canal, lying in loops of varying length, and uniting in a single duct under the mouth, as in the silk-worm, *Bombyx mori*. The Chinese make a transverse cut across the back of the caterpillar, take hold of one of the loops of the silk-gland, draw it out entire, drop it in vinegar to take off its external coat, then stretch it to double or treble its original length, and dry it. A durable filament is thus formed, strong as catgut, and much cheaper. The tenacity of the filament is constantly restored by soaking it for a few minutes in warm rice-water, that is, in the water in which rice has been boiled for food. The fishermen say that when thus prepared a line will hold the largest fish taken on the coast. It was found, however, that a single filament would not sustain more than four and a half pounds. Dr. Causland, in charge of the Hospital in the English Presbyterian Mission at Swatow, had successfully used these filaments for tying arteries in surgical operations. It was suggested that the cocoon-spinning lepidoptera of the United States might furnish in their silk-glands, for the joining of wounds, a thread which would have all the virtues of spun silk, without its objectionable traits. Silk-worms have been successfully reared in the neighborhood of Swatow, on lettuce, the silk from such caterpillars being coarser than that from those fed on mulberry leaves.

AUGUST 17.

Mr. CHARLES MORRIS in the chair.

Twelve persons present.

On the Effect of Scorpion Stings.—The following communication was read from Mr. EDW. H. THOMPSON, United States Consul at Merida, Province of Yucatan:—

"I am advised of an interesting letter from Dr. Gonzalez, of Durango, read by Dr. Leidy before the Academy, in which mention was made of the extremely venomous character of the Mexican Scorpion.

"I would state that while many cases of scorpion stings have occurred within the range of my personal observation, I have yet to record one that has even approached a fatal termination. During the month of January last, while exploring some of the ruined cities of the interior, two of my men, native Mayas, were stung by scorpions dislodged from the ruined walls, one receiving a sting upon his shoulder, while the other was punctured directly upon his naked back, and very close to the spine.

"The man receiving the sting upon his shoulder was soon relieved by a few applications of strong ammonia. The other complained for some time of a numbness almost approaching paralysis. This feeling, however, was not sufficient to prevent him from keeping upon his horse. After I had applied the ammonia, and when at the end of a hard day's ride we dismounted, he had practically recovered.

"Of thirteen cases noted by me within a short while, but two were of a serious nature. One was the case of my native boy, and the other was that of a young Englishman who, stung upon the thumb, remained in an almost paralyzed state for several hours, eventually recovering. It may be well to state, in relation to this case, that the young man had been in the country but a short while, and was at the time exhibiting the physical effects of such a radical change of climate.

" In making the above statements I do not wish it to be understood that I impugn the truth of the statements of Dr. Gonzalez. Durango and Yucatan are two States in the Mexican Republic widely separate, and circumstances governing as facts in the one may not so govern in the other."

The Form of the Pupil in Snakes.—Mr. LOCKINGTON stated that amongst the colubriform snakes, the Boidæ, a family which has its headquarters in South America, and has representatives in the West of this country, have elliptical vertical pupils, like those of rattlesnakes. At least, this is the case with *Boa constrictor*, *B. eques*, *Eunectes murinus* (the anaconda), *Xiphosoma caninum, and Xomolochirus multisectus.* The Acrochordidæ, or wart-snakes of eastern Asia, have circular pupils. The venomous snakes with fixed fangs are usually classed in three families: Elapidæ, Naiidæ, or cobras, and Hydrophidæ, or sea-snakes. Some herpetologists unite the first two families. As far as the shape of the pupil goes, they seem to agree. *Naja tripudians*, the cobra, *Naja haje*, the African asp, *Pseudechis porphyriacus*, *Sipedon hæmachates*, have circular pupils, as well as the species of *Bungarus* and *Elaps.* The sea-snakes, so far as examined, have circular pupils. This is the case with the common and well-known *Pelamys bicolor*, with *Hydrophis palamidoides*, *H. gracilis*, *H. nigrocinctus*, *Disteira dumerilii*, and *Platurus fasciatus.*

Among the snakes with movable fangs, the Crotalidæ (rattlesnakes), and among the Viperidæ, examples of the genera *Clothe*, *Pelias*, *Vipera* and *Cerastes*, have elliptical pupils, but *Causus rhombeatus* (Causidæ) has rounded ones. It is thus evident that the form of the pupil has no relation to the venomous or non-venomous character of the snake.

AUGUST 24.

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

Nine persons present.

A paper entitled "On the Fertilization of Cassia Marylandica," by Thomas Meehan, was presented for publication.

The death of Wm. R. Cruice, M. D., a member, August 15, 1886, was announced.

AUGUST 31.

The President, Dr. JOS. LEIDY, in the chair.

Fifteen persons present.

The death of Roger Sherman, a member, was announced.

C. L. Kilburn was elected a member.

The following were ordered to be printed:

REVERSE VISION.

BY CHARLES MORRIS.

The fact that we perceive objects in their correct position, while their impression upon the retina is a reversed one, forms a problem which has given rise to much speculation, often unprofitably metaphysical, in the effort to explain it. None of these theories of the older writers now remain current. More modern authors give explanations which are little more satisfactory. Giraud Teulon says: "The retina sees or localizes objects where they are; that is what we call 'erect;' if the picture be reversed it is a mere matter of geometry." Helmholtz says: "Our natural consciousness is completely ignorant even of the existence of the retina and of the formation of images; how should it know anything of the position of images formed upon it?" It cannot be claimed that these remarks are explanations, and we may proceed to the more elaborate theory advanced by LeConte, in his work on "Sight." He remarks that "the retinal image impresses the retina in a definite way. This impression is then conveyed by the optic nerve to the brain, and determines changes there. . . . And then the brain or the mind refers or projects the impression outward into space as an external image, the sign or facsimile of an object producing it." He proceeds: "The law may be thus stated: *When the rays from any radiant strike the retina, the impression is referred back along the ray line (central ray of the pencil) into space, and therefore to its proper place.*"

It cannot be said that his arguments are sufficient to establish this theory. That we mentally refer an impression to the nerve extremity that received it is unquestionable, and where a limb has been lost, impressions seem to be referred to the location of the original nerve termination. But this is very probably a result of long-continued hereditary influences, through which each nerve becomes adapted to give a mental picture of the location of its impressions, and continues to do so even if touched at some intermediate point. In the case of sight, no localized reference to the nerve extremity exists. In this sense the source of our impression seems external to the body. And yet this is in all probability equally a result of hereditary accommodation.

What we really perceive is the impression produced upon the retina, which is transmitted by the optic nerve to the brain. The theory that the brain or mind, by some secondary action, physically refers this sensation back again to the nerve extremities, or even projects it beyond them into space, along reversed lines, has no warrant in known physiological facts. Far more probably the seeming projection is a mental action only. Natural selection may have adapted each nerve to yield a sense of the distance and direction of its impressions and, therefore, of their external location. An animal destitute of such sense would be unable to estimate the exact point of a threatened danger, and only those capable of localizing their sense impressions could survive. Yet if the brain estimates the distance from which any sensation comes only through conditions hereditarily existing in the transmitting nerve, the idea of referred sensations, with all theories based upon it, falls to the ground. The reference of a pain to the natural location of an amputated foot would form a constituent portion of the impression conveyed to the brain by the nerve which formerly passed to that foot. In like manner the optic nerve may, among its hereditarily-gained powers, have that of referring its impressions to a point beyond the nerve extremity—or in external space, the locality from which danger from visible objects comes. But this would have no bearing upon the question of the character of its impression, the retinal image as a whole being mentally transferred to an external region, but in no sense changed in character. The question seems to be solely one of a certain power or strength possessed by the nerves, through which each of them indicates that location of its impressions best adapted to the efficiency of protective activity. In the case of sight this distance would necessarily be beyond the actual position of the retina, and external to the body. The same rule holds good in the case of sound. In every case it is very probably a resultant of long-continued natural selection.

We do not actually see objects. We simply perceive the images of them which are impressed upon the retina. This stands as a picture-plane between our mind and the universe. We perceive the impressions with which it is affected—incorrectly, if this affection is in any sense an incorrect one. But the conception gained from these impressions is subject to mental accommodations, the result of experience and of hereditary influences; and we may, therefore, gain a correct idea from an impression which is physically incorrect.

Though the retinal image seems to be referred by the optic nerve to a position external to the eye, yet it is certainly not exactly located by the sense of sight, and the mental accommodations above mentioned are the locating influences. It is said that to a blind man suddenly restored to sight, the surrounding objects seem like the details of a picture, and within easy reach. He appears to see the retinal picture, somewhat projected, but with no correction except that the reversal of the image does not appear. Our perception of roundness or solidity is, then, a result of experience. This is followed by a knowledge of relative distance, comparative location being one of the most apparent relations between objects. But the actual distance of objects which are somewhat removed from the body is learned by experience, aided by several of the senses. Of more distant objects, we seldom properly estimate the actual distance. All this, however, is a result of the action of the reasoning powers, guided by the senses. The evidence of the blind man assures us that what we actually see is the retinal image, somewhat projected into space, and differing from an ordinary picture mainly in that it is perfect in its lights and shades, and thus forcibly tends to produce that illusion of solidity which is the effect sought in all pictures. The only correction is that of the reversal of the image. This correction, therefore, seems a natural one, inherent in the sense or the mind.

In attempting an explanation of this phenomenon, in view of the considerations above taken, the question may be asked: In what way can the mind discover that there is anything incorrect in the direction of the retinal image? To do so it must have some standard of direction with which the impressions upon the retina can be compared, and their agreement or disagreement observed. If there be any such standard, it must exist in one of three locations: on the retina itself, in external nature, or in the mind. If on the retina, it could only be some line, or group of lines, apparent to sight, and serving as directive guides with which to compare retinal impressions. It need not be said that nothing of the kind exists.

The standard of comparison, therefore, by whose aid alone we can discover that the retinal image is reversed, if it exists, must do so either in the mind or in external nature. If it be internal, it must be of the nature of an idea—an innate sense of absolute direction, a mental power by which we can at once distinguish the truth or falsity of any apparent direction. That we have any such idea of the absolute, is in itself highly improbable. It may, in fact, be readily disproved. We are aware that the revolution of the earth on its axis reverses the absolute direction of all the objects upon its surface every twelve hours. And yet this reversal is not perceptible to us. The direction of all objects, as related to that of our bodies, remains unchanged, and this relation is all that we perceive. Indeed, we must have remained forever ignorant of the revolution of the earth but from the fact that the spheres of space do not revolve with it. These retain their positions in space, while those of all objects upon the earth change. They, therefore, serve us as standards of comparison by whose aid we intellectually discover the earth's motion. We never become sensibly aware of it, for the only motion apparent to us is that of the spheres of space. We impute motion to objects at rest, and rest to objects in motion. This error could not arise, had we any innate idea of absolute direction, or an internal standard of comparison. Therefore the mind in itself is incapable of perceiving that there has been a reversal of the retinal image. It has no faculty of deciding on questions of direction, and what is relatively correct is absolutely correct to its perceptive powers.

If we have no internal or retinal standard of direction, have we any external one? No object upon the earth's surface will serve this purpose. The images of all objects alike are reversed upon the retina. The same is the case in regard to the spheres of space. They do not retain their true positions in this case, as in the former case considered, but are reversed in direction, and the whole universe is turned upside down by the crystalline lens of the eye, and is perceived by the mind thus reversed. Though nothing is absolutely correct, everything is relatively correct in direction, and we have no guide to teach us that such a reversal has taken place.

The fact is that in this, as in the other case, we involuntarily take our body as the measuring rod of the universe. Distance is at first estimated by the length of the arm, dimension by the spread of the fingers and the sweep of the arm, and direction by that of the body. Our knowledge that the retinal image is reversed is not gained by perception, but by our study of the laws of optics. We conceive of a picture upon the retina whose direction is reverse to that of the body, and are puzzled to understand why the mind does not perceive it thus reversed. In this we are comparing sensations with ideas. The image of the body is also reversed upon the retina, and thus its direction, as optically recognized, agrees with that of all other objects. Our accepted standard of direction therefore fails us in this particular. The universe, as perceived by the mind through the medium of the eye, is relatively in harmony in all its particulars of direction and position, and unless the mind had some innate conception of absolute direction, it would be impossible for it to discover that a reversal of the image had taken place. We have already shown that it has no such innate ideas of direction, and is entirely dependent upon its perceptions in this particular. The body, our accepted standard of direction, is perceived to be erect as compared with our perception of the earth's surface. All other objects upon this surface bear the same relation to it, and we have no means of discovering that we are optically deceived, except by a secondary process of reasoning, based upon the laws of optics. No tree, for instance, could seem to us upside down unless the earth's surface seemed upside down, which is impossible.

The mystery in which this question has been so long involved, therefore, vanishes when considered from this point of view. The mind fails to discover that its optical image is reversed simply from the fact that this reversal includes all things, nothing retaining its erect position to serve as a standard of comparison, and from the second fact that the mind has no innate idea of direction to make it aware of its error. There is no error in our perception. Relatively it is in every particular correct, and of the absolute we have no knowledge except through the process of reasoning.[1]

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[1] Since forming these theoretical views, the writer has become aware that the same theory has been previously presented. Dr. William Mackenzie—"Physiology of Vision," London, 1841—says: "In the image on the retina, the relative position of the parts of the object remain unchanged, as well as its relations to surrounding objects. The images of all objects, even those of our own bodies, are equally inverted on the retina, and therefore maintain the same relative position. Even the image of our hand,

while used in touch, is inverted. Hence, the notion is evidently absurd, that infants at first see objects upside down, and learn to see things in their proper positions, by comparing the erroneous information acquired by sight with the accurate information acquired by touch. Many of the lower animals manifest a perception of the true position of objects by means of the sense of sight from the very first, and before any experience derivable from touch can have had time to operate. To some philosophers, then, there appears no difficulty respecting erect vision, so long as all things equally, and not some objects only, are seen by means of impressions coincident with inverted images." He further says: "The mind neither views the images on the retina, nor is in any way conscious of their existence."

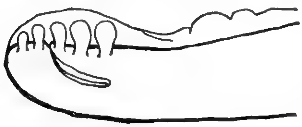
This theory is so identical with the one we have given, as to render the latter, in a considerable sense, a repetition. Yet Mackenzie's views do not seem well known, and are worth restating. Moreover, his theory is far from being fully argued out, and no theoretical views can be held as in any sense substantiated until they have been shown to be logically defensible. This we have attempted to do. The hypothesis we have given of the principle through which nerve impressions are mentally localized in position has, we believe, not been previously advanced, but is here first presented.

NOTICES OF NEMATOID WORMS.

BY PROF. JOSEPH LEIDY.

Filaria scapiceps.

Body cylindrical, nearly equally tapering at the ends. Cephalic extremity abruptly narrowing, cylindric, rounded at the summit and smooth. Mouth a terminal pore without labia, papillæ or inner armature. Caudal extremity of female nearly straight, conical, obtusely rounded, smooth, without appendages; of the male curved, conical, obtusely rounded alate and papillate; alæ half oval; papillæ five pairs, pyriform, successively decreasing to the last at the end of the tail. Genital aperture opening between the ante- and penultimate papillæ; penal spicules short, curved.



Side view of the caudal extremity of the male. 125 diameters.

Female 25 to 30 mm. long; 0·75 wide at middle; head 0·175 wide. Male 12 mm. long; 0·375 wide at middle.

Eight females and five males were obtained from beneath the skin of the hind foot of a rabbit, *Lepus sylvaticus.*

Filaria obtunsa.

Body cylindrical, nearly uniform; head conical, obtusely rounded, or rounded truncate, smooth; mouth a minute central pore, devoid of lips, papillæ, or internal armature; caudal end of female straight, conical, obtusely rounded, devoid of papillæ; of male abruptly narrowed, a length about equal to the breadth of the body, nipple-shaped, obtusely rounded and devoid of papillæ. Female genital aperture near the head end. Male aperture terminal; penis of a longer curved spicule and a spiral one of half the length.

Female 4 inches or more long, 0·625 mm. wide. Male 2 inches long, 0·5 mm. wide. Abundant in the visceral cavity of the snow bird, *Junco hyemalis.* = *Filaria obtusa*, Leidy, Pr. A. N. S., 1885, 10.

In the meadow lark, *Sturnella magna.* = *F. obtusa*, Ibidem. Chester Co., Pa. Obtained by Dr. B. H. Warren.

Many specimens from the visceral cavity of the meadow lark in the collection of the Army Medical Museum, Washington.

Female from $4\frac{1}{2}$ to $7\frac{1}{2}$ inches long, mostly to 6 inches; width 0·625 mm. Male $2\frac{1}{2}$ to $3\frac{1}{2}$ inches.

Four females and a male from the crow black bird, *Quiscalus purpureus.* They are proportionately more robust than the preceding. Female 4 inches long and 0·875 wide. Male $1\frac{1}{4}$ inches long and 0·5 mm. wide. Florida. Dr. B. H. Warren.

I at first viewed this species as the *Filaria obtusa*, Rudolphi (Diesing, Syst. Hel., ii, 267). The caudal extremity of the male, with its penal armature, accords with Dujardin's figure of that species (Helminthes, Pt. iii, fig. *j*, 2). In *F. obtunsa* I can detect no buccal armature such as exists in *F. obtusa*, according to Dujardin; and later, Molin (Versuch einer Monographie der Filarien, Sitzungsb. Wien. Akad. Wis., 1858, 397).

Filaria cirrura.

Body cylindrical, nearly equal, cephalic end conical, rounded truncate, smooth; mouth a minute funnel-like orifice without papillæ or interior armature; caudal end of female slightly curved or nearly straight, conical, obtusely rounded, without appendages; of male closely rolled inward, conical, blunt, without alæ or papillæ; penal spiculæ strongly curved, with the points projecting from the prominent genital aperture situated above the tail end.

Length of female 16 mm., breadth 0·5 mm. Length of male 10 mm., breadth 0·375 mm.

Four females and two males from the orbit of the jackdaw, *Quiscalus major.* Florida. Dr. B. H. Warren.

Filaria nodulosa. Rudolphi. Diesing, Syst. Hel., ii, 274.

Body cylindrical, nearly uniform, slightly more narrowed behind; head conical, obtusely rounded, with a circle of minute tubercles. Caudal extremity of the female straight, conical, obtuse; of the male slightly curved, obtuse; genital aperture a little in advance of the tail end; penal spicules short, curved.

Female 3 inches long, 1 mm. wide. Male $1\frac{1}{4}$ inches long, 0·5 mm. wide.

One of each sex from beneath the skin of the head and neck of a shrike, *Collurio ludovicianus.* Florida. Dr. B. H. Warren.

Filaria stigmatura.

Body filiform, nearly uniform cylindrical, but attenuated at the cephalic extremity; head rounded truncate, smooth; mouth large, bordered by two or three ? minute, conical papillæ, unarmed within; integument smooth throughout, not annulate. Female: caudal extremity straight, smooth; tail straight or slightly bent back from the distinct anal aperture, conical, blunt. Male: caudal extremity spirally enrolled two or three times, furnished with narrow band-like granular alae sustained by twelve pairs of ribs or cylindroid papillæ, of which seven pair are preanal; tail curved conical, subacute; penal spicules, one four times the length of the other.

Length of female 40 to 55 mm., breadth 0·5 mm.; tail 0·3 long. Length of male 24 to 30 mm.; breadth 0.375 mm.; tail 0·25 from genital aperture. Long penal spicule 0·88 mm.; short one 0·2 mm.

Pharynx cylindrical, 0·25 mm. long; œsophagus cylindrical, slightly expanded at lower end, 3 mm. long; intestine nearly same diameter. Eggs thick shelled, oval, 0·04 long, 0·024 broad.

A multitude of individuals obtained from the swimming bladder of the lake trout, *Salvelinus namaycush*. Lake Superior. Dr. James H. Bissel.

The species bears considerable resemblance to *Ancyracanthus cystidicola* (Rud, Schneider, Mon. d. Nematodon, 105), from a like position of *Salmo furio* of Europe, but it possesses distinct characters even generic. It also resembles *Filaria denticulata* (Ib. 102), but is devoid of the tegumentary spines and other characteristic marks of that species.

Filaria helecina. Molin, Sitzungsb. Wien. Akad. Wiss., 1858, xxviii, 391.
Filaria anhingæ. Wyman, Proc. Boston Soc. Nat. Hist., 1868, 100.
Eustrongylus. Packard, Hayden's Rep. U. S. Geol. Surv., 1873, 735.
Filaria Wymani. Leidy, Proc. A. N. S., 1882, 109.

Numerous additional specimens from the brain of a dozen individuals of *Plotus anhinga*. Florida. Dr. B. H. Warren.

Trichosomum tenuissimum. Diesing, Syst. Helm., ii, 256.

Body cylindrical, obtuse at both ends, viviparous. Four females, 7 lines long by 0·25 mm. thick. Intestine of the dove, *Zenaidura carolinensis*. From two birds. Florida. Dr. B. H. Warren.

? Monopetalonema eremita.

Body cylindrical, slightly narrowest anteriorly; head with an annular expansion of the integument, which is more dilated below; mouth with a pair of half-conical lips, divided into four papillæ at the apex; tail short, straight, conical, obtuse.

A single female 19 lines long and nearly 1 line thick at the middle. Obtained by Dr. J. Van A. Carter, from the masseter muscle of a badger, *Meles labradorica*, at Ft. Bridger, Wyoming.

The head and mouth have the characters of *Physaloptera*. Two apertures are visible in advance of the end of the tail, one at the distance of 0·25 mm., the other 0·625 mm.

Ascaris simplex. Rudolphi, Diesing, Syst Hel., ii, 155.

A large quantity, from the stomach of a dolphin, *Lagenorhynchus?* Pacific ocean. Dr. Wm. H. Jones, U. S. N.

Ascaris compar. Schrank, Diesing, Syst. Hel., ii, 170.

One male, 1¾ inches long. Intestine of the quail, *Ortyx virginianus*. Florida. Dr. B. H. Warren.

Ascaris vesicularis. Fröhlich, Diesing, Syst. Hel. ii, 148.

Two females and two males. Intestine of the quail, *Ortyx virginianus*. Florida. Dr. B. H. Warren.

Ascaris depressa. Rudolphi, Diesing, Syst. Hel., ii, 156. Intestine of *Strix nivea*, Leidy, Pr. A. N. S., 1858, 112.

Two females 2½ inches by 3 mm. Intestine of *Strix brachyotus*. Florida. One female 1¾ inches. *Bubo virginianus*. Chester Co., Pa. Dr. B. H. Warren.

Ascaris ensicaudata. Rudolphi, Diesing, Syst. Hel., ii, 184.

Labia large and prominent; apex of tail defined as a short ensiform appendage. Five females, to 3 inches long, by 1 mm. broad. Ejected from the mouth of a mocking bird, *Mimus polyglottus*. Jacob Geismer.

Ascaris microcephala. Rudolphi, Diesing, Syst. Hel., ii, 155.

Numerous specimens from the stomach of the night-heron, *Nyctiardea grisea*. Chester Co., Pa. G. W. Roberts, through Dr. B. H. Warren. Specimens from *Ardea herodias*, *Hydronassa tricolor* and *Botaurus mugitans*. Florida. Dr. Warren.

Ascaris spiculigera. Rudolphi, Diesing, Syst. Hel., ii, 157.

From *Graculus dilophus*, *Plotus anhinga*, *Pelicanus trachyrhynchus* and *P. fuscus*. Leidy, Proc. Acad. Nat. Sci., 1858, 110; 1882, 109. Numerous additional specimens from the former two birds. Florida. Dr. B. H. Warren.

Ascaris tenuicollis. Rudolphi, Diesing, Syst. Hel., ii, 160.

Numerous specimens, all females, up to 1½ inches long, and 2 mm. thick. From the *Alligator mississippiensis*.

Ascaris anoura. Dujardin, Diesing, Syst. Hel., ii, 161.

Numerous females, 3 and 4 inches long to 2 mm. thick. These were all suspended in the stomach, through double apertures of the mucous membrane, and thus tightly retained in position. From a snake, which, from the description, is supposed to be the milk-snake, *Ophibolus*. Obtained by Dr. James Bissell, in the vicinity of Harrisburg, Pa.

Ascaris penita.

Body cylindrical, tapering at the extremities, and most attenuated in front; mouth trilabiate. Tail of female, long, straight, conical, subulate; of male of same form, strongly curved, with the point brought near the genital aperture; provided at the posterior third with four pairs of papillæ. Penal spiculæ remarkably robust.

Length of female 5 to 7 lines, by ½ line in width; of male, to 5 lines, by 0·375 mm. in width. Numerous specimens from the intestine of *Trachemys scabra*. Generative aperture of the female at the posterior third of the body. Œsophagus long cylindrical, followed by an oval or spherical gizzard. Commencement of intestine dilated. Œsophagus 1·75 mm. long, by 0·125 wide; gizzard about 0·25. Tail of female 1·25 mm. long. Breadth of penal spicules 0·08 mm.

Physaloptera torquata.

Body cylindrical, most attenuated anteriorly; head with a conspicuous narrow annular fold or collar; mouth bilabiate, labia half conical with a pair of lateral papillæ and the apex provided with a group of four, of which one is external to the other. Tail short, conical, obtuse, recurved from the anal aperture.

Numerous specimens, all females, from 3 to 6 lines wide and one-fourth of a line thick. Worms all more or less spirally coiled. From the stomach of the badger, *Meles labradorica*.

Physaloptera turgida. Rudolphi, Diesing; Syst. Helm., ii, 233. Leidy, Pr. A. N. S., 1856, 53.

From stomach of the opossum, *Didelphis virginiana*. Collection of the Army Medical Museum, Washington. Also received from Dr. Benjamin Sharp.

Physaloptera abbreviata. Rudolphi, Diesing; Syst. Helm., ii, 235.

Numerous females from 3 to 8 lines, and three males about 2 lines. From the visceral cavity of *Phrynosoma regale*. Collection of the Army Medical Museum, Washington. Nose, mouth, and throat of *Phrynosoma hernandezi;* Sonora, Mexico. Dr. T. H. Streets.

Hedruris androphora. Nitzsch, Diesing; Syst. Hel., ii, 205.

Synplecta pendula Leidy, Pr. A. N. S., 1851, 210; 1856, 52. Diesing, Sitzungsb. Wien. Akad. Wis., xlii, 1861, 647.

Stomach of *Nanemys guttatus.*

Cuculanus roseus. Leidy, Pr. A. N. S., 1851, 155; 1856, 54.

Intestine of *Manouria fusca*, Java.

Tropidocerca certa.

? *Filaria dubia.* Leidy, Pr. A. N. S., 1856, 55.

Female subglobular, broader than long, divided into zones; tail abruptly projecting and conical. Male of the ordinary nematoid shape, cylindrical, most attenuated in front. Mouth trilabiate. Caudal extremity strongly rolled inwardly, sigmoid at the end, which is conical, recurved from the genital aperture, mucronate and alate; alæ half oval, narrowing to the end of the mucro, which is truncate. Female 7 mm. long by 7 and 8 mm. broad. Male 12 to 18 mm. long, and 0·375 to 0·5 wide. The specimens of this curious parasite were contained in two spherical cysts in the wall of the stomach of the albatross, *Diomedia exulans.* Each cyst contained a corpulent female with severally four and five males. Obtained by Dr. W. S. W. Ruschenberger.

ON THE FERTILIZATION OF CASSIA MARILANDICA.

BY THOMAS MEEHAN.

The relation of insects to flowers continues to be a question of profound interest. It has never been clear to my mind that insects are any material aid to plants through the pollinization which they often undoubtedly accomplish. There has been little to prove that in-and-in or close breeding is an injury; and it has been assumed that cross-breeding among plants must be a benefit, solely because arrangements for its accomplishment surely exist. I have shown in various papers (see chiefly *Proceedings of American Association for the Advancement of Science*, Detroit meeting), that in a scheme of nature for progressive development there must be provided arrangements for the removal of old as well as for the introduction of new forms, and from the facts adduced we have as much right to look on them in the light of agencies for removal as for the strength and preservation of a race. In my mind, the facts rather show that instead of any material aid to the propagation of the race being gained, the dependence of a plant on insect aid for fertilization is rather an indication that its race is nearly run, and that it is on the downward track in the order of nature.

The assumption that cross-fertilization is a factor in development instead of in degradation, has, I believe, been an injury to the study of the main question, as it has led to generalizations that cannot be sustained, and to assertions regarding facts that I think would not have been made had not the observers been prepossessed in favor of this hypothesis. The followers of those who have done so much to advance this branch of science, have gone much further in their speculations than those who first originated the line of thought; and even the leading minds in that path have often been the victims of an enthusiasm of which their cooler moments would not approve. Here and there we meet with statements by even such eminent naturalists as Darwin and Asa Gray, that would seem to sustain the wide genralizations of Grant Allen or Sir John Lubbock; but a careful study of their writings will show that they look on cross-fertilization as a fact, and as a measure of race utility, from a much more limited field than the supporters of the wider speculations seem to believe. It is not the most eminent writers who assert that "cross-fertilization is the general rule," "the greater number of flowers are cross-fertilized," etc. (see *Popular Science Review*, 1873), though the casual expression of Dr. Asa Gray, in his papers of 1877, that "many flowers freely self-fertilize," certainly might imply self-fertilizers to be a minority of the whole; but the same eminent botanist has also said "it is a common case that flowers cross-fertilize when duly served by insects or wind, and self-fertilize when not," and this by no means bears the impression that he regards self-fertilizing flowers as composing a particularly limited class. Indeed no one is more severe than Dr. Gray on theory-makers who run off in haste on one line of facts. The true sentiments of Dr. Gray are that "cross-fertilization, we may well believe, is a very risky affair," and in view thereof very few plants have become wholly dependent on this mode, but act on the rule to prefer cross-fertilization "if they can," but failing in this, to self-fertilize, "if they must," And, though it is not so generally understood, I think a careful study of Mr. Darwin's works will show that this is essentially his view also.

Though unwilling to concede that any material benefit comes to the races of plants from the aid which insects give to plants by cross-fertilization, the fact that some species are evidently wholly dependent on this agency for fertility, is no less interesting, and any original observations must have value to the student of this branch of science.

Cassia, in a general way, has been a subject of study. In 1875 Dr. Leggett writes (Bull. Torr. Club, p. 171) that Dr. Torrey had noticed the difficulty *Cassia nictitans* had in rejecting its pollen. Dr. Torrey believed, however, that though the anthers seemed to provide a pore at the apex for the emission of pollen, they finally slit longitudinally, and thus permitted the pollen to escape. Dr. Leggett does not seem satisfied of this. In 1882, however, Prof. J. E. Todd published some extremely interesting observations on this species, and on *Solanum rostratum*, which has a similar staminal arrangement (see *Am. Naturalist.* Ap. 1882, p. 281–287). *C. Marilandica* is referred to as one that would probably behave in the same way. Before noting what Mr. Todd saw in these, I will note the observations I have made on this species.

As nothing seems to have been placed on record in relation to

Cassia Marilandica, and I having a good opportunity for daily observation, I undertook its close investigation this year. In *Cassia Marilandica* the flower consists of five petals, as in other leguminosæ; but the two which usually unite and form the carina are here distinct and spread widely, taking the place apparently often occupied by the wing-petals. The two actual wing-petals are somewhat erect and lap under the upper or vexillum. This arrangement gives the flower a "somewhat two-lipped appearance." The style curves gradually, but more rapidly at the apex, curving there so much that the stigmatic surface can scarcely be closely examined without breaking the style. If the petals be opened just before the natural time for their expansion, a globule of liquid is pendant from the surface. The stamens are arranged in separate sets. There are three beneath the pistil—the two lateral ones are very strong and equal the pistil in length—the central one immediately beneath the pistil is as long as those on each side, but more slender. Immediately above the pistil are four stamens, with short, stout filaments, the anthers being perfectly formed, and nearly as long as in the lower set. Above are three petaloid stamens, which we can only see are staminal efforts, by noting the intermediate stages of the several parts between the stamens and petals. The only use for them seems to be to afford a good morphological lesson to the student.

The most interesting feature of this *Cassia* is that the stamens, not mono or diadelphous as in many leguminosæ, have long, black anthers, full of pollen, but which seem never to burst the anther cases. The only "opening is at the apex," and this "opening" is covered by a membrane—never opening, as I believe, except by insect agency.

As soon as the flower expands it is freely visited by humble bees, and, as their loaded thighs evidence, for the pollen. To collect this, they alight on the anthers of the long and lower stamens, as on a platform—make an opening in the apex of each of the four shorter ones, and then rifle them of their contents. I watched a mass of plants containing eighty-eight flower stems, on the 30th of July, and the same lot for an hour on 6th of August, but saw no attempt to get pollen from the longer anthers, or to use them in any way but as a platform. It would, indeed, be hardly possible for the bee to stand anywhere so as to get power to pierce the apical membranes of the longer stamens. When the flower matured, and the anthers were ready to fall, they were examined—the four short ones were empty sacs—the three lower ones proved they had not served any purpose to the bees, for they were full of pollen. There could be no doubt that, perfect and full of pollen as they were, they served no purpose that I could see either to the flower or to its insect visitors. Hive bees on honey-collecting expeditions hunted around among the base ot the petals, but were not, apparently, well rewarded for their work. No pollen could be detected on the stigmatic surface; but as about three out of every twelve flowers yielded a pod, they were evidently fertilized in some way. On the 30th of July I covered one panicle that had not yet opened a blossom, with a gauze bag twelve inches wide and eighteen inches deep, tied at the bottom to prevent ingress. Not one of these enclosed flowers produced a seed vessel, nor could I see that any one anther "opened at the apex." The membrane covered it as completely as it did in the unopened flower.

Now all these observations confirm those of Mr. Todd in the other plants except in the following particulars: As in my case, he found that the bees never attempted to collect pollen from the longer and lower anthers, but "by the movement of her feet the larger stamen is repeatedly sprung backward, and as often throws a cloud of pollen on one side of her body." I am sure no pollen was ejected in this way from *Cassia Marilandica*, for the membrane at the apex was not even ruptured when the stamens were ready to fall. In regard to the manner in which the pollen is extracted, he found that "this she does by seizing each anther near its base between her mandibles, and, with a sort of milking motion, crowds the pollen out of the terminal pore." If this were the general way there would be no necessity for any pollen being ejected from the long stamens, for the stigma would certainly receive some during the "milking" process; and the pore at the apex in the long anther is beyond the line of the stigma, so that on ejection from the pore the pollen would go still further beyond. At any rate I am satisfied that in this species the anther cases did not under my observation ultimately split longitudinally, as stated by Dr. Torrey in an allied species, nor was there any drawing out of the pollen, as observed by Prof. Todd. It is abstracted solely through the pores; and although I could see no evidence that such was actually the case, I suspect fertilization could only occur through some of this extracted pollen escaping from the insect to the stigma.

However, the fact was clearly demonstrated that *Cassia Marilandica*, in this experiment, does not produce a single seed, when the flowers are protected from the visits of insects.

This plant is the more interesting as it belongs to an order which the enthusiasts to whom I have referred, see "from its structure" to be so well "arranged for cross-fertilization," but which those who, like the following author, have followed results, see just the reverse. "To the casual observer of typical structures the papilionaceous plants must present the most difficult nut to crack for a student of cross-breeding. * * * As might be expected from the structure of the flowers, we have in these plants persistent examples of self-fertilization, and hence the constancy of garden varieties" (*Gard. Mag.*, Feb. 3, 1877).

SEPTEMBER 7.

Mr. CHARLES MORRIS in the chair.

Thirteen persons present.

SEPTEMBER 14.

The President, Dr. LEIDY, in the chair.

Thirty-four persons present.

SEPTEMBER 21.

Mr. JOHN H. REDFIELD in the chair.

Twenty-four persons present.

The death of Wm. P. Jenks, a member, was announced.

Chinese Women and Spiritism.—The following communication was read from Miss ADELE M. FIELDE:—In the eighth month of the year, early in autumn, when the full moon is worshipped; when the gods of grain are rewarded with gifts; when friends exchange many souvenirs; when the upper and nether worlds are thought to touch boundaries, then the Chinese women meet privately and fall into trances. Nearly all women are interested in these secret sessions, but many are prevented from being present by necessary occupations elsewhere, or by fear of rebuke from the men of their households. These conclaves are entered by women only, and are regarded by men with great disfavor. The women assemble in an apartment where they may be for a few hours secure from interruption. From three to a dozen or more gather around a table in the centre of the room. Incense-sticks, spirit-money and bamboo-roots, bought by a previous contribution of farthings, are distributed among all present. A fetich of some sort, a decayed splint hat, an old broom, a chopstick, or possibly a more uncleanly object, taken from a rubbish heap, is brought in, and spirit-money is burned before it, with obeisances. Then those who desire to fall into trance sit down at the table, throw a black cloth over the head, hold a sheet of spirit-money and a lighted incense-stick between the palms before the face, shut the eyes, and remain motionless and silent. Of the other women, some light incense-sticks and whirl them around the heads of the sitters; some rap constantly, gently and rapidly, with the bamboo-roots on the edge of the table; some chant invocations, petitioning the gods to admit these their children to their abode. Many and diverse incantations are iterated. One, given to me by a woman who appeared to be an expert, may be translated as follows:

Sister spirit, ghost of nun,	Spirit, spirit, come and reach
Body take by sharing one;	Hand to lead us; vouchsafe speech;
Two or three await thee here,	Be incarnate in us here;
Choose in which thou wilt appear.	Choose in whom thou wilt appear.

Two or three of the women, perhaps, fall into trance. Their doing so is indicated by their trembling violently, dropping the incense-sticks they were holding, beginning to beat the table with the palms of their hands, and to discourse incoherently. They speak of meeting their own lost friends, or those of other women who are present. They weep bitterly while they appear to converse with the dead. They describe streets, shops and houses and say that certain person are engaged in agriculture or trade. Sometimes they, by request, make inquiry concerning the whereabouts of a dead person, and then give the information that he has been born into the human family for the second time. Sometimes they report that a dead neighbor is shut up in Hades with nothing to eat but the salted flesh of the infant daughters she destroyed when she was alive.

Many women go to these meetings merely as observers; many more go in order to avail themselves of what they believe to be an opportunity to hear from dead relatives; a few go with the hope that they may themselves fall into trance, and see the spirit of some recently deceased friend. It is said that those who wish to enter Elysium and see the dwellings of the gods and geni, must make the attempt in the forenoon, while those who wish to visit lower spheres get admittance only in the afternoon.

As no pecuniary benefit accrues, directly or indirectly, to the actors in these scenes, there is less reason for suspectiug conscious deception than in the case of the public interpreters for the gods.

No foreign lady can get access to these sittings, and no native Christian woman is admitted to them. It is said that no one falls into the trance-state, if a Monotheist be within sight or hearing. My knowledge is gained wholly from a score of Chinese women, now my pupils, who in former years attended these sittings, and who have described to me the scenes of the eighth month.

Throughout the whole there is indication that the minds of the women are, during these trances, moving in customary grooves. They evidently see what they expect to see. The gardens of Elysium are laid out in Chinese style; the architecture of the buildings is Chinese; the punishments are those made familiar to the imagination by Buddhism and Tauism; the costumes, the implements, and the paraphernalia are such as are common in Swatow. These seekers after truth in the land of shades bring back no ideas save those which they took with them when starting on their quest; and this leads one to doubt, in spite of their disheveled hair, pallor and exhaustion, whether they have after all really been away from home.

At nightfall the supposed traveler is lured back by incantations, and then she slips slyly back into her accustomed duties, with no chance, for another whole year perhaps, to take a jaunt either with body or soul.

Swatow, China, August 1, 1886.

SEPTEMBER 28.

Mr. W. W. JEFFERIS in the chair.

Seventeen persons present.

The death of Charles Baeder, a member, was announced.

Richard H. Day was elected a member.

The following was ordered to be printed :—

HISTORY AND BIOLOGY OF PEAR BLIGHT.

BY J. C. ARTHUR.

To the American orchardist or nurseryman the name of pear blight, or fire blight, as it is often called, brings to mind a serious malady of fruit trees, which has been the theme of incessant discussion by horticultural writers and speakers since the earliest days of fruit culture in this country. The most marked features of the disease were admirably characterized by William Coxe[1] at the beginning of the present century, in the following words: "That species of blight which is sometimes called the fire blight, frequently destroys trees in the fullest apparent vigor and health, in a few hours, turning the leaves suddenly brown, as if they had passed through a hot flame, and causing a morbid matter to exude from the pores of the bark, of a black ferruginous appearance; this happens through the whole course of the warm season, more frequently in weather both hot and moist." The disease occurs from Canada and Minnesota on the north, to Georgia and Louisiana on the south, and from the eastern limit of the Rocky Mountains to the Atlantic ocean. No part of this vast extent of country is exempt, although it does not appear with the same frequency and power in all localities, and is usually rare in the immediate vicinity of the sea-coast.

So far as at present known, it is exclusively confined to this part of North America. This is partly inferred from the absence of any distinct mention of such a disease in the horticultural literature of other regions, and partly from direct testimony. Prof. Dwinelle, late of the University of California, has told the writer that it does not occur on the Pacific coast. Dr. De Bary,[2] whose word carries great weight, says, after giving a brief description of the disease, "this phenomenon is not to my knowledge known in Europe." A long account of the disease has been published by Dr. Wakker,[3] in a gardening journal of Holland, in order to learn if it occurs in that country, but up to the present

[1] Cultivation of Fruit Trees, Philadelphia, 1817, p. 174.

[2] Vorlesungen über Bacterien, 1885, p. 137.

[3] Nederlandsche Tuinbouwblad, II (Jan. 9, 1886), p. 9.

time no one has intimated any knowledge of it. In a recent letter Dr. Masters, editor of the Gardeners' Chronicle of England, says that no such disease has been recognized in the British Isles. The testimony of one of our own horticulturists, Prof. Budd,[1] of Iowa, who is familiar with the disease in this country, and has inspected the orchards of the old world far into Russia, is especially valuable; he says "no trace of blight of pear- or apple-trees can be seen in Europe." From these statements, and the inferences to be drawn from other sources, it appears highly probable that the disease does not extend to Europe. An account of the principal diseases of fruit-trees of New Zealand, by Prof. T. Kirk,[2] has been published, which describes a disease of the pear known in that country as *fire blight*, due to a fungus, and another of the apple, the *American blight*, due to an insect. No true pear blight, as recognized in the United States, is mentioned, and in a recent communication the author has definitely stated that it is not known in the colony. Whether it occurs in other parts of the world is not yet ascertained, if some slight testimony regarding its absence in Japan be excepted.

It is only within a year or so that European writers have become aware of its existence, and this only through American authors. It is remarkable that a disease of such virulence and so easily transported should not have found its way across the ocean, when one remembers the number of destructive plant maladies that America has already involuntarily foisted upon European cultivators. It will not be profitable to speculate much at this time upon the reasons for this, but we may suppose that the small exportation of American fruit-trees, or of scions,[3] has been a factor in keeping it in check. The influence of climate, and some less evident factors, need not be discussed in this connection.

Amount of Loss.—It has already been intimated that pear blight is a frequent and destructive affection; it will tend to give a fairer appreciation of the subject if it be stated how frequent and how destructive it is. Coxe,[4] as early as 1817, in the oldest pomological work by an American author, says it "frequently

[1] Trans. Minn. Hort. Soc. for 1883, p. 281.

[2] Fruit Blights and Diseases of Fruit-trees in New Zealand, 1885.

[3] For an account of the destruction of stored scions by blight, see Rep. Hort. Soc. of Mich. for 1881, p. 137.

[4] L. c., p. 174.

destroys trees in the fullest apparent vigor and health, in a few hours; I have in twenty years lost upwards of fifty trees." The years 1826 and 1832 were notable in horticultural circles for the increased prevalence of the disease; but it was in 1844 that the most widespread and fatal epidemic, that the country has yet known, occurred. Few, if any, pear-orchards escaped at that time without the partial or total loss of many trees, and some orchards, even large ones, were quite destroyed. The following year the epidemic was much lighter, and had fully disappeared by 1846. Although it had subsided as an epidemic, it still occurred in localities here and there, and has continued to do so until the present time. Judging from the communications in the horticultural press, the whole country, or various sections of it independently, have been subject at various times to epidemic visitations, but none have equaled in severity that of the memorable year of 1844.

It is often maintained that a certain periodicity of occurrence is observable, the periods usually being placed at five, ten, or twenty years. A careful examination of the literature of the subject, however, gives little support to these views, and makes it more probable that the intervals are irregular, and that they vary for different sections of the country. The year of maximum prevalence may or may not be preceded by one in which the disease is noticeably common, but it is quite invariably followed by a year or two of successive decadence.

In the absence of exact statistics, which it has not been practicable to obtain, something of the important nature of the disease may be gathered from the statements of horticultural writers and the phraseology which they employ in speaking of it.

The renowned horticulturist, A. J. Downing,[1] called it the "monstrous malady of the pear." Chas. R. Baker[2] says it is "the worst malady with which the cultivator of the pear-tree has to contend." In southern Pennsylvania "the pear is so generally destroyed by the blight," according to J. B. Garber[3] writing in 1850, "that very few trees are to be found." At Philadelphia, however, the disease has been rarely observed, according to

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[1] Horticulturist, vol. i, 1846, p. 62.

[2] Practical and scientific Fruit Culture. Boston, 1866, p. 476.

[3] U. S. Patent Office Report for 1850, pt. ii, p. 418.

Thomas Meehan.[1] T. T. Lyons,[2] of Michigan, states as the opinion of many cultivators in that State, that the pear-tree cannot be grown with financial success on account of the blight. Illinois has always been much subject to the disease, and Prof. J. B. Turner,[3] in 1868, gave expression to the general feeling of his region by describing it as "that deadly Upas of the pear-tree known par excellence as the pear-blight." In 1882 Dr. J. L. Hallum,[4] speaking for southern Illinois, says, "pears have failed, utterly failed, so that none are now cultivated for market, the blight has destroyed the trees—branch and root," and S. G. Minkler,[5] in the northern part of the State, observes that it is a very uncommon thing to see pear-trees without dead branches or other signs of the ravages of blight. Wm. A. Nourse,[6] of the same State, is led to "doubt if one-tenth of the pear-trees that are set, live ten years," on account of this one destructive agent. Geo. M. Dewey,[7] of Missouri, says that "with good cultivation and rich soil the pear generally dies of blight before the eighth year." In Minnesota the severe climate has not permitted the cultivation of pears, and almost the only apples grown for many years were the hardy crab-apples. The latter have been rapidly improved, and together with the hardier varieties of the common apple would now furnish this part of the country with an abundant supply of fruit, were it not for this same disease, which elsewhere most conspicuously preys upon the pear-tree. E. H. S. Dartt[8] held the opinion in 1874 that the severity of winter was not so much to be dreaded as the ravages of blight. He had at that time one or two thousand trees affected. Dr. P. A. Jewell,[9] up to 1876, had lost ten thousand Tetofsky apple-trees by it. F. G. Gould[10] says that "only for this scourge every family living on a farm in Minnesota could have a supply of apples."

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[1] Rep. Penn. Fruit-Grower's Soc. for 1877, p. 77.
[2] Rep. Pomol. Soc. of Mich., for 1878, p. 368.
[3] Trans. Ill. Hort. Society for 1868, p. 42.
[4] Same for 1882, p. 118.
[5] Same for 1880, p. 30.
[6] Trans. Ill. Hort. Soc. for 1880, p. 63.
[7] Proc. Mo. Hort. Soc. for 1870, p. 18.
[8] Trans. Minn. Hort. Soc. for 1874, p. 22.
[9] Same for 1876, p. 73.
[10] Same for 1884, p. 127.

Citations enough have doubtless been given, although several pages of equally strong ones might be added, to show that fruit-growers, who have the best opportunities for observation, consider it a disease greatly to be dreaded and one of special economic importance. Other sections of the country, notably those of Ohio, western New York and Georgia, could furnish equally important proof of these propositions. All that is desired in this connection, however, is to give those not familiar with the subject some idea of the disease and its effects as ordinarily observed

Early Records.—The oldest mention of the disease, that gives a good and reasonably full description of it, is in Coxe's work on fruit-trees, bearing the date of 1817. The manner of the author leaves no doubt that it was well known at that time, and the reference to his losses during twenty years makes it reasonably certain that he had observed the disease as early as the opening of the century. The earliest notice, however, which has yet come to hand, is in a letter written by Wm. Denning,[1] describing the disease in apples, pears, and quinces. He speaks of first observing it on the Highlands of the Hudson in 1780.

There is no interest, however, in tracing chronologically the various notices found in different publications, for without exception they have the tone of treating a familiar theme, and show no evidence that the disease in the first part of the century was in any respect different from to-day.

Conjectures Regarding its Cause.—A brief treatment of this topic will be all that is required for the purposes of this paper; and only those hypotheses will be touched upon which received such careful presentation as to attract the favorable attention of the public.

Few writers appear to ascribe the disease to a single agency, but regard it as resulting from several causes, either acting together or brought about by dissimilar circumstances. Little discrimination is made between predisposing conditions and active agents. In fact sharply defined treatment could not be expected when all was conjecture, and when the shrewdest observers did not hesitate to avow that after years of loss under all kinds of experimentation, and after interminable discussions, the cause still lay shrouded in impenetrable obscurity.

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[1] Trans. Soc. for Prom. of Agric., vol. ii, 1794, p. 219.

Coxe,[1] who has had many followers, thought that the hot rays of the sun when acting through a misty or saturated atmosphere deranged the vital activities of the plant and brought about the disease. He considered old varieties more subject to it, on account of having lower constitutional vigor, than new varieties, of which the St. Germain and Seckel were respectively conspicuous instances.

The insect theory, as it was called, was promulgated at this time. It was started upon firm facts by the discovery of a small brown beetle, about two millimeters long, which penetrated the branch, and caused the part beyond to die. The beetle received the name of *Scolytus pyri* Peck, now changed to *Xyleborus pyri* Pk., and is still known as the blight beetle. The effect of its attack appears to the casual observer similar to that of the true blight—the branch in June or July rapidly withers, and the leaves and fruit turn black. The beetles being minute and inconspicuous escape attention, and the fact that the branch does not die below a definite point is sometimes overlooked. It is not difficult to see how many persons came to connect this comparatively rare affection with the common fire blight, and to believe that insects of some sort were to be held accountable for all—their supposed minuteness and wary habits being sufficient reasons for the failure to find them, and the spread of the disease along the limbs of a tree being ascribed to a poison which the insects were supposed to emit. Among the prominent supporters of this view was the "Genesee Farmer,"[2] published at Rochester, N. Y., with Patrick Barry as the horticultural editor. It has not, however, been so strongly advocated for the last decade or two.

The next hypothesis that attracted general attention was known as the frozen-sap theory. This was based upon the supposition that the autumn or winter freezing of unripe wood produced a poison which the moving currents of sap the next spring and summer distributed, causing the death of the parts. It was first published in 1844 by Rev. H. W. Beecher,[3] of Indiana, in a long and able article in "Hovey's Magazine." In the following year

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[1] L. c., p. 175.

[2] See Genesee Farmer, vol. vii, 1846, p. 216; vol. viii, 1847, pp. 122, 218, etc.

[3] Magazine of Horticulture, vol. x, p. 441.

it was independently elaborated by A. J. Downing[1] in his work on Fruits and Fruit-trees of America, who first called it the frozen-sap theory, and who is usually spoken of as the author of it. This view has probably had more firm adherents than any other, as it explained many phenomena connected with the disease in a fairly satisfactory manner. It was especially well received in the western States.

The next hypothesis which gained the attention of the public was the fungus theory. Its first successful presentation was in 1863 by Dr. J. H. Salisbury,[2] who figured the fungus which he decided to be the specific cause of this kind of blight, and ventured to give it a name, although he was sadly in error in most that he did. Thomas Meehan,[3] editor of the "Gardener's Monthly," has ably championed this explanation, and done much to keep it in favor. In 1875, Dr. J. G. Hunt,[4] by Mr. Meehan's request, undertook a microscopical examination of blighted pear-twigs, and confirmed the opinion that it was due to a fungus, without, however, deciding upon the specific character of it.

Blighted trees often attract attention immediately after a thunder storm, and from this and other circumstances the belief that the malady is due to electricity has gained many adherents, but the argument has not had a full and connected presentation.

The last hypothesis of historical importance is the bacterial theory. Although hinted at by a number of horticultural writers, yet the credit of it is due to Prof. T. J. Burrill,[5] who in 1878 distinctly stated his belief that the cause resides with the bacteria which he found in great abundance in the tissues of affected branches. In 1880 he performed a series of experiments[6] by inoculating healthy branches with the juices of diseased ones, the results of which were presented to the American Association at its Boston meeting, thus first bringing the subject clearly to the

[1] Fruits and Fruit-trees of America, p. 594; same, 2d Revision by Chas. Downing, p. 646.

[2] Ohio Agric. Rep. for 1863, p. 450.

[3] Proc. Amer. Pomol. Soc. for 1867, p. 59; and elsewhere.

[4] Gardener's Monthly, vol. xvii, 1875, p. 245.

[5] Trans. Ill. Hort. Soc. for 1878, p. 80.

[6] Proc. Amer. Assoc. Adv. Sci., vol. xxix, 1880, p. 583; Rep. of Ill. Industrial Univ., for 1880, p. 62; Trans. Ill. Hort. Soc. for 1880, p. 157; Amer. Naturalist, vol. xv, 1881, p. 527.

attention of the scientific world. Although this was now the popular hypothesis, it cannot be said to have received more substantial credence than those which had gone before, either from the horticulturists or the scientists. The experimental results gained by Prof. Burrill were confirmed and extended by the writer [1] during 1884, by means of a similar series of inoculations.

Of the multitude of minor hypotheses which were put forth in explanation of phenomena connected with pear-blight, and which were variously received, and of all degrees of plausibility, it is impossible to speak at this time without carrying this paper to undue length.

Beginning of Experimental Research.—The question of the cause of pear-blight was finally removed from the domain of speculation to that of established fact by a series of crucial experiments performed by the writer [2] a year ago, and recorded in a paper before the American Association at the Ann Arbor meeting. These consisted in showing that the bacteria when removed from the tree and passed through a series of artificial cultures would generate the disease when again introduced into the tree, and that the juices accompanying blight when cleared of bacteria by filtration will not produce the disease.

Having now come to a firm basis for scientific advancement, let us look over the historical ground again to see if some one did not hit upon the true explanation of the disease, although he may not have been aware of its significance. In a connection like this, facts derived from experiment have greater weight than statements of opinion; the latter acquire importance in proportion as they are logically derived from correct and close observation. Bearing this in mind, we need not give much heed to the not uncommon inference that pear-blight was in some way intimately related to the epidemic diseases of man, *e. g.* cholera. This view is said to have been quite frequently entertained in the early part of the century, but was not sanctioned by the learned. The use of such phrases as "first cousin to the cholera," "a species of vegetable ferment," etc., surely does not entitle the author to any priority in way of discovery.

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[1] Rep. N. Y. Agric. Exper. Station for 1884, p. 357.

[2] Proc. Am. Assoc. Adv. Sci., vol. xxxiv, 1885, p. 295; Bot. Gazette, vol. x, 1885, p. 343; Gardeners' Chronicle, vol. xxiv. 1885, p. 586.

We turn from these slight hints to the record of an experiment in inoculation, made in 1845 and published the following year. We are told by S. B. Gookins,[1] of Indiana, that visiting Mr. Ragan (the same person who furnished Mr. Beecher with many of the facts on which he founded the theory to which we have already referred) he was shown a thrifty young pear-tree in the nursery, which had been "inoculated" "by way of experiment" with "the sap of a blighted tree," "a few days previous." "He made an incision about three feet from the ground, lifted the bark as in the process of budding, and injected a small quantity of the diseased sap." "We found the leaves of the patient changing color, and emitting that peculiar odor which is always present in cases of blight, and upon applying the knife, the inner bark was found to be black from the root to the top, while nothing of the kind appeared elsewhere in the nursery."

This admirable experiment was combined with a no less admirable interpretation of the cause of blight. The writer cites facts to disprove the hypothesis of Mr. Beecher, and then says: "I strongly incline to the belief, that the pear-blight is an epidemic, that it prevails like other epidemics, and will pass off like them. The atmosphere is, I believe, generally admitted to be the medium by which they prevail, and are carried from place to place. What that subtle principle may be, which pervades our atmosphere, by which infection is retained and transmitted, human science has not discovered; but that such a principle exists is sufficiently obvious from its effects."

This clearly conceived elucidation of the matter could only have been improved by a knowledge of the germ theory of disease, and when we remember the date at which it was uttered, we do not feel that the writer was guilty of any lack of acuteness in not perceiving the relation which we now know to exist between his theory and his facts. He seems to have been a modest man, for he only signs his initials, and does not defend his views when the editor, A. J. Downing,[2] opposes the opinion that "an epidemic conveyed by the atmosphere is too slightly supported by facts to weigh at all against the observations of cultivators," which "strongly point to the freezing of the sap as the cause."

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[1] Horticulturist, vol. i, 1846, p. 253.

[2] Horticulturist, vol. i, 1846, p. 255.

Another interesting experiment was performed by Dr. E. S. Hull,[1] of Illinois, in 1868. Having received some blighted apple twigs from a correspondent, he cut pieces from them with which he "inoculated several succulent pear shoots by tying in the pieces as in budding." This was done the middle of June, and no observation taken for thirty-four days, when the blight was found to have extended several inches into the healthy tissues. From this he very justly concludes that the blight in apples and pears is but one disease, but seems to take it for granted that in both it is due to "vitiated sap."

The fact that the disease may be transferred to healthy trees by the pruning knife has been observed by several persons. H. Wendell,[2] of New York, says in 1849, "I am also careful that the blade of the knife is perfectly clean, and that it has none of the sap of a diseased tree adhering to it, because I have known many valuable trees destroyed by having been inoculated in this manner." Prof. Turner,[3] of Illinois, makes a similar statement: "I found that this disease is exceedingly contagious, for if I used my knife to prune a healthy tree after having used it in shaving the diseased one, I communicated the disease to that tree."

Prof. Burrill first observed the bacteria of blight in 1877,[4] but did not recognize them as such till the following year,[5] when he avowed his belief that they were the cause of the disease. His first inoculation experiments were made in 1880, as already stated. In 1882 he characterized the organism under the name of *Micrococcus amylovorus*.[6]

Description of Micrococcus amylovorus Bur.—The form of this species of bacteria is very constant, under all conditions. The single cells are from oval to roundish-ovoid, and only vary by slight changes in the ratio between their length and breadth

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[1] Trans. Ill. Hort. Soc. for 1868, p. 220.

[2] U. S. Patent Office Rep. for 1849, pt. ii, p. 446.

[3] Trans. Ill. Hort. Soc. for 1878, p. 81.

[4] Same for 1877, page 114.

[5] Same for 1878, page 79.

[6] The Bacteria (a reprint from Rep. of Ill. Industrial Univ. for 1882), p. 42; Amer. Naturalist, vol. vii, 1883, p. 319. In the last publication, by a typographical error, the name was made to read *M. amylivorus*, a mistake which has been copied into other works—see Grove's Bacteria and Yeast Fungi, London, 1884, p. 10.

(Pl. III, figs. 1, 2, 6). They are 1 to $1\frac{1}{4}\,\mu$ long, by $\frac{1}{2}$ to $\frac{3}{4}\,\mu$ broad, and quite colorless. For the most part, they exist as single independent cells, but may often be found in pairs, especially when still multiplying, and in rare instances are united into a series of four or even more, but never extend into chains.

During rapid vegetation, in rich nutritive media, the movements reach a stage of extreme activity. The appearance is what is termed swarming, in which the bacteria move rapidly back and forth, in and out among each other, but never in a straight line to any distance. As the rate of growth becomes less from any cause the movements are retarded. Taken directly from the tissues of a blighting tree, the movements of translation are usually sluggish or imperceptible, although the universal Brownian movement is likely to give a misleading appearance of activity. Under specially favorable conditions, as when grown during hot weather in very succulent shoots, or from artificial inoculation in unripe fruit, the movements are much increased and may become quite rapid. When taken from the tree in winter, or when grown in solutions that are too acid or too alkaline, or which are deficient in the proper nutritive substances, there is no perceptible locomotion.

When in active growth, the cells present a uniformly dull appearance. By conditions which are unfavorable to normal growth, yet do not entirely check it, such as strongly acid or alkaline solutions, deficient nutriment, or exhaustion by keeping the cultures several months, the cells become highly refractive, and to some extent take on the appearance of the spores of other species of bacteria. Whether in this state they possess any of the characteristic powers of resistance which belong to spores, has not been ascertained.

Formation of Zooglœa.—By far the most characteristic feature in the life history of *Micrococcus amylovorus* is the formation of zooglœa (figs. 2, 3, 5). These have never been observed in the tissues of the tree under any conditions, or in or upon any sort of solid media, but they occur with much regularity in fluid cultures, when placed under favorable conditions for rapid growth.

They are produced to some extent throughout the fluid, but are most abundant in the thin pellicle which forms upon the surface, appearing within forty-eight hours from the beginning of the culture. The substance of the pellicle consists of a colorless matrix uniformly filled with motionless bacteria, and against this the zooglœa are sharply defined. They are often brought out yet more distinctly by being surrounded by a colorless layer, free of bacteria, which is doubtless an extension of the ground substance of the zooglœa mass (fig. 4).

The masses are far more dense than the pellicle, and are compactly filled with refractive bacteria. They possess a definite outline, and are recognizable when very small; and although they may reach 30 to 40 μ long by 20 to 30 μ wide, they rarely lose their distinctness. When below 10 μ in length, their usual form is oblong, varying to globular. They occur singly, or united more or less intimately end to end in pairs, and sometimes several form a short chain. At this stage they possess a uniformly even and unbroken surface, which now becomes uneven and wrinkled, and is finally thrown into folds, giving some resemblance to the external aspect of the brain. Zooglœa more than 20 μ in length have the folds of somewhat unequal height, and the sinuses deeper, giving a stronger cerebric look, or when the folds are small and circular, they are better described as mulberry-like. The elongated forms, which at some stage of growth might doubtless have been composed of two or more distinct masses, often take on a vermiform appearance. But whatever the variations may be, the distinctness of outline, the general form, and the cerebric surface are unfailing characters, which so far as my knowledge extends, are not found in any other species of bacteria.

Cultivation in Fluid Media.—The range of substances which may serve as culture media for this organism is very wide. An infusion of almost any vegetable substance containing a fair amount of soluble carbohydrates is likely to be sufficient to enable growth to take place, even if not very luxuriantly.

The substance which on the whole has proved most satisfactory is an infusion of potato. This is prepared by paring a potato and slicing it into three or four times its bulk of water. This is kept for a couple of hours at about 70° C., by placing it over a water-bath, during which time it is occasionally stirred. It is then filtered, and is ready to be placed in the culture vessels for sterilizing and use. If the heat is allowed to rise much above 70°, the starch is gelatinized, and it is only with difficulty that the solution can be filtered. The resulting liquid is clear and watery, but is often light brown from coloring matter contained in the potato, which does not, however, materially interfere with observations on the growth of bacteria in it. Iodine gives a blue coloration to this liquid, showing that it contains starch, probably in the form of amylon. Another equally good culture fluid is made by treating corn (maize) meal in a similar manner. The solution is colorless, but it is very apt to throw down a troublesome sediment, which makes it less desirable to use than the potato solution.

Test-tube or flask cultures with these liquids, when kept at a temperature of 25° to 30°C., usually show some turbidity in twenty-four hours after being infected, and if the growth is very rapid, bubbles of gas (CO_2) will be given off, which collect at the surface into a slight froth. In forty-eight hours the liquid has become thoroughly turbid. By this time a thin whitish pellicle has formed on the surface, which does not increase much in thickness up to the end of active growth, and rarely becomes wrinkled. With the formation of the pellicle, a sediment gathers at the bottom of the liquid, often a centimeter in depth, but which is so light that it only apparently differs from the liquid above by being whiter. In the course of some weeks this sediment will mostly gather upon the bottom of the vessel. No difference has been observed in the appearance of the bacteria taken from different parts of the culture. Those imbedded in the pellicle are not arranged in any recognizable order.

In proportion as liquids are less suitable to the growth of the organism, the visible changes are less. The pellicle may not be formed, and there may be no turbidity, but if any growth at all takes place there will be some evidence of it by formation of a slight sediment. But the occurrence of a precipitate does not necessarily imply growth, for it not infrequently separates from a liquid containing organic matter, although remaining perfectly sterile.

An infusion of hay, and also of dead, partly decomposed grass from a marsh, gave nearly a normal growth of blight bacteria, but the cells were considerably more refractive than usual.

A solution of starch, having one part of starch to fifty of water, gave but a slight growth of highly refractive bacteria, without a pellicle, turbidity, or zooglœa. A strong decoction of old barnyard manure acted in the same manner. A solution of one part of glucose to fifty of water gave no growth of the bacteria.

In testing the effect of acids upon the development of blight bacteria, a $\frac{1}{2}$ per cent. of malic acid was added to the usual infusion of potato. This prevented the formation of a pellicle, turbidity or zooglœa, but gave a very considerable cloudy sediment, largely made up of loosely aggregated groups of blight bacteria, which were brilliantly refractive. A similar solution with 2 per cent. of malic acid gave a slightly less abundant sediment, but with otherwise the same results. Some of the latter was transferred to a corn-meal solution, producing the characteristics of a pear-blight culture, except the formation of zooglœa. After some days this was introduced into a pear tree, which in due course of time gave the true blight, showing that the bacteria of the acid solution were really blight bacteria. Attempts to grow them in a nutrient 5 per cent. solution of citric and tartaric acids have not been successful.

Testing the nature of the bacteria in cultures producing limited growth, by inoculating directly into the tree, has not, as a rule, proved successful, as for some reason they seem unable to gain a footing in the living tissues. It is therefore necessary to transfer them first to richly nutrient cultures, from which, after a time, they may be introduced into the tree, and, if the blight bacteria are present, will start the disease.

Cultivation in Solid Media.—In test-tube cultures with nutrient gelatine the most characteristic results have been obtained by adding a drop containing blight bacteria to the gelatine while liquid, and thoroughly distributing the germs by shaking the tube. In from two to three days the gelatine contains numerous small white dots, which, upon examination under the microscope, prove to be a mass of bacteria of the usual appearance. The dots are globular or oval, and increase to about .5 mm. in diameter. No further growth or change takes place, and in this condition they remain for weeks, without liquefying or otherwise affecting the gelatine.

When sown upon the surface of the gelatine by drawing a needle or glass rod over it, or by placing a drop on it, the growth is feeble and does not amount to more than a slight shining appearance of the surface.

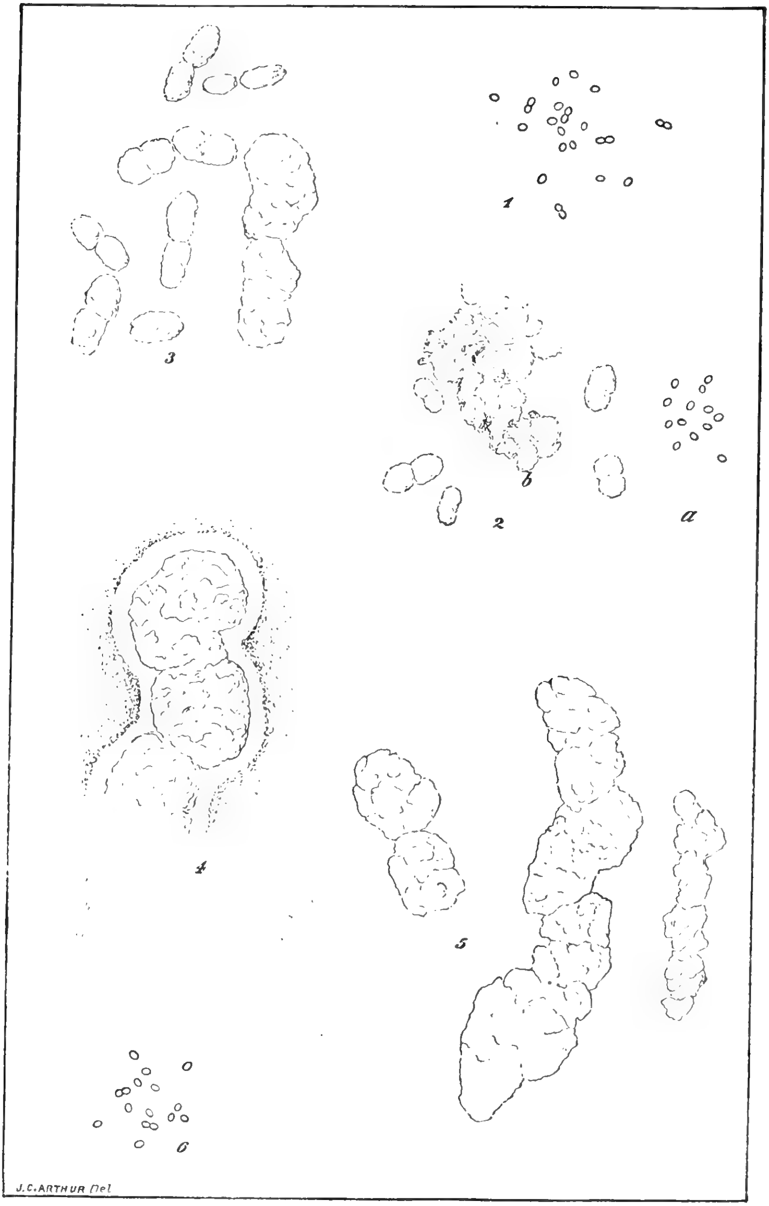
A nutrient solution made from an unripe pear, in which blight germs were well distributed by shaking and then left undisturbed for two days, gave the same isolated white dots as in gelatine; but they dropped to the bottom of the liquid upon being jarred. The bacteria were evidently prevented from moving freely by the jelly, which was not, however, thick enough to keep the groups in place when its cohesion was once disturbed. Fruit jellies, doubtless, may be found to be convenient media for the cultivation of this species of bacteria.

No success has been attained in the use of agar agar, but whether due to a want of adaptability in the substance, or to wrong manipulation, must be left to future experiments to determine.

The opaque solid cultures proving most successful have been conducted upon freshly gathered unripe pears. Slices of these are placed under a moist bell-jar, and infected by touching with a needle that has been dipped in some substance containing the bacteria. In two or three days fine milky drops, like beads of dew, will appear scattered over the surface for 5 mm. or more about the infected spot. These will become somewhat larger after a time, while the spot which received the infection will turn slightly brown, the tissues gradually wasting away and forming a small depression.

If, however, the slices, having freshly cut surfaces both above and below, are laid upon a plate with a little water, and placed under a bell-jar, the result is not the same. The dew-like drops appear within forty-eight hours, as in the other case, but increase rapidly in size, while a drop is also formed at the point of infection. Drops finally appear over the whole surface of the slice. They remain more or less distinct, and soon become as large as a pea, retaining the globular or rounded form to a remarkable degree. Microscopically they are composed of the usual form of blight bacteria, suspended in a colorless fluid. After about a week, the drops coalesce and the tissues of the pear begin to break down. This sort of culture requires no precautions of sterilizing, as no other bacteria can multiply upon it till after the cells of the pear begin to die.

When blight bacteria are sown upon slices of baked or boiled potato, they spread out over the surface in a thin, slightly moist layer, which is usually somewhat yellowish, but do not grow



MICROCOCCUS AMYLOVORUS BUR.

readily, or produce a characteristic appearance. Under the microscope the cells are strongly refractive.

A boiled potato was infected by thrusting a platinum wire, smeared with blight bacteria, into one end. After sixteen days it was cut open. No external change had taken place, and, to the unaided eye, no internal change either; the odor and texture were still those of a freshly boiled potato. The microscope, however, revealed the blight bacteria in every part of the potato, in irregular motionless masses, and with more than the usual refractiveness.

These opaque solid cultures have brought out one fact very distinctly, which is, that *Micrococcus amylovorus* requires a large supply of water for its best development—a fact which has an economic bearing.

Behavior toward Staining Fluids.—So far as trial has been made, nothing especially characteristic has been detected to distinguish this form of bacteria from the majority of micrococci. The most successful results have been obtained with a watery solution of Bismarck-brown, especially in cover-glass preparations. These make excellent specimens when mounted in Canada balsam.

The zooglœa are inclined to be too deeply stained by this process, and for most purposes they are best studied unstained. They may be well preserved by mounting in glycerine.

Hæmatoxylin has also given good results, but has not been found particularly useful.

Chemical Products.—The chemical changes brought about by the activity of the blight bacteria have not yet been fully and carefully worked out. The most obvious product is carbon dioxide, which often passes off so freely from a cultivation as to produce a slow effervescence. Butyric acid and alcohol are formed in very small quantities, if at all. The tests by which these facts have been determined have already been published,[1] and need not be repeated here. Vigorous cultures of the bacteria in infusion of potato give no reaction for glucose with Fehling's solution; and blighting tissues from the tree give no indication by the same test of more than the normal amount of glucose to be found in healthy tissues. On the other hand a quantitative

[1] Rep. N. Y. Agric. Exper. Station for 1885, p. 247; and less fully in Amer. Nat., vol. xix, 1885, p. 1181.

determination of sound and blighting pears, taken from the tree at the same time, shows considerably less sugar in the latter.

A favorite explanation with horticulturists of the action of fire-blight upon the pear-tree, has been to say that the sap is poisoned. This poison was supposed to be introduced by insects, or to be due to some disorganization of the tissues. Although it is now known that specific bacteria are directly answerable for the disease, it is yet worth while to see if the old idea of a poison has not some foundation in fact.

It has been ascertained that certain bacteria produce, during their growth, characteristic poisons which are classed under the name of ptomaines. Most of the ptomaines are non-volatile, and readily soluble in water or alcohol. The chemical tests which are applied for their detection cannot be considered conclusive except when taken collectively. The tests tried below are among the most satisfactory known at present.[1]

A cultivation in infusion of potato, giving about 200 cc. of liquid was filtered, and the filtrate evaporated to a syrup. This was treated with alcohol, and the solution tested with the most characteristic test for ptomaines—the reduction of potassic ferric-cyanide. Other portions of the solution were successively tested with phospho-molybdic acid, potassio-mercuric iodide, and iodine in potassic iodide, all of which failed to give any distinctive reactions.

Another trial was made with about 200 cc. of material prepared by cooking a potato in just enough water to cover it, sterilizing, and cultivating the bacteria in it as usual. In four days from beginning of the culture it was filtered; the residue upon the filter was treated with 100 cc. of distilled water, slightly acidulated with hydrochloric acid, heated to 70°C. and filtered. The two filtrates were united and evaporated to a syrup. This was digested in the cold with alcohol containing a little sodic hydrate. This solution was tested as before, and also with platinic chloride and concentrated sulphuric acid, and all with no distinctive reactions.

A third trial was made with a boiled potato, which had been permeated with the blight. The extract was made by the Stas-Otto method, and the same reagents used as in the last case, with equally negative results.

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[1] Cf. Brieger, Ueber Ptomaine, 1885, p. 22, *et seq.*

These tests do not cover the possibility of the ptomaine being volatile, which is really not very great. It is yet necessary to make tests of freshly blighted tissues from the tree, which can only be done during the hot months.

Action of the Organism in the Living Plant.—The bacteria of blight have the power of growth and multiplication in the presence of the living cells of the pear, and in this one important respect differ essentially from other species of bacteria. By artificial inoculation into growing unripe pears, which give most marked and certain results, it is found that other bacteria are entirely innocuous, at once disappearing without having made any growth or induced any changes in the tissue of the pear. If blight bacteria in active condition are intermixed with the other forms, they penetrate the cells, multiply, and finally bring about the disorganization and death of the tissues which marks the progress of the disease, but the associated forms disappear the same as when introduced alone, and the product is a mass of practically pure blight bacteria.

This result is rendered possible on account of the fact already stated, that the blight bacteria penetrate the tissues, and maintain their normal growth for some time (days or weeks), before the life of the cells is sufficiently interfered with to permit the growth of other forms. The bacteria always extend beyond the visible location of the disease—in small branches, often to the distance of a third of a meter or more.

One of the properties which enables this species to successfully penetrate the pear-tree is evidently its unusual indifference to acids, which prevents most other forms from making any growth; the juices of the pear give a strong acid reaction with test paper.

What chemical changes are brought about by its activity in the plant cannot be definitely stated, further than to say that a mucilage or gum, which is soluble in water, is produced in abundance, with the disengagement of carbon dioxide. The contents of the cells, together with the cell-walls which have not been liquefied or changed into stony tissue, pass over into this viscous product.[1]

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[1] Rep. N. Y. Agric. Exper. Station for 1885, p. 248; Amer. Nat., vol. xix, 1885, p. 1181.

It was early observed by cultivators, being recorded by Coxe, that succulent shoots blight the most readily, and any process of cultivation which as far as possible prevents succulency has always been considered an aid in keeping the disease in check. The avidity of the blight bacteria for water has been well demonstrated in the cultures on slices of pears. There seems to be some connection between these facts and the well-known fact that the disease shows different degrees of virulence in different varieties of fruit trees, especially in different varieties of the pear. The variation, or at least part of it, to be observed in pears, apples, quinces, hawthorns, etc., may be due to some inherent difference in the nature of the host, not readily formulated; for we find that the blight bacteria will grow to only a slight extent in the succulent peach shoots, and not at all in most other plants.[1] But in varieties of the same fruit it may reasonably be inferred that to a considerable extent the difference in the progress of the disease is due to physical causes.

To determine what relation the hydration of the tissues holds to this question, a series of determinations of the percentage of water in the parts of the tree most subject to blight has been begun. These are yet incomplete, and can only now be referred to briefly.

The Bartlett and Seckel pears very well represent the extremes, the first being most affected by the disease and the second least. Twigs taken from the tree in February were found to contain 50·2 per cent. and 50·85 per cent. of water respectively. Twigs taken in the same way April 30, bearing flower buds, but with the leaves removed, gave 68·7 per cent. and 67·3 per cent. of water. The half-grown fruit, taken the first week in July, gave 79·3 per cent. of water for the Bartlett and 77 per cent. for the Seckel. According to these figures the amount of water in the Bartlett and Seckel twigs during the winter is practically the same, but during growth both the twigs and fruit of the Bartlett contain more water than those of the Seckel. These numbers give some support to the view that succulency and the strength of the disease are directly related, but the data are yet too incomplete to warrant a definite statement.

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[1] Rep. N. Y. Agric. Exper. Station for 1884, pp. 362, 377; Amer. Nat., vol. xix, 1885, p. 1182.

EXPLANATION OF PLATE III.

The drawings were made with a camera lucida and a Spencer's $\frac{1}{10}$-objective, homogeneous immersion, of 125° balsam angle. They are uniformly magnified 890 diameters.

Fig. 1.—*Micrococcus amylovorus* Bur., grown upon a slice of boiled potato, stained with Bismarck-brown and mounted in Canada balsam.

Fig. 2.—From a cultivation in hay infusion : *a*, separate bacteria ; *b*, zooglœa. The large mass, only part of which is shown, is made up of smaller masses more or less united.

Fig. 3.—Small zooglœa from a potato infusion, drawn from a preparation in Canada balsam, stained with Bismarck-brown.

Fig. 4.—Portion of a zooglœa mass from the same culture, showing an envelope free from bacteria. Drawn from an unstained preparation mounted in glycerine.

Fig. 5.—Three zooglœa from the same culture.

Fig. 6.—From another culture in hay infusion.

October 5.

The President, Dr. Leidy, in the chair.

Twenty-four persons present.

A paper, entitled "Observations on Multiplication in Amœbæ," by Lillie E. Holman, was presented for publication.

October 12.

Mr. Chas. Morris in the chair.

Twenty-two persons present.

Notes on the Lichens in the Herbarium of the Academy.—At a meeting of the Botanical Section, held October 11, Dr. J. W. Eckfeldt, to whom had been committed the task of examining and arranging the Lichens in possession of the Academy, reported the result of his work, which had extended over two years. Besides the collections upon the shelves, made by Schweinitz, and by him bequeathed to the Academy, and that received from the late Prof. Tuckerman, he had found stowed away among miscellaneous packages: 1st, a collection made by Thomas G. Lea, of North American species, many without names, or incorrectly named; 2d, a small collection made by H. W. Ravenel, chiefly from the vicinity of Aiken, or along the Santee Canal in South Carolina, in all about 60 to 70 species; 3d, a small collection of Arctic species made by Dr. Hayes; 4th, a small collection of European species made by Parmentier at a very early date; 5th, a set of Scotch Lichens from Mr. Manghen; and a few scattered species from various American collectors. To each of these collections he had given a careful microscopic examination, and had named and classified them on the basis of Prof. Tuckerman's Genera Lichenum. He had also added to these from his own private herbarium more than 400 species, both North American and foreign. All these collections had been incorporated in one, and occupy one of the cases in the lower room, as a nucleus for the Academy's general collection of Lichens.

For obvious reasons it had been deemed advisable to maintain apart and undisturbed the type collections of Schweinitz and Tuckerman, but a general catalogue has been prepared including all, by which proper reference to the contents of each is facilitated. He had, moreover, gone carefully through the Schweinitzian collection, and, while leaving the original names unchanged, had indicated upon the outside of each packet such changes as are required by the present state of knowledge.

The total number of species of Lichens now in the Academy's

Herbarium is 736. In the general collection are 570 species, and in the Schweinitzian are 462. The general collection contains 244 species not found in the Schweinitzian, and the latter has 282 species not found in the former. In all, 65 genera are well represented.

In regard to the Schweinitzian collection he remarked that the same species often there appeared under several names, being simply in different stages of development. Genera too were founded upon juvenescent stages or gonidial conditions which, from the time of Acharius to that of Schweinitz and later, were considered sufficient to establish generic distinctions. For example, such genera as *Leparia*, *Isidium* and *Byssus*, were then deemed valid, but are now considered to be, some of them young and irioid states of plants mostly belonging to the section *Lecanora*; others, sterile states of *Omphalaria*, *Cænogonia*, or other Collematous Lichens.

He spoke of several rare and interesting specimens in the collection. Of these, in the Schweinitz Herbarium, is a crustaceous Lichen found in 1812 at Salem, N. C., on a granitic rock, and called by the collector *Gyalecta candida*, and by this name known only to a few up to the year 1866. At this period Prof. Tuckerman described the plant in an Appendix to his Lichens of California as *Opegrapha ontocheila*, thus placing it permanently in a well-established genus of gymnocarpous Lichens. This specimen was the only one known until 1885 when Mr. Green found upon high projecting schist rocks along the Catawba River at Landsford, Chester Co., S. C., a lichen which was supposed to be new, until Prof. Tuckerman, just previous to his last illness, identified it with that found by Schweinitz as above. Dr. Eckfeldt also referred to a remarkable foliaceous Lichen found near Cincinnati by Mr. T. G. Lea in 1839, formerly known as *Parmelia Ohionis* (Lea, Catal. Pl. Cincinnati, p. 45), but since described by Tuckerman as *Physcia Leana*. So far as Dr. Eckfeldt was aware, this rare species had not since been found. He also referred to the difficulties encountered in the examination of much of the material, many of the types being old and fragile, having lost the parts most important for study, for want of proper care. Only a practiced eye, aided by constant use of the microscope, and by comparison with authentic specimens, can surely determine the doubtful and difficult forms present in this section of cryptogamic botany.

OCTOBER 19.

The President, Dr. LEIDY, in the chair.

Twenty-seven persons present.

A paper entitled "The Genera Mesonyx and Pachyæna Cope," by Wm. B. Scott, was presented for publication.

On the Interdependence of Plants.—Mr. THOMAS MEEHAN called attention to the well-known fact in geographical botany, that species of plants which once had evidently a wide dispersion now existed only as separate colonies often of a few plants only, the intermediates between these widely separated colonies having evidently disappeared. The cause of these disappearances had not been definitely determined. It was found that the still existing individuals were evidently in good health; they flowered freely, and perfected seeds, but still the plants did not spread. He gave a number of illustrations within his own observation of a few rare plants that had maintained their existence for over a quarter of a century, with about the same number of individuals now as at the beginning of the term. As the seeding was regular and perfect, why was dispersion arrested? There could be but one answer. Something prevented the germination of the seeds, or of subsequent growth after germination. No doubt there may be other causes, but this one must have a leading influence.

It then becomes an interesting branch of study to inquire why these seeds do not germinate, and thus aid the plant to recover the ground lost through destructive agencies?

An observation extending over about six years led him to conclude that there was much in the interdependence of plants. Whatever affected the existence of individuals of one species might lead to the extermination of numerous others, and the successful endeavor of one to establish itself in one locality gave the necessary opportunity to follow and sustain themselves. This observation was as follows: A wood, chiefly of chestnut and oak, of about an acre in extent, was turned into a picnic ground—a place for summer pleasure parties. All the shrubby undergrowth was cut away. The plants which might have grown up, were kept tolerably well trodden down by the numerous visitors to the wood, except one solitary blackberry plant (*Rubus villosus*), which, being thorny, led to its avoidance by human feet. After the second summer, some change in railroad arrangements led to the abandonment of the wood for picnic purposes, and plants had a chance to grow up again without disturbance from human beings. The blackberry plant, by the aid of its creeping roots now forms a thicket of about thirty feet in diameter. The following list of plants growing among the blackberries, that were not found in any part of the wood, except the last two, which were in small quantities here and there, was made in October of this year:—

Eupatorium perfoliatum, *Rubus occidentalis*, *Liriodendron tulipiferum*, *Cornus alternifolia*, *Smilacina racemosa*, *Ambrosia artemisiæfolia*, *Laurus sassafras*, *Polygonum Persicaria*, *Achillea millefolium*, *Solidago canadensis*, *Mulgedium acuminatum*, *Bidens frondosa*, *Silene verticillata*, *Fragaria virginiana*, *Aster longifolia*, *Eupatorium album*, *Circæa lutetiana*, *Geranium maculatum*, *Acer rubrum*, *Phytolacca decandra*, *Muhlenbergia diffusa*, *Potentilla canadensis*, the last two to some extent in the wood.

All the kinds, however, grew in the vicinity of the acre of woodland, though not within its limits, and it was easy to note that they had grown from seeds falling or brought to the blackberry patch during the last three or four years. Those who are familiar with the seeds of these plants will understand that there is nothing special about the seeds of these species that would easily lead to their being brought there by birds that might rendezvous in the thickets. We must look to the wind as the chief agent in transporting them there. This being the case, we should look for the plants from wind-sown seeds in other portions of the wood, as well as in the blackberry patch. That they are not in the wood elsewhere permits us to say that the shade, moisture, preservation of decaying leaves, or of some other incident not acceptable to other plants in the wood, but favorable to these strangers, gave them the chance to sprout and grow. They were, in fact, dependent on the blackberry for their first start in life. This conclusion was further evidenced by the fact that, though some of the annuals had evidently seeded and reproduced plants for several successive seasons, no plants were found spreading out of the protecting area of the blackberry thicket. Certainly these species were all dependent here on this plant, as this plant would probably be dependent on others in some other instances.

How some plants can exist, grow healthily, produce seed, and not spread, Mr. Meehan illustrated in the case of *Shortia galacifolia*, the original locality of Michaux having a few months ago been rediscovered by Professor C. S. Sargent. Though it had maintained itself for the best part of a century, it had existed without spreading. Some circumstance had evidently prevented the seed from germinating, and these circumstances would undoubtedly be controlled by the presence or absence of some friendly plant. He offered the facts as a contribution to the study of the interdependence of plants.

OCTOBER 26.

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

Thirteen persons present.

The following was ordered to be printed:—

OBSERVATION ON MULTIPLICATION IN AMŒBÆ.

BY LILLIE E. HOLMAN.

On the 4th of July, 1886, I was examining the forms of life contained in a Holman life-slide, which had been filled for several hours. It contained different Infusoria, and among other animals, specimens of *Æolosoma*. But it seemed for some time as if there were no amœbæ in the slide, until I discovered a small one near the channel. In shape it seemed like an elongated triangle, and was rather torpid, or at least moved but little. While I was examining it, it moved up closer to the line of the channel, and another amœba, about twice the size of the first one, came gliding on the scene. It moved up very close to the other, and in a few moments I noticed that it looked as if it were trying to swallow the smaller amœba, in the same manner that it does its ordinary prey. As I had watched many amœbæ and had never seen anything like this, and as I knew that they did not prey on each other, and the question of their conjugation was a very doubtful one, I dismissed the idea of the larger absorbing the smaller, and concluded it was merely the fact that they were in too tight a place to allow of their passing each other which gave them this appearance. I watched them constantly for about half an hour, in course of which time I became convinced that something unusual was going on.

The larger amœba had entirely surrounded the smaller one, which, however, did not seem to lose its vitality. First it seemed to be under the endosarc of the larger, and then above it. Sometimes it would project a pseudopod out from beyond the ectosarc of the larger animal. All the time it was distinctly visible in its own individuality, if one may so call it, and did not at all seem to be trying to escape. I called Mr. Holman's attention to the singularity of their behavior, and expressed my belief that it was a case of either cannibalism or conjugation. He expressed his disbelief in either of these cases, and observing that the water in the slide was evaporating, we allowed a little to creep in under the closed edge of the cover-glass. This seemed to relieve the large amœba from the constrained position and flat contour which it had assumed, and it immediately commenced to put out pseudopods and move away; and the smaller one moved off with it, evidently engulfed in the larger one, and quiescent in that position.

The small amœba occupied a position in the upper part of the larger one. As this last moved on, it seemed to push the small one in an opposite direction from that which its granules were taking, till it reached about the centre of its body. Then it commenced an evident effort to expel the smaller one. It reached out its pseudopods in every direction, gradually expelling the smaller one until it was completely discharged. The smaller one, by this time, assumed an almost spherical shape.

At last the large amœba ceased moving, and commenced to expel refuse matter such as is common with them. It had anchored itself near some other refuse matter, probably vegetable, and really looked as if it was using it as a sort of grapple for the purpose of ridding itself of the rejected smaller amœba. It was successful; for in a few moments it moved away to the upper part of the field, leaving the round ball, looking in every respect like an encysted amœba, near the little group of refuse. It went on in the field, and we followed it for some time, when it became quiet, and we went back to the encysted one. I watched it to see what would happen next, for it seemed as if there must be some strange sequel to our remarkable observation, and the watching was not in vain. The flat disk commenced by a sort of contractile movement, to throw out particles or granules, as if it were laying eggs. I can think of no other expression, although the particles, while approximate in size, had no regularity of shape. This continued till the amœba again assumed its clear and transparent appearance, and at last, seeming to fully regain its activity, put out a pseudopod and moved in the field, leaving behind it a group of the particles or granules. Only for a little while, however, did it move; in a few moments it lost its animation, seemed to become transparent, and at last faded into one of those disks which seem to be merely the shells of once active forms. I did not see it move again.

This observation was carried on continuously during two hours and a half, and every stage watched most closely. I was at a loss what to call it, if not a clear case of conjugation and separation.

The most convincing proof to my mind that this was a proceeding which was for a purpose, was given when, two nights after, this slide, which was laid carefully aside for future examination, was found to be full of young amœbæ. They literally swarmed; I counted in the field at one time twenty-four of uniform size, while I have no hesitation in saying that there were between one and two hundred in the slide, which had before held but two. The worn-out disc was recognized, and also what seemed to be the remains of the larger amœba.

NOVEMBER 2.

The President, Dr. JOS. LEIDY, in the chair.

Nineteen persons present.

The death of Dr. Geo. Martin, a member, October 28, 1886, was announced.

NOVEMBER 9.

Mr. GEO. W. TRYON, JR., in the chair.

Twenty-two persons present.

The death of Chas. C. Phillips, a member, November 5, 1886, and that of John S. Haines, a member, November 4, 1886, were announced.

The Publication Committee reported that the paper entitled "The Genera Mesonyx and Pachyæna, Cope," by Wm. B. Scott, would be published in Vol. IX, Part 2, of the Journal of the Academy.

NOVEMBER 16.

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

Twenty-five persons present.

A paper entitled "On an Undescribed Meteoric Iron from East Tennessee," by F. A. Genth, Ph. D., was presented for publication.

On Petiolar Glands in some Onagraceæ.—Mr. THOMAS MEEHAN remarked that stipules were unknown in *Onagraceæ*, but in *Ludwigia* (*Isnardia*) *palustris* there were two minute conical gelatinous glands that appeared to be stipular. They existed in series of specimens representing the Atlantic and Pacific coast, and from Europe, those from California being larger than in specimens from other locations. They are found in all the species of *Ludwigia* and *Jussieua* that he had been able to examine. In these they appeared petiolar rather than stipular. In the dried specimens of *Circæa* a dark spot indicated the position occupied by the glands in other species. They mostly varied in form and exact position with the species, and only for having been wholly overlooked by describers might have afforded some good specific characters. The discovery he regarded as interesting, as confirming the views of those botanists who had brought *Turneraceæ*, in which the petiolar glands were known to exist, in close relation with *Onagraceæ*.

In the specimens of *Ludwigia palustris*, dried to exhibit with this communication to the Academy, a single capsule only, cut across for examination, projected the seed into his face while the capsule was being examined with a lens, indicating a projecting power not before known to exist in the species.

NOVEMBER 23.

Mr. JOHN H. REDFIELD in the chair.

Nineteen persons present.

Manganese Zinc Serpentine from Franklin, N. J.—Prof. GEORGE A. KOENIG placed on record the determination of a manganese zinc serpentine from Franklin, N. J. The material was collected in summer, 1885, as a very peculiar *Willemite*, so called at the mine. It is a very compact mineral substance, having a dark brown dull color and subconchoidal fracture, the splinters resembling horn chips. It is translucent on the edges, and when ground into a thin plate transmits a uniform brown-yellow light. Under the microscope this section of the purest material shows strings of minute black grains. Between two crossed nicol prisms the section appears light, proving a crystalline structure other than isometric. But a few grains, a light yellow in ordinary light, behave like an isometric substance, and are probably grains of yellow garnet, which is one of the associate minerals. Spec. gr. = 2·635. It is decomposed by sulphuric acid like Serpentine.

The mean of two well-agreeing analyses gave

SiO^2	= 42·20 (including 0·298 MgO, 0·2 ZnO).
Fe^2O^3	= 2·80
MnO	= 7·44
ZnO	= 3·90
MgO	= 29·24
H_2O	= 14·04
	99·62

Let Fe^2O^3 be supposed to be present as Franklinite, requiring 0·8 ZnO and 0·53 ZnO, then we have 4·15 per cent. of Franklinite mixed with the silicate, and the composition is now

SiO^2	= 41·70	: 1·390	
MgO	= 29·24	: 1·462	1·733 (MgO, MnO, ZnO)
MnO	= 6·91	: 0·194	
ZnO	= 3·10	: 0·077	
H^2O	= 14·04	: 1·533	
Franklinite	= 4·15		
Pyroxene	= 1·02		
	100·16		

This gives the ratio, $SiO^2 : RO : H^2O$
1 1·25 1·1

TORONTO, November 8th, 1907.

To the Members of St. Alban's Cathedral Congregation.

BELOVED BRETHREN,

In making my Annual Appeal to you on behalf of the Missionary Society of the Canadian Church, I regret to have to report a falling off in your contributions to this date from those of last year.

The figures stand as follows:—

	1906	1907
For Epiphany Appeal................	$32 53	$49 50
For Ascensiontide Appeal............	56 25	36 39
From Sunday School...............	77 50	42 18
	$166 28	$128 07

To make up this deficit of $38.21 will require a sum of $382.46 in Annual Subscriptions to bring the total up to that of last year, which fell short of the preceding year's by $115.05.

I therefore appeal to you most earnestly for the sum of $500 through this individual canvass, as the least contribution that can be regarded as worthy of our increasing and favoured congregation towards such a cause.

The flow of emigration from the Old Country into our North West is growing by leaps and bounds year by year, calling upon us to put forth our most strenuous efforts to seize the opportunity of building up a strong Church to be the bulwark of onr Canadian nation.

Our obligations to Japan, our chosen Foreign Mission Field, also steadily increase, while the awakening of China is loudly calling upon us to enter in and possess that mighty Empire in the name of Christ, the King of all the earth.

You will find herewith (1) a card on which to enter the names of all contributors in the family, with amounts, (2) an envelope for the card and contributions, to be placed in the Offertory plate at the Cathedral on the earliest Sunday possible.

All these envelopes should come in not later than the 15th of December.

Praying that you may all, old and young, have grace given you, to enlist heartily in the cause of the world's conquest for Christ and enjoy the blessedness of the cheerful giver and the earnest Missionary,

I am,

Your faithful Friend and Archbishop,

ARTHUR TORONTO.

60.00
10.00

70.00

171.00
20.00

28.00

1875.00

9.25
172.50
30.00

181.75

Under the circumstances, that is, in view of the microscope showing the admixture of an isometric or amorphous body, this ratio is sufficient to establish the material as a Serpentine.

Associated with the Serpentine, besides the minerals already mentioned, is a light grayish fibrous mineral. This is composed of Calcite and two Silicates, a silicate decomposable by Hcl (probably equal to the above serpentine), and a silicate insoluble in Hcl, which is probably a pyroxene. Several analyses have been made without establishing the nature satisfactorily.

On Miocene Fossils from Southern New Jersey.—Prof. HEILPRIN called attention to a limited collection of fossils from near Bridgeton and Jericho, Cumberland Co., New Jersey, representing the Miocene formation of that State. The species identified were: *Terebra curvilirata, Turritella æquistriata, Turritella Cumberlandia, Trochita centralis, Fissurella Griscomi, Chama congregata, Astarte distans (undulata), Crassatella melina, Arca centenaria, Nucula obliqua (proxima), Perna maxillata, Pecten Madisonius, Pecten* sp. ? *Orbicula lugubris.*

A number of these forms—nearly one-half—had not been identified in the State before, although fairly abundant in the Miocene tract of the region to the south. They are therefore interesting as bearing directly upon the question of horizon which the scantily-represented Miocene fauna of New Jersey indicates. The speaker stated that in his work, "Contributions to the Tertiary Geology and Paleontology of the United States" (1884), he had suggested that the probable position of the deposits in question would be found to be in the "Marylandian" series—Lower Atlantic Miocene—a view sustained by the additional fossils that have now been brought to light.

On the Helictites of Luray Cave.—Dr. CHARLES S. DOLLEY remarked that during a recent visit to the celebrated Luray Caverns his attention was called to the peculiar branching stalactites known as helictites (ἕλιξ, a spiral), and the question arose as to the method by which a stalactite gives off a horizontal branch at right angles; this branch in its turn perhaps sending out twigs at greater or lesser angles, and at varying degrees of inclination.

For a better opportunity of studying this interesting phenomenon he was permitted to visit in company with Dr. Leidy a chamber seldom opened to inspection, and which, from the delicate and fantastic character of its limy deposits, has been called the "Toy Shop." Here the stalactites were found to be of very recent formation, small, hollow, and increasing rapidly. Many branching specimens, or helictites, in all stages of growth, were to be seen. After some time spent in a vain search for an explanation of this anomalous structure, he happened to notice two specimens, the incipient branches of which were directed towards each other; stretched tightly between the branches, and entering the hollow tip of each, was a delicate thread, bearing a string of dew-like drops glistening brightly in the candle-light. Further search revealed numerous specimens in which the lime-water trickling down the stalactite met a similar filament, and being partially diverted had formed a drop at the point of junction; about this drop beautiful aragonite spicules were forming the hollow horizontal branch, the drop of water in the end being retained in position by the filament piercing it, and upon which it is gradually pushed along as evaporation deposits the lime behind it. The length of the branch depends, of course, upon the length of time in which the filament remains intact.

These filaments, which are thus seen to be the cause of the formation of lateral offshoots to stalactites, are the products of a small cave spider.

NOVEMBER 30.

The President, Dr. JOS. LEIDY, in the chair.

Thirty-three persons present.

A paper entitled "On Schorlomite as a variety of Melanite," by Geo. A. Koenig, M. D., was presented for publication.

On Hæmatoxylin in the Bark of Saraca Indica.—Miss HELEN C. DE S. ABBOTT stated that De Candolle[1] and Linnæus describe *Saraca Indica* as a member of the family Leguminosæ. According to De Candolle it belongs to the genus *Jonesia*, *Saraca* Linn., and is separated by five genera from the genus *Hæmatoxylon* or the logwood.

In an article on certain drugs indigenous to India, Dr. Waring[2] gives an account of the medicinal uses of the bark of *Saraca Indica*. The attention of Messrs. Parke, Davis & Co., Detroit, Michigan, was called to this drug, and through their correspondents in India they secured a supply, samples of which have been submitted to the speaker for a chemical analysis. The full results of this analysis will appear elsewhere, but it is now desired to announce a discovery of practical and scientific interest in this connection.

A coloring principle, identical with logwood dye, has been isolated by her from the bark of *Saraca Indica*, where it existed in two conditions, as hæmatoxylin and an oxidized product. The former was separated as yellow crystals, analogous in form to hæmatoxylin crystals from the true logwood, *Hæmatoxylon campechianum*. The alcoholic extract of the bark contained about 18 per cent. of a red colored substance, which agreed in color and dye tests with a like constituent found in logwood.

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[1] Pro. Sys. Nat. Reg. Vegetabilis, vol. ii, p. 487.

[2] British Med. Jour., June 6, 1885, p. 1145.

Mordanted cotton fabric was dyed with hæmatoxylin, extracted by ether from the *Saraca* bark, and presented the characteristic logwood dye colors.

The following is a table of dye wood colors with reagents, yielded by Brazil wood and logwood:[1]

Reagents.	*Brasilin.*	*Hæmatoxylin.*
Alkalies, ...	Claret-red sol., . .	Reddish purple sol.
Acids (dilute), . . .	Orange ppt., . . .	Pink solution.
" (strong), . . .	Yellow " . . .	" "
Alum sol., ...	Crimson-red ppt., .	Yellow then violet sol.
Lime-water, ...	" " .	Bluish purple ppt.
Ferrous salts, . . .	Purplish bl'k " .	" black "
Ferric " . . .	Brownish red " .	Black "
Copper " . . .	" " " .	Purple sol.
Lead " . . .	Crimson-red " .	Violet "
Mercuric " . . .	Yellow " .	Yellow "
Silver " . . .	" " .	Gray ppt.
Tartar emetic, . . .	Rose-colored " .	Purple sol.
Stannous chloride, . .	Red " .	" ppt.
Sodium aluminate, .	Claret-red " .	" "

The extracts of *Saraca Indica* bark, containing the coloring principle, were tested with these reagents, and it was observed that the reactions agreed with the hæmatoxylin colors, and in no case with those of brasilin. However, the colors produced by different alkalies varied in tints as she had found in both the logwood and *Saraca* extracts, but the general term "reddish purple solution" is comprehensive. A rose-violet precipitate was yielded by stannous chloride solution with the neutralized acidified extracts of the barks.

The bark of the logwood-tree is not used for making the commercial logwood extracts, the wood of the tree being employed for this purpose. The presence of a small quantity of hæmatoxylin was determined in the specimens of logwood-bark which she examined, and with the bark extracts the same reactions with reagents were obtained as with the logwood extracts, but owing to the smaller percentage of dye in the bark the colors were less intense. In the case of the *Saraca Indica* bark the colors were very brilliant and indicated the presence of a larger proportion of the coloring matter than in the logwood bark. These results should encourage investigators to secure specimens of the *wood* of the *Saraca*, in order to determine if it contains the coloring principle, and should this be ascertained affirmatively, whether it exists in sufficiently large quantities to warrant its introduction as a new source of this commercial product.

To exhibit the colors produced by alkalies upon the dye from

[1] S. P. Sadtler and Wm. L. Rowland, Am. Jour. of Phar., Feb., 1881.

logwood bark and *Saraca Indica* bark, the powdered material was macerated over the water-bath with distilled or filtered river water acidulated with dilute sulphuric acid (1 part to 50), the extract was filtered and the process repeated until no more color was removed. This extract was treated directly with the reagents. Excess of reagents produced darker tints, and after a time the solutions were decolorized.

Reagents.	*Saraca Indica.* / *Hæmatoxylon Campechianum.* } Bark. Acidified Extract.
Sodium Carbonate.	Pale purple to reddish violet sol.
Sodium Hydrate.	Blue violet ppt. and sol.
Potassium Hydrate.	Red-colored solution.
Ammonia.	Pinkish-purple solution.

Among other constituents contained in the Saraca bark, catechin and saponin were determined. Their presence along with hæmatoxylin is significant as showing the chemical position of *Saraca* in relation to the genera *Acacia* and *Hæmatoxylon ;* catechin and saponin being found, as is well known, in *Acacia.* The evolutionary position of the order Leguminosæ, to which these genera belong, was pointed out in a former paper,[1] and it was stated that all orders containing saponin came under the middle division of M. Heckel's botanical scheme,[2] or multiplicity of floral elements. The facts accumulated from recent researches, since the publication of her article in the *Botanical Gazette*, and the discovery of saponin in many plants of widely different genera and families, seem to justify and confirm what was stated in the article referred to above, "saponin is invariably absent where the floral elements are simple; it is invariably absent where the floral elements are condensed to their greatest extent. Its position is plainly that of a factor in the great middle realm of plant life when the elements of the individual are striving to condense, and thus increase their physiological action and the economy of parts."[3]

George McClellan, M. D., and George L. English were elected members.

Prof. E. Selenka was elected a correspondent.

The following was ordered to be printed :—

[1] Certain chemical constituents of plants considered in relation to their morphology and evolution, by H. C. De S. Abbott. Botanical Gazette, vol. xi, 1886, p. 270.

[2] Les plantes et la théorie de l'évolution, *Revue Scientifique*, 13 Mars, 1886.

[3] *Loc cit.* Botanical Gazette.

ON SCHORLOMITE AS A VARIETY OF MELANITE.

BY GEO. A. KOENIG, PH. D.

On the basis of a *titanium Melanite* from a new locality in Southwestern Colorado, the hypothesis is proposed that *Schorlomite* from Magnet Cove, Arkansas, may be considered as a Melanite in which Titanium replaces both Silicon and Aluminum. By a series of analyses of Schorlomite and Melanite, it is proposed to establish the above hypothesis beyond doubt. The following results are merely given as preliminary information.

The material from Colorado, obtained through Moritz Stockder, Mining Engineer at Lake City, shows the Melanite as black masses imbedded in a greenish yellow, fine granular matrix, with undefined boundaries. No crystal planes were observed. The color is deep black, brownish at thin edges, and in thin plates. It has an uneven fracture, rather resinous lustre. Sp. gr. = 3·689.

Thin sections under microscope show the homogeneous character and optical indifference of the substance.

B. B. several splinters fused at 3 with slight formation of bubbles (CO^2). Hydrochloric acid decomposes the mineral very slowly. The analysis gave in two determinations:

SiO^2	=	30·71
TiO^2	=	8·11
Al^2O^3	=	2·26
Fe^2O^3	=	22·67
CaO	=	34·29
MgO	=	0·304
CO^2	=	1·48 (loss by fusion).
		99·82

0·5 gr. decomposed in sealed tube required 2·2 cc. of permanganate (titre = 0·0058 Fe). $TiO^2 + Al^2O^3$ were separated from Fe^2O^3 by $(NH^4)^2S$ in tartaric solution, and Al^2O^3 from TiO^2 by acetic acid according to Gooch.

Assuming that Ti replaces Si the ratio is obtained $(Si, Ti)O^2$: $(Fe, Al)^2O^3$: CaO = 3·728 : 1 : 3·49. But assuming that Ti replaces the sesquioxides in part as Ti^2O^3 under the hypothesis that the permanganate was reduced by Ti^2O^3 we obtain 3·28 Ti^2O^3 as replacing alumina = 3·64 TiO^2. It having been ascertained that the loss by ignition is owing to CO^2 and not to water, its equivalent of CaO was subtracted. Thus corrected the composition of the mineral is:

SiO^2	= 30·71 : 60	= 0·5120	} 0·568
TiO^2	= 4·47 : 80	= 0·0560	
Ti^2O^3	= 3·29 : 144	= 0·0230	} 0·187
Fe^2O^3	= 22·67 : 160	= 0·1420	
Al^2O^3	= 2·26 : 103	= 0·0220	
CaO	= 32·41 : 56	= 0·5730	} 0·580
MgO	= 0·30 : 40	= 0·0070	
MnO	= trace		
$CaCO^3$	= 3·36		
	99·47		

This gives the ratio

$$(Si, Ti)O^2 : (Fe, Ti, Al)^2O^3 : (Ca, Mg)O^3$$
$$3{\cdot}03 \quad : \quad 1 \quad : \quad 3{\cdot}102$$

quite satisfactory to the formula of Garnet

$$Ca^3(Fe, Al)^2\, Si^3O^{12}$$

The greenish yellow matrix shows under the microscope an intimate mixture of three minerals, one of which is Calcite, one a green and one a white Silicate. Its composition is given without at present expressing an opinion as to its mineral nature.

Spec. Gr. 3·137

SiO^2	= 40·76
TiO^2	= 1·21
Al^2O^3	= 8·20
CaO	= 29·60
FeO	= 3·98
MgO	= 5·62
K^2O	= 0·89
Na^2O	= 0·96
Co^2+H^2O	= 6·96
	98·18

A specimen of Schorlomite from Arkansas was analyzed with great care to test the hypothesis that Schorlomite is simply a titanium Melanite. The material was like anthracite in lustre and color, quite opaque, even in thinnest sections. It decomposes readily with HCL. The reduced permanganate was calculated as Ti^2O^3.

Spec. Gr. = 3·876 at 23°C.

SiO^2	= 25·80 :	60 =	0·430	0·586
TiO^2	= 12·46 :	80 =	0·156	
Ti^2O^3	= 4·44 :	144 =	0·031	0·185
Al^2O^3	= 1·00 :	103 =	0·009	
Fe^2O^3	— 23·20 :	160 =	0·145	
CaO	= 31·40 :	56 =	0·561	0·597
MgO	= 1·22 :	40 =	0·030	
MnO	= 0·46 :	71 =	0·006	
	99·98			

This gives the ratio—

$$(Si, Ti)O^2 : (Fe, Ti, Al)^2O^3 : (Ca, Mg, Mn)O$$
$$3{\cdot}16 \quad 1 \quad : \quad 3{\cdot}22$$

While not so near to the normal ratio, it is near enough, especially considering the difficulty of estimating Ti^2O^3, in warranting the hypothesis that Schorlomite has the formula of garnet, is isomorphous with it, and exists, as the writer hopes to establish, in a complete series of intermediate members; so much so, that it will be impossible to say where Melanite stops and Schorlomite begins, even though every titanium Melanite be not called Schorlomite.

DECEMBER 7.

Mr. WM. W. JEFFERIS in the chair.

Seventeen persons present.

A paper entitled, "Observations on the upper Triassic mammals Dromatherium and Microconodon," by Henry F. Osborn, Sc. D., was presented for publication.

DECEMBER 14.

The President, Dr. LEIDY, in the chair.

Twenty-one persons present.

The death of Isaac Lea, LL. D. was announced.

The following was ordered to be printed:

OBSERVATIONS UPON THE UPPER TRIASSIC MAMMALS, DROMATHERIUM AND MICROCONODON.

BY HENRY F. OSBORN, SC. D.

In 1857 Prof. Emmons [1] described portions of three small mammalian jaws from the Upper Triassic (Chatham Coal Fields) of North Carolina, which he assigned to the new genus *Dromatherium.* The type-specimen is now in the Geological Museum of Williams College. Another specimen is in the collection of the Academy of Natural Sciences of Philadelphia. I cannot ascertain the whereabouts of the third fragmentary specimen mentioned by the author. I am indebted to Prof. Samuel F. Clarke, of Williams College, for an opportunity of studying the type specimen. Although slightly injured in the original removal of the matrix, this fossil is in beautiful preservation, and gives the complete mandibular dentition, with the exception of two molar crowns. I soon observed that my drawing, made under a camera, did not

Microconodon and *Dromatherium.* Natural size.

agree with that given by Emmons, in his American Geology, Part VI, p. 94, which has since been copied by Owen, Dana and others. This discrepancy was apparently explained later by a comparison of the Williams College specimen with that in the Academy of Natural Sciences of Philadelphia. In the latter, although the mandible is nearly complete, two molars and two premolars only are preserved, but these indicate a distinct genus. As Emmons referred both jaws to the same genus, it is not unlikely that he supplemented the rather obscure characters of the teeth in his type-specimen with the very obvious tooth patterns of the less perfect specimen. Thus, while the number of the molars in Emmons' drawing follows the type-specimen, their form resembles that observed in the Microconodon molars, which will presently be described.

Those familiar with the works of Professors Owen and Marsh upon the Mesozoic mammalia are aware that sharp distinctions

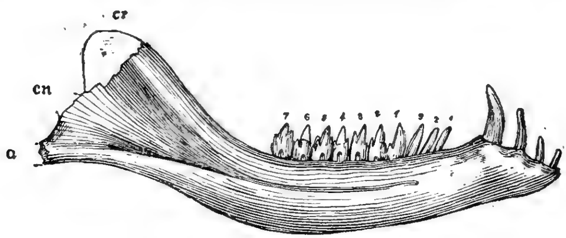
[1] American Geology, Part VI, pp. 93 and 94.

in the molar series of the mammals of this period do not exist. That is, the only distinction drawn between molars and premolars is one of form; we have no data as to permanent and deciduous dentition, except possibly in the genus *Triconodon.* The rule adopted is that, where the post-canine teeth are not all alike, the series of like form following the canine are called premolars; and those behind these, of another form, are called molars. This rule has been applied to all genera, excepting *Phascolotherium* and *Diplocynodon*, where all the post-canine teeth are practically alike.

DROMATHERIUM.

Dromatherium sylvestre Emmons.

Generic Characters.—Incisors and canines erect. Molars and premolars unlike. Molar-premolar series compact, leaving a wide diastema between the canine and first premolar. Premolars



Dromatherium sylvestre Em. Magnified.

high, styloid and procumbent, with no cingulum and probably single fanged. Molars bifanged with high pointed crowns and minute sometimes bifid cusps on the anterior slope and distinct pointed cusps on the posterior slopes. The dental formula is

$$I.\ \frac{-}{3} \quad C.\ \frac{-}{1} \quad Pm.\ \frac{-}{3} \quad M.\ \frac{-}{7}$$

The incisors are nearly erect, and are separated by interspaces equaling the diameter of their crowns, which indicates that the superior incisors interlocked with them. I_1 is low and small; I_2 is larger and more erect; I_3 is very high, slender and slightly recurved, resembling the canine. The canine is tall, stout and recurved, and in form is similar to the canine of *Peralestes.* There is no indication of a double fang. A wide diastema separates this tooth from the premolars. These teeth are styloid in shape, and strongly procumbent. The two anterior are apparently supported on single fangs. The crowns are subcylindrical, with obtuse tips. The third premolar is larger, more tapering from base to summit, and has an indication of a double fang. The first molar in general outline is transitional between the molars and premolars. On the anterior slope of the main cone, near the summit, is a fine accessory cusp; while near the base of the posterior slope is a more distinct cusp. The second molar has two accessory cusps on the anterior slope of the main cone, and one on the posterior slope placed half way down. The third molar differs from the others in the large size of the posterior cusp. On the anterior slope there is an indication of a small accessory cusp. In the fourth molar the crown tip is detached, but there is an indication of the usual anterior and posterior accessory cusps. The fifth molar, besides the anterior and posterior cusps, has the trace of a posterior cingulum and possibly of a postero-external cusp. The sixth molar is like the fourth. The seventh molar is the most complex tooth in the series; like the second, it has two accessory cusps on the anterior slope of the main cone, the uppermost of which is distinctly bifid. The posterior slope also has a bifid accessory cusp, and a faint basal cingulum. The anterior cusps throughout rise like needle-points on the sides of the teeth; the posterior cusps are more distinct. All the molars are compactly placed with high, rather narrow crowns, and deep depressions above the double fangs. The characters of these crowns were made out with the greatest difficulty, and a more perfect specimen may show slight difference of detail.

The mandible of *Dromatherium* is heavy and well-rounded in section. It is marked on its inner face by a deep mylohyoid groove, widening posteriorly into a broad pterygoid fossa. The upper border rises behind the molars into the coronoid process, *cr*. The summit of this process is broken, but a faint impression on the matrix shows that it had a high, slightly recurved outline. A small portion of the hind border seems to be preserved just above the angle which would indicate that the condyle, *cn*, was placed midway between the coronoid and angle, somewhat as in *Amblotherium*. The thick lower border has a gentle double curvature. There is no trace of the symphysial surface.

The unique character of the dentition separates *Dromatherium* widely from any known fossil or recent genus.

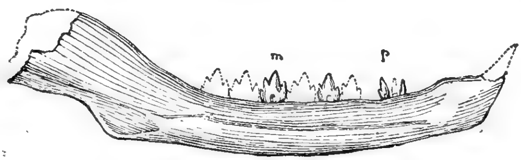
MICROCONODON.

Microconodon tenuirostris, gen. et sp. nov.

This genus is founded upon the specimen in the collection of the Academy of Natural Sciences of Philadelphia, which was described by Emmons as *Dromatherium.*

Generic Characters.—A wide diastema between the canine and first premolar. Molars and premolars unlike. Premolars simple, erect cones with a faint posterior cingulum and partly bi-fanged. Molars bi-fanged with broad crowns supporting a large median cusp, at the sides of which are anterior and posterior conical cusps, sub-equal in size, and a distinct posterior cingulum.

The ramus is about two-thirds the length of that of *Dromatherium.* Its general lower curvature is single. There is a depression extending beneath the molar-premolar series, but this is shallower than the mylohyoid groove, and I infer that the outer



Microconodon tenuirostris Osb. Magnified.

surface of the jaw is the one exposed. The coronoid rises by a gentle curvature above the molars and the fractured portion seems to have left a faint impression on the matrix, which indicates a low rounded contour. The posterior half of the lower border is marked by a downward process, somewhat similar to that in *Peramus.* The surface of the process bears a shallow fossa. Above this the crotaphyte fossa is faintly marked. The symphysial portion of the jaw is partly fractured. The matrix bears an impression which may have been left by a tooth, but more probably is accidental. Altogether, the delicate character of this ramus indicates an animal of feebler masticating power than *Dromatherium.*

The molars probably extended backward to the rise of the upper border. If so, the molar-premolar series covered a greater proportional space than those of *Dromatherium.* This arose from the comparatively broader crowns of the molars. By analogy with several other Mesozoic genera, we may suppose that the foremost molar preserved is the second, and that behind the hindermost were two other molars. This would give four premolars and six molars. Or there may have been three premolars and seven molars as in *Dromatherium.* Unfortunately no casts are preserved to settle this point, and the restoration of the missing teeth is purely conjectural.

The molars are somewhat like those of *Amphitherium* except that the crowns are higher and the anterior and posterior cusps arise from the sides of the main cusp instead of from the base of the crown. The posterior basal cusp which may be the continuation of an internal cingulum is well marked, as is the depression between the two fangs. The third premolar is much larger than the first, and has an indication of two fangs. There is a trace of the fang of the intermediate premolar. These teeth, unlike those of *Dromatherium*, are erect and do not rise to the level of the molar crowns. The simple premolars differentiate the genus from *Amphitherium.*

PRINCETON, N. J., *December 20th.*

DECEMBER 21.

Mr. JOHN H. REDFIELD in the chair.

Fourteen persons present.

A New Species of Aplysia.—Prof. HEILPRIN exhibited specimens of a new species of *Aplysia*, or sea-hare, from Little Gasparilla Bay, west coast of Florida. The animal in general appearance was probably most nearly related to the European *A. depilans* (*leporina*), but differed in several well-marked points of structure, notably in color, the position of the buccal aperture, and in the character of the pore connecting with the shell cavity. While in *A. depilans* the mouth is placed beneath the tentacular lobes—*i. e.*, the latter are superior—in the Florida species it is central with regard to these organs, the lobes being circumferentially connate, and completely encircling the aperture. The pore leading to the shell-sac is minute, and raised on a small papilla; the stellate markings radiating from the base of the papilla are very feeble, and can barely be discerned without close examination. The shell, which is about an inch and three-quarters in length, is horny-calcareous, deeply emarginate, and striated longitudinally and transversely. General color of the animal sea-green, tinged with purple, and irregularly blotched and speckled with spots of lighter color. Length, 7–8 inches. The animal emits a brilliant crimson fluid. It was proposed to name the species *Aplysia Willcoxi.*

ALBERT DOD BROWN.

Announcement having been made that the collection of shells formerly belonging to ALBERT DOD BROWN had been presented to the Academy by his mother, Mrs. Susan D. Brown, Dr. A. E. Foote stated that Mr. Brown, who was formerly Curator of the Princeton College Museum, died April 30, 1886, aged 45 years. He had a well-recognized reputation as a student of conchology, botany, and horticulture, the latter years of his life having been devoted to the last-named pursuit. He was one of the founders of the Conchological Section of the Academy, and was for years associated with it as a member.

The collection now given to the Academy is to be known by his name, but no other condition accompanies the generous gift. A valuable portion of the collection consists of the cabinet of the late Mr. Thomas Bland, including his types of West Indian shells. By this valuable accession about five thousand species of shells represented by perhaps thirty-five thousand specimens have been added to the already unrivaled Conchological cabinet of the Academy.

DECEMBER 28.

The President, Dr. LEIDY, in the chair.

Thirty-five persons present.

The following was ordered to be printed :—

ON AN UNDESCRIBED METEORIC IRON FROM EAST TENNESSEE.

Plates IV and V.

BY F. A. GENTH.

The history of this interesting meteoric iron is very meagre. In August, 1867, I received from the late Dr. Isaac Lea a small fragment, weighing about five grams, with the request to determine whether or not it was meteoric iron. The analysis (1), finished August 11, 1867, proving it to be meteoric iron, induced Dr. Lea to purchase the specimen.

Under date of May 11, 1868, the late Julius E. Raht, of Cleveland, Tenn., wrote me: "I send you to-day a small piece (it weighed 44 grams.—F. A. G.) of meteoric iron, which was broken off from a mass, weighing fifty pounds, which *fell* about eight years ago near the State line of Georgia, ten miles from here (Cleveland, Tenn.). The piece has been sold into Mississippi."

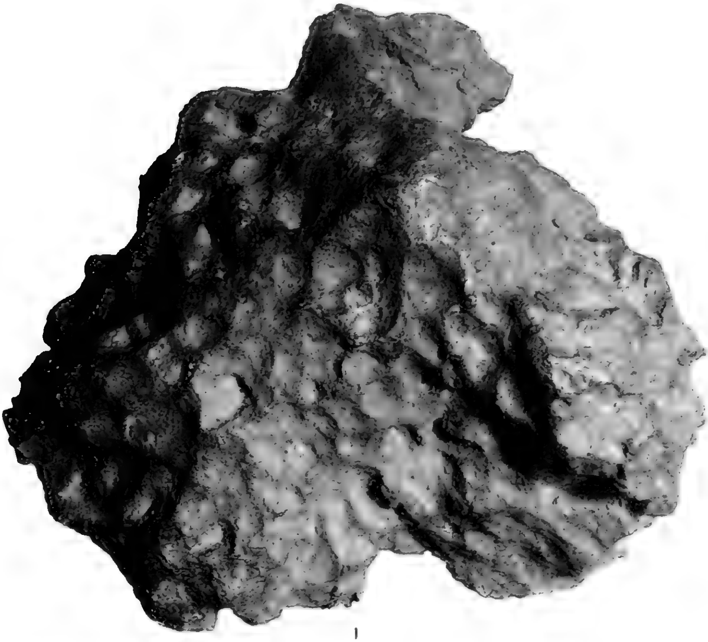
In the fall of the year 1868, the late Dr. James L. Smith, of Louisville, Ky., the celebrated investigator of meteorites, on his return from Europe, wrote to Dr. Isaac Lea, congratulating him on the acquisition of the *Mississippi* meteorite, regretting at the same time that his absence in Europe had prevented him from securing it for his own cabinet.

It now remained in the possession of Dr. Lea, until he presented it to the Academy of Natural Sciences of Philadelphia. The Museum record of the Academy simply notes the date of its reception, on October 24, 1876, that it was from the mountains of East Tennessee, and that it weighed 254 pounds. All my efforts to obtain fuller information about its fall and discovery have proved unsuccessful.

The discrepancy between the weight given by Mr. Raht and the actual weight of the mass, must be charged to incorrect information received by Mr. Raht; this is insignificant, however, compared with the proof which Dr. Smith's letter gives to the fact that his Mississippi meteorite is identical with the one which Mr. Raht stated to have been sold into that State.

The mass shows on one corner the place where the 44 grams which Mr. Raht sent me had been broken off.

It is an irregularly shaped, somewhat triangular mass, the largest diameter being about 45 cm., the height about 40 cm. and its greatest thickness about 22 cm.

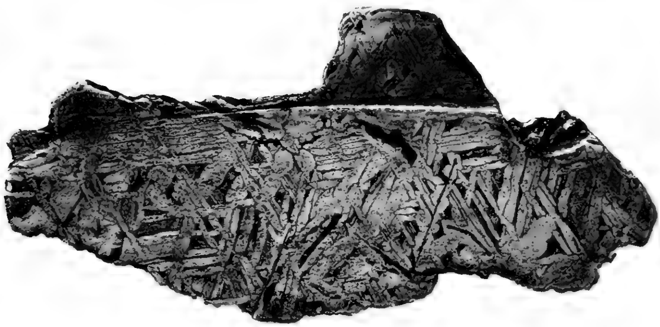


1

2

GENTH, METEORIC IRON FROM EAST TENNESSEE.

1



2

3

GENTH, METEORIC IRON FROM EAST TENNESSEE.

Its crust is very thin and mostly free from rust, only here and there covered with small spots of the same. It shows one fracture, which, however, cannot be seen on the photographic representation on Plate IV, as it is on the opposite side near the indentation, and extending for about 15 cm.; its widest part is about 10 mm. in size.

This meteoric iron appears to be an original whole mass, and not a fragment torn off from a larger one; its surface is pitted all over and shows numerous depressions and excavations, from a few centimetres in diameter and depth to about 15 cm. in length, 8 cm. in width and nearly 5 cm. in depth. The photograph shows beautifully the pitted appearance of the mass.

Its original weight was nearly 115·5 kilos.; probably 2·5 kilos. have been cut off in slabs which have been distributed amongst learned societies and individuals.

The crystalline structure of this meteorite is beautifully shown on three etched slabs which are represented in their natural size on Plate V, 1 from my cabinet, 2 in the Vaux Collection, and 3 in the general collection of the Academy of Natural Sciences. All three show the very perfect octahedral structure of this meteorite. The specimen presented to me by Mr. Raht gave on etching exactly the same crystalline structure, which adds another proof that both came from the same piece.

The usual constituents of this class of meteorites are quite perceptible: the Kamacite (Balkeneisen) largely predominating and forming bands from 1 to 3 mm. in width. The Taenite (Bandeisen) enveloping the Kamacite, frequently subdividing in narrow lines the broader bands of the latter. The length of the Kamacite individuals is from 1·5 cm. to 2 cm. It has a dull gray color; when magnified, it can be seen to be intersected in every direction by very fine lines, probably of Schreibersite. The Plessite, somewhat darker than the Kamacite, mostly shows a very fine crystalline, mottled structure (moire metallique) and a glittering lustre; a small portion, however, is quite dull and much darker.

On my specimen, fig. 1, Plate V, there is in two places a remarkable admixture of an iron which is a great deal smoother and hardly shows any crystalline structure. One begins about 9 mm. below the right-hand corner, first forming a somewhat oval mass of 2 to 3 mm. in diameter and then extending in a dagger-shaped form for 7 mm.; the other is 15 mm. from the right edge and 8 or 9 mm. below the border, about 12 mm. long, on both ends 1·5 mm. and in the centre about 1 mm. wide. This iron is brighter than any other portion of the edged surface and has a slightly yellowish hue. The patches are not perfectly smooth, however, but show many very minute depressions. In the centre where this iron is narrowest and on some portion of the unetched surface of my slab, small spots of rust have made their appearance. An examination proved the presence of considerable quantity of chlorine, from which it is evident that they are the result of the oxidation of ferrous chloride, which this meteorite contains in small quantities.

The so-called "*alteration zone*" next to the *brandrind* is quite distinct and from 1 to 1·5 mm. in width.

I have made three analyses of this meteoric iron, the first nearly twenty years ago, of the slightly rusty fragment, sent by Dr. Lea (1), the second of a perfectly fresh fragment of that portion cut off for specimens (2), and the third of the carefully purified sawdust obtained by this operation, which represents the average composition of the whole mass where it was cut (3).

They gave the following results:

	1.	2.	3.
Specific gravity =			7·521
Iron =	88·92	89·940	89.93
Copper =	0·23	0·080	0·06
Nickel =	9·82	8·507	8·06
Cobalt =	0·77	0·690	0·56
Phosphorus =	0·19	0·109	0·66
Sulphur =	not det'd.	0·006	not det'd.
	99·93	99·332	99·27

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, 1886, twelve members and four correspondents have been elected.

Resignations of membership have been received and accepted on the usual conditions, from Dr. Charles Harrod Vinton and Jerome B. Gray.

The deaths of seventeen members and one correspondent have been announced.

Eighteen papers have been presented for publication, as follows:—Prof. Angelo Heilprin, 2; Chas. Morris, 2; S. Frank Aaron, 1; Calvin McCormick, 1; W. D. Hartman, 1; C. Rominger, 1; Chas. D. Dolley, 1; Geo. Vasey, 1; Jos. Leidy, 1; J. C. Arthur, 1; Thos. Meehan, 1; Lillie E. Holman, 1; John W. Eckfeldt, 1; Wm. B. Scott, 1; F. A. Genth, 1; Geo. A. Koenig, 1.

One of these has been withdrawn; one will be printed in the Journal; one has been deferred in consequence of the inability of the Publication Committee to provide the required illustrations, and the others have been reported on favorably and form part of the current volume of the Proceedings.

One hundred and twenty-eight pages of the Proceedings for 1885, and three hundred and twenty-eight pages of the volume for 1886 have been printed, together with three plates.

Four foreign societies have been added to the list of exchanges to which the Academy publications are sent, making the entire number at present 379.

The average attendance at the meetings has been 21. Verbal communications have been made and for the most part reported for the Proceedings by Messrs. Meehan, Koenig, Heilprin, Woolman, Moody, Morris, Potts, Leidy, McCormick, Holman, A. H. Smith, Seiss, Holstein, Allen, Brooks, Sharp, Harvey, Willcox, U. C. Smith, Foote, Gibbons, Horn, Lockington, McCook, Lewis, Ryder, Dolley, Redfield, Tryon, S. R. Roberts and Miss Abbott.

At the meeting held June 22, the Academy, by resolution, joined with other scientific societies in an invitation to the International Congress of Geologists, to hold in America, the meeting after that provided for in London.

On November 2, a committee consisting of Messrs. U. C. Smith, Thos. Meehan, Angelo Heilprin, Rev. Henry C. McCook and T. D. Rand, was appointed to solicit aid from the Legislature in the erection of an addition to the present building. No result has as yet been reported to the Academy.

All of which is respectfully submitted.

EDW. J. NOLAN,
Recording Secretary.

REPORT OF THE CORRESPONDING SECRETARY.

During the year the duties of the Corresponding Secretary have been unusually light, and have consisted in great part of the reception of acknowledgments from corresponding societies of publications sent by us and the usual letters of transmittal from them. As many of our exchanges are now sent through the mail, the acknowledgments are in the form of postal cards, which indicate by their dates how much earlier our publications are brought to the notice of the scientific world.

The four corresponding members elected during the year have been promptly notified, and letters in return have been received from them and read to the Academy.

The donations to the Museum have been many and important, as will appear in the Curators' report. It is one of the duties of my office to send receipts for these, but to the Curator-in-charge I must acknowledge my indebtedness for the fulfillment of a duty of which I officially know nothing, having merely affixed my signature in former years.

Very little correspondence of a miscellaneous nature has been received, the Bureau of Scientific Information having apparently been communicated with directly.

Acknowledgments of the receipt of our publications have been received by postal card, in total, 56; representing foreign societies, etc., 12; American, 15; Canadian, 3.

Letters of acknowledgment, numbering . .	105
From British and Colonial Societies, etc., . .	16
From Continental European Societies, etc., .	18
From American Societies, etc., ...	15
Letters of transmittal, number in total, . .	36
Representing twenty-eight foreign societies, etc., and but two American.	
Letters asking deficiencies and desiring exchange, number	11
Miscellaneous letters, ...	11

The number of societies with which we exchange publications shows an annual increase greatly to the advantage of those who use the library.

Respectfully submitted,

George H. Horn, M.D.,
Corresponding Secretary.

REPORT OF THE LIBRARIAN.

I have the pleasure of reporting to the Academy that 3765 additions have been made to the Library from December 1, 1885, to November 30, 1886. These consist of 481 volumes, 3245 pamphlets and parts of periodicals, and 39 maps.

We are indebted to the following for the additions, a detailed list of which accompanies the report:—

Societies, ...	1513
Editors, ...	915
Isaiah V. Williamson Fund,	648
Authors, ...	323
C. H. Hitchcock, ...	46
Department of the Interior, .	30
University of Kiel, ...	30
Wilson Fund, ...	24
War Department, ...	24
Geological Survey of Sweden,	23
University of Wurzburg, . .	14
Stuart Wood, ...	13
Thos. Meehan, ...	11
Geological Survey of Belgium,	11
Geological Survey of Pennsylvania, ...	10
British Museum, ...	9
Dr. Jos. Leidy, ...	7
Chas. M. Betts, ...	7
Geological Survey of India, .	7
Her Majesty's Government, .	6
Treasury Department, ...	6
Engineer Department, U.S.A.	5
Australian Museum, . . .	5
Geological Survey of New Jersey, ...	5
George Vaux, ...	4
Geological Survey of Russia,	4
Cambridge Scientific Instrument Company, ...	4
Geological Survey of Roumania, ...	4
United States Commission of Fish and Fisheries, . . .	3
Geological Survey of Canada,	3
Smithsonian Institution, . .	3
Hon. Charles O'Neil, . . .	2
J. Stockton Hough, . . .	2
George W. Tryon, Jr., . .	2
E. Indian Government, . .	2

Wm. John Potts,	2	Geological Survey of Portugal,	1
Minister of Public Works in France,	2	Adele M. Fielde,	1
S. R. Roberts,	1	Department of Agriculture, Canada,	1
J. Fletcher Williams,	1	Geological Survey of New Zealand,	1
Royal College of Surgeons,	1	S. H. and H. Chapman,	1
Bureau of Ethnology.	1	In Exchange (other than periodicals),	18
Isaac Lea,	1		
Charles C. Abbott,	1		
University of Pennsylvania,	1		
Department of Agriculture,	1		

They were distributed to the several departments of the Library as follows :—

Journals,	2696	Bibliography,	15
Geology,	315	Encyclopedias,	13
General Natural History,	130	Agriculture,	13
Botany,	92	Mammalogy,	13
Conchology,	74	Anthropology,	12
Anatomy and Physiology,	62	Ornithology,	12
Chemistry,	62	Helminthology,	10
Mineralogy,	58	Ichthyology,	7
Physical Science,	47	Languages,	6
Medicine,	36	Geography,	5
Voyages and Travels,	35	Herpetology,	2
Entomology,	24	Miscellaneous,	23

It will be seen from the above summary that our main dependence for increase during the year has been, as heretofore, upon our exchanges and the I. V. Williamson Fund.

Through the kindness of friends of the Academy I have been again enabled to avail myself of the assistance of Sig. Emanuele Fronani during the four months from June 14 to October 14, inclusive. Besides helping me with the routine work of the Library, especially during my vacation, he has completed the copying of more than half of the card catalogue. This work has progressed slowly, as it is only during the engagement of the assistant that time can be devoted to it. It is, however, desirable that means should be provided for placing the cards now prepared at the service of those using the Library. Additional cases for the reception of journals, also, are now absolutely necessary, and it is hoped that an appropriation may be made early in the year for their erection. No other department of the Library grows so rapidly, and it is impossible to maintain the geographical arrangement which has been found convenient without more room.

For the reason that I have had to refer to so often before, namely, lack of funds, I have been able to have but 168 volumes bound since the last report. These have been for the most part Williamson books, the work being paid for from the I. V. Williamson fund. Nearly all our exchanges and accumulated pamphlets remain unbound, thereby not only exposing the Library to loss, but causing serious inconvenience to readers and students. A liberal appropriation for binding, therefore, is one of our immediate and pressing needs. It will be seen by the accompanying list of journals and periodicals received, that our exchanges have been kept up and increased. The applications made for deficiencies last year have been productive of their full result, and the gaps still existing will probably have to be supplied by purchase.

The shelf list begun last year has been carried forward as rapidly as my other duties would permit. Four or five sections of the Library yet remain to be included, but even in its incomplete condition the catalogue has proved useful in locating accessions, detecting displacements and facilitating reference to the shelves.

All of which is respectfully submitted.

EDW. J. NOLAN,
Librarian.

REPORT OF THE CURATORS.

The Curators present the following statement of the Curator-in-Charge, as their report for the year 1886:—

The Curator-in-Charge respectfully reports that during the past year the work of arranging, classifying and preserving the collections of the Academy has made considerable progress, for which, as heretofore, the institution is largely indebted to volunteer labor. The special thanks of the Academy are due to Mr. George W. Tryon, Jr., Conservator of the Conchological Collections, to Mr. John H. Redfield, Curator of the Herbarium, and to Mr. Jacob Binder, Curator of the Collection of Minerals covered by the Wm. S. Vaux Trust, for their disinterested labors in their several departments. To the Entomological Section, likewise, acknowledgment is due for work done in connection with the caring of the collection of insects.

In the departments other than those here indicated, the work has been done under the immediate superintendence of the Curator-in-Charge and his assistant. Almost the entire collection of recent Invertebrata contained in the Museum—barring the Mollusca—has been re-arranged and re-classified, and the different groups have been so placed as to follow one another serially according to their position in the natural scale. The very extensive series of crabs, which have heretofore occupied the window spaces on the first gallery, filling some twenty-four cases, have been intercalated with the general collection of Invertebrata on the top floor, where they occupy practically the entire western wall. A re-arrangement of the Carcinological groups, following Gerstæcker, has been effected. By this shifting of the collections, the first gallery will be relegated exclusively to ornithology, the vacated window cases having been removed to the main floor to relieve the crowded condition of the geological and paleontological collections. Despite this large accession of table cases, and the addition of an equal number from other parts of the hall, the collections of Invertebrate Paleontology will barely find accommodation. Roughly estimated the fossils of the different geological formations fill some 20,000–22,000 trays, and in point of individual numbers probably do not fall short of 75,000–80,000 specimens, or about one-half the number that is registered in the department of recent conchology. The work of arranging the American series of fossils is now practically complete, and considerably over three-quarters of the collection is permanently labeled. The re-labeling of the entire series of fossils collected by the late Wm. M. Gabb in Santo Domingo and California has been effected during the year, and much has been done toward re-determining the type fossils of the first New York survey, collected by Mr. T. A. Conrad. The largest and most important accession to this department is a collection of fossils from the Miocene and Pliocene formations of the State of Florida, collected in the early part of the year by the Curator-in-Charge, to whom leave of absence had been granted by the Academy for the purpose of prosecuting researches and collecting, in conjunction with the Wagner Free Institute of Science. This collection, together with an extensive series of invertebrates dredged in the Gulf of Mexico and in the inland waters of the State, have not yet been placed in the Museum proper, but are temporarily deposited in a side room, where the specimens may be conveniently studied and determined. This work is now accomplished in great part.

Some attention has been given during the year to the re-arranging of the collections of Vertebrata. The lizards have been removed from the south wall of the second gallery to the east wall, and the amphibians to the north wall, thereby placing the collection of reptiles in a continuous series. In the department of Ornithology, beyond a general oversight of the collections, no work has been accomplished. Some four or five Dermestes-eaten specimens, which had apparently not been properly cured, have been permanently removed from the cases, being no longer fit for exhibition. Barring such sporadic cases of destruction the collection is in a fairly good condition; nevertheless, it is absolutely necessary that an early examination of all the specimens be made by an expert taxidermist, and such steps be taken as will insure the collection from further loss.

Work in the department of Vertebrate Paleontology has been almost exclusively restricted to the collections of mammals and fishes; both of these have been entirely re-arranged, and are now much more accessible than they have been heretofore. The large specimens of fossil reptiles from the Lias of England, the valuable gift of Dr. T. B. Wilson, which had been built up into cases on the main floor of the Museum, have been permanently placed on the wall surface of the vestibule, where they are displayed to good advantage. It is designed to cover the remainder of the wall-space with two large maps, respectively illustrative of the geology of the national domain and of the zoogeographical regions of the earth's surface. The undersigned has charged himself with the preparation of this work.

The collection of alcoholics is in good condition, the entire series having been overhauled as in previous years. Considerable alteration has been made in the disposition of the cases throughout the Museum hall, and much floor space has been gained thereby; but such gains are far from sufficient to satisfy the wants of the institution, the future usefulness of which will be largely impaired unless immediate aid toward the erection of an extension to the present building is afforded. It is well within the truth to say that the existing collections, if properly displayed, would completely fill a building of twice the dimensions of the present one. The large and very valuable collections of the

Pennsylvania Geological Survey, contained in upwards of 200 cases, still remain in the cellar, boxed, for want of exhibition space. The types of the greater number of the fossil plants described by Lesquereux in his Coal Flora of the United States, probably one of the most valuable collections of fossil plants in the world, have been added to this collection during the year, but, for similar reasons, still remain boxed. The report of the Professor of Ethnology and Archæology indicates that accessions to this department of the Academy's Museum could readily be had were proper exhibition space provided, but that under present conditions the same is impossible. In view of these facts the necessity for an extension to the Academy's building cannot be too strongly insisted upon.

Of equal importance to the future welfare of the institution is a fund designed for the purposes of zoogeographical exploration. As suggested in our last report, the interest derived from a principal fund of $50,000 would fairly equip an annual expedition to any of the largely unexplored regions lying about our domain, such as Mexico, Central America, the Bahamas, Labrador, etc. Only through this method of research can it be hoped to bring in large accessions of new material to the working naturalist, and thereby place him in direct relation with the problems of nature. The success attending the Florida Expedition of the Wagner Free Institute of Science of this city, which was organized with the co-operation of the Academy in the winter of the present year, fully demonstrates the wisdom of such a plan of explorations, at the same time that it proves its ready feasibility and possible economic character.

Specimens have been loaned for study during the year to Profs. Whitfield and Britton, of New York, to Profs. Osborn and Scott, of Princeton, and to Messrs. Ridgeway and Vasey, of Washington, all of whom have rendered service to the institution in the determination and description of its specimens. The Academy has also profited through the studies of three Jessup Fund beneficiaries, who have at various times rendered service to the Curator-in-Charge; to these persons the Curator-in-Charge begs to tender his thanks.

Very respectfully,

ANGELO HEILPRIN,

Curator-in-Charge.

REPORT OF THE CURATOR OF THE WILLIAM S. VAUX COLLECTIONS.

The Curator of the William S. Vaux collections respectfully submits his fourth annual report to the Council of the Academy of Natural Sciences:—

The collections are in good order and condition, no change having been made since the report of 1885, except the introduction of one hundred and fourteen mineral specimens, purchased by the approval of the Curators of the Academy, during the year ending November 30, 1886.

No. of mineral specimens as by report of Nov. 30, 1885,	6,516
Purchased between Nov. 30, 1885, and Nov. 30, 1886, .	114
Total, ...	6,630
Archæological specimens (same as noted in report of 1885), no additions, ...	2,940

The growth of the collection since it came into possession of the Academy is as follows:—

Nov. 30, 1884, specimens purchased, ...	60
Nov. 30, 1885, specimens purchased, ...	104
Nov. 30, 1886, specimens purchased, ...	114
In all, ...	278

These 278 specimens have been purchased at an aggregate cost of $1448.70.

It will be conceded that the new material added to the mineralogical collection since 1883 has very materially improved its character, not only in beauty, but for scientific study.

Among the specimens most worthy of special note which have been added are a number of fine transparent crystals of Topaz from Siberia. One of these is a crystal $1\frac{1}{2}$ inches square, $2\frac{1}{4}$ inches in height, on a matrix of Feldspar, coated with Albite; it is a well terminated rhombic prism, showing the basal cleavage planes with great beauty. Also worthy of mention are a fine specimen of Zircon from Canada, weighing $12\frac{1}{2}$ pounds, made up of a group of square prismatic crystals, measuring $3\frac{1}{2}$ x 4 inches and $9\frac{1}{2}$ inches in height; a specimen of Stibnite from Japan, a cluster of long, well terminated crystals, with interesting modifications $2\frac{1}{2}$ by $3\frac{1}{2}$ inches, 18 inches long; specimens of Vanadinite, Wulfenite, and Descloizite, from Arizona; emerald and Hiddenite from North Carolina. The Tourmalines, Rutiles and Molybdenites, already well illustrated, have received rich addition.

A number of new species, not before represented in the collection, have been obtained together with many varieties from new localities.

All the income of the fund has been expended on the collection, except a balance in hand of $513.54, applicable to the purchase of new specimens and of books. As the cases are now paid for and no other expense anticipated, the entire income can be used for the purchase of additional specimens and books, which will—unless some unforeseen accident occurs—always keep the collection up to a high standard of importance. From a scientific point of view it is one of the best public collections in our country.

Respectfully submitted,

JACOB BINDER,

Curator.

REPORT OF THE RECORDER OF THE BIOLOGICAL AND MICROSCOPICAL SECTION.

During the year the Section held fourteen meetings, with an average attendance of twelve persons.

At these meetings a great variety of objects was shown. Especial notice should be made of the observations on embryology at various meetings by Messrs. Sharp, Wingate and Ryder; upon the fungi, by Dr. Rex, and upon the different methods of mounting, by Drs. Hall and Brinton.

The following are some of the more important events occurring during the year:—

December 21, 1885. Lecture by Dr. Thomas Taylor, of the Agricultural Department, Washington, upon "The Work and Results in the Investigation of Butter and other Fats."

February 1, 1886. Communication by Mr. H. Wingate, upon "The So-Called Visual Organs of the Amphioxus."

February 15, 1886. Communication by Dr. M. B. Hartzell, upon "Glycerine as a Mounting Fluid."

Four lectures were delivered in course by Dr. Benjamin Sharp, upon the "Special Senses," October 18.

Communication by Prof. J. A. Ryder, upon "The Eggs of Pelagic Fishes;" by Mr. H. Wingate, upon "Cribraria purpura."

November 1. Communication by Dr. L. B. Hall, upon the "Comparative Merits of Demar and Canada Balsam mounts;" by Prof. J. A. Ryder, upon the "Moulting of the Lobster," also on a "New Section Cutter;" by Dr. J. B. Brinton, upon a "New Cell for Opaque Objects."

November 15. Communication by Dr. George A. Rex, upon "The Use of the Brass Cell."

Two new members were elected: Dr. Charles S. Dolley, Prof. John A. Ryder.

Mr. E. S. Campbell resigned as a contributor.

The Section passed a resolution of respect upon the death of Dr. J. G. Richardson, who, although not connected with the Section at the time of his death, had been at one time an active and useful member.

Very respectfully,

Robert J. Hess,

Recorder.

REPORT OF THE CONCHOLOGICAL SECTION.

The Recorder of the Conchological Section respectfully reports that during the year ending December 1, 1886, the Academy has continued the publication of conchological papers as heretofore. The death of one member has occurred, that of Mrs. Lucy W. Say, the venerable and esteemed widow of the eminent naturalist, Thomas Say, which occurred November 15th last, at the advanced age of 86 years.

No new members or correspondents have been elected, nor has there been any change in the By-Laws of the Section.

Mr. George W. Tryon, Jr., Conservator, reports as follows:—

"During the past year, thirty-nine donations and purchases of shells have been received from twenty-six persons, aggregating 1252 trays and 7506 specimens. A detailed list of these accessions is appended (see 'Additions to Museum').

"Among them may be especially mentioned the purchase of nearly 500 species from Greece and the eastern portion of the Mediterranean Sea, collected by Mr. Conemenos; and another purchase of 277 species from southern France and the western part of the Mediterranean, collected by M. Dollfus.

"From the Polynesian and Australian regions we have received important collections from Mr. John Brazier, of Sydney, Australia, Mr. Andrew Garrett, of Papeete, Taheiti, and Mr. W. F. Petterd, of Hobart, Tasmania; these collections, numbering about 200 species, were mostly new to our museum.

"Shells of our own country have been received from Messrs. Binney, Dall, Dore, Ford, Hermann, Heilprin, Jefferis, Leidy, Mazyck, Morrison, Morse, Orcutt, Pilsbry, Quintard, Redfield, Rush, Sharp, Singley, Stearns, Thompson. These collections embrace some of the new and rare species needed to complete our series, but for the most part add new localities for species already possessed by us. Your Conservator purchased from Mr. Sowerby, of London, and presented about 100 species, all new to us, and filling some important gaps in the collection.

"The Conchological Museum now contains 45,184 trays and written tablets, and 165,858 specimens.

"Mr. Frank Stout has, as usual, mounted and labeled the accessions of the year, and they have been distributed to the cases in the museum by Mr. Wm. B. Marshall.

"The work of redetermining the collection, in connection with the preparation of monographs of the genera for the 'Manual of Conchology,' progresses steadily. Our species of the families Calyptræidæ, Xenophoridæ, Turritellidæ, Cæcidæ, Vermetidæ, Pyramidellidæ, Turbonillidæ and Scalariidæ, have been carefully studied by your Conservator; the Solariidæ by Mr. Marshall. In the land shells, the Zonitidæ have been completed, and a commencement made upon the Helicidæ.

"In accordance with the new plan of arrangement of the Museum sketched in the last Annual Report, a considerable portion of the marine gastropods have been classified, both in the Systematic and Geographical Series, and the Synoptical Collection (a representation of the principal generic types, with printed descriptions of their characters) has been finished. It is believed that for completeness, beauty of arrangement and adaptability to the needs of students, these several collections will compare favorably with similar ones in any other museum. An index is intended to be added to the Synoptical Series, by the aid of which the student, after determining the genus of any specimen, will be referred to the case containing the species; in the latter he will find represented, either by specimens or colored illustrations, all the (figured) species of the genus known to science, arranged in the order of their natural relationships.

"Much of the success of these features of arrangement is due to the efficient co-operation of my assistant, Mr. Marshall.

"Messrs. J. H. Redfield, S. R. Roberts and Wm. L. Mactier, have contributed to the Section's collection of autograph letters of conchologists."

The officers of the Section for 1887 are—

Director, ...	W. S. W. Ruschenberger.
Vice-Director, . . .	John Ford.
Recorder, ...	S. Raymond Roberts.
Secretary, ...	John H. Redfield.
Treasurer, ...	Wm. L. Mactier.
Librarian, ...	Edward J. Nolan.
Conservator, . . .	Geo. W. Tryon, Jr.

All of which is respectfully submitted by

S. Raymond Roberts,
Recorder.

REPORT OF THE ENTOMOLOGICAL SECTION.

(American Entomological Society.)

The Entomological Section of the Academy has experienced an improvement this year, in comparison with preceding ones. The meetings, which have been regularly held, have been better attended, and a more general interest taken in the proceedings.

One member and five associates have been elected. During the year the Section has lost two members by death. Mr. Chas. Wilt, one of the deceased members, was one of the founders of the American Entomological Society, and had been very active in all the work of the Section. His valuable collection of Coleoptera has been given by his son, Mr. H. C. Wilt, to the American Entomological Society, while the Lepidoptera were purchased at an almost nominal price by the same society. The custodian of the society is now engaged in arranging these collections. All duplicates will be set aside for placing in the public exhibition of the Academy. This collection for public view is now assuming a more definite form than heretofore, through the earnest efforts of Mr. G. B. Cresson, the Custodian.

During the year twelve written communications have been accepted by the American Entomological Society for publication in its Transactions, which still continue to maintain their standard of previous years. In addition to these, a work entitled "Synopsis of the Hymenoptera of North America," by Mr. E. T. Cresson, is being published by the society, in separate form, as an intercalary volume. The display made by the Section at the exhibition of the Microscopical Section was of great interest to those present.

At the meeting held in December, the following officers were elected for the year 1887:

Director, ...	Geo. H. Horn, M. D.
Vice-Director, ...	Rev. H. C. McCook, D. D.
Recorder, ...	J. H. Ridings.
Treasurer, ...	E. T. Cresson.
Conservator, ...	H. Skinner, M. D.

Respectfully presented,

J. H. RIDINGS,
Recorder.

REPORT OF THE BOTANICAL SECTION.

The Vice-Director of the Botanical Section respectfully reports that the prosperity noted in past years still continues, chiefly through the voluntary work of its active members. The Conservator's account, adopted as part of this report, shows a very gratifying growth in the Herbarium, which is one of which the Academy may be proud. The membership, with some few additions and losses, remains about the same as last year. The Section is wholly free of debt, and has a balance in the treasury. Meetings have been held regularly on the second Monday evening in each month, except during the summer recess, and many new or interesting facts in botany have been brought to the notice of members—some of which have been thought worthy of recording in the Proceedings of the Academy.

The officers elected for the ensuing year are:—

Director, . . .	W. S. W. Ruschenberger, M. D.
Vice-Director, . .	Thomas Meehan.
Recorder, . . .	Chas. Schaffer, M. D.
Treasurer, . . .	Isaac C. Martindale.
Conservator, . . .	John H. Redfield.

Respectfully submitted,

THOMAS MEEHAN,
Vice-Director.

Conservator's Report for 1886.—The Conservator of the Botanical Section reports that the donations to the Herbarium, during the year just closed, consist of 2452 species of plants, of which 2433 are of phanerogams and vascular cryptogams, and 19 of lichens. Of these, 726 species are new to the collection, and among them are representatives of 40 new genera. Of the 2452 species, 847 are North American, 858 are from Tropical and South America, and 747 are from the Old World. The total number of species of phanerogams and vascular cryptogams now in the Herbarium is estimated at 26,189.

A list of the donations for the year is appended to this report. Among them may be specified 232 species of North American grasses from the U. S. Department of Agriculture at Washington, embracing 73 new species. These, with a collection of 54 species, made by F. Tweedy in the Yellowstone Park, make our series of N. American grasses unusually complete. From Dr. A Gray, of the Harvard University Herbarium, we have received about 300 species from the Old and the New World, embracing many novelties. Members of our Section have presented two fine collections made by Pringle and by Palmer in the Mexican province of Chihuahua, consisting of 710 species, of which 267 are new to us, and a very choice collection of South African plants made by Miss M. E. Cummings, nearly one-half of which were not in our Herbarium. Mr. Aubrey H. Smith has presented us 154 species which he collected in Colorado, New Mexico, and California (see Additions to Museum).

The work of mounting the specimens in the North American Herbarium is still continued, and considerable progress has been made during the past year with the assistance of Mr. Burk.

During this period the N. America species of *Cyperus* have been carefully revised by Prof. Britton, of Columbia College, New York; and the perplexing species of *Paspalum*, by Dr. Vasey, of Washington. Dr. John W. Eckfeldt has continued his special care of the lichens of the Academy, adding to their number, and has so arranged and catalogued the several collections of this order, as greatly to facilitate reference. Similar work is greatly needed for the remaining order of the lower Cryptogams.

John H. Redfield,
Conservator.

REPORT OF THE MINERALOGICAL AND GEOLOGICAL SECTION.

The Director of the Mineralogical and Geological Section of the Academy of Natural Sciences would respectfully report that meetings have been held regularly during the year, but that owing to the enforced absence of several of the more active members the attendance has not been as great as formerly. The additions to the cabinet, while not as numerous as in former years, have been considerable and valuable. A number of them have 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 lectures, with practical demonstrations, on geology and paleontology, which course was supplemented by a number of field excursions in the surroundings of Philadelphia. A special excursion, designed for the purposes of original investigation, and extending over a period of two weeks, was conducted during the month of July to Nantucket and Martha's Vineyard, resulting in valuable acquisitions of both zoological and geological material. Special attention was directed to the study of the fossiliferous deposits of the Island of Nantucket, with the result of demonstrating the erroneousness of the hitherto described sections of those deposits. The data obtained during this trip will be published in the Proceedings of the Academy.

The collections of the Academy in the department of Invertebrate Paleontology have been, as far as arrangement and classification are concerned, materially improved during the year; the entire series of fossils pertaining to American geology is now readily accessible, and in a condition for easy reference. More than three-fourths of this collection are permanently labeled. Roughly estimated, the collections in this department, embracing both foreign and American fossils, occupy upwards of 20,000 trays, and are probably second to no other collection in importance in this country. Special importance attaches to the series of Cretaceous and Tertiary fossils, especially the latter, in which are included probably four-fifths of all the types that have been described from this country. The Paleozoic fauna is, on the other hand, very inadequately represented, although the collections of the Pennsylvania Geological Survey, now deposited with the institution, will add very materially to this section when displayed.

Further reference to the collections in the department of Invertebrate Paleontology is contained in the report of the Curators of the Academy.

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 of ten lectures on the "Special Senses."

He further reports that the collections under his charge have somewhat increased.

There is a good collection of marine invertebrates, not yet officially presented to the Academy, from the West Coast of Florida, collected in the spring of this year by Prof. Angelo Heilprin.

A course of ten or twelve lectures will be given in the spring of the coming year (March and April), the subject being "Sense Organs in the Animal Kingdom."

Very respectfully,

BENJAMIN SHARP,

Professor of Invertebrate Zoology.

REPORT OF THE PROFESSOR OF ETHNOLOGY AND ARCHÆOLOGY.

During the last year two short courses of lectures were delivered in the rooms of the Academy, one on the General Principles of Ethnology, the second on the special topic of American Archæology. The latter was illustrated by numerous specimens from the collections of the Academy. Both were reasonably well attended, and it is believed that an increasing interest is shown in these subjects.

Some material was added to the collections in this department during the year, but the same difficulty mentioned in the last report, has interfered with obtaining as many specimens as would be practicable—that is to say, a lack of space for their proper accommodation and display.

Respectfully submitted,

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, 1886.

Cr.

By Salaries, Janitors, etc	$3265 76	
" Printing and Binding Proceedings, etc	1431 37	
" Printing and Stationery	154 79	
" Repairs	86 36	
" Plates and Engravings	71 75	
" Gas	91 40	
" Postage	142 44	
" Coal	775 00	
" Paper Boxes and Trays	73 42	
" Glass	6 35	
" Insurance	55 00	
" Freight	68 41	
" Alcohol	70 50	
" State Taxes on Mortgage Investments	123 48	
" Examination of Title to West Virginia Lands	100 00	
" Water Rents	33 35	
" Miscellaneous	635 65	
" Inspection of Boiler	10 20	
" Prof. Angelo Heilprin. Lecture Fees	62 50	
" Benjamin Sharp, M. D. " "	15 00	
" D. G. Brinton, M. D. " "	38 00	
" Life Memberships transferred to Life Membership Fund	150 00	
		$7460 73

Dr.

To Balance from last account	$892 15	
" Initiation Fees	120 00	
" Contributions (semi-annual)	1489 97	
" Life Memberships	150 00	
" Admissions to Museum	259 54	
" Publication Committee—Sales of Proceedings, Journal, etc	645 40	
" Microscopical and Biological Section—Donation	50 00	
" State Taxes on Mortgages	113 09	
" Interest (Joshua T. Jeanes' Legacy)	900 00	
" Freights returned	11 11	
" Miscellaneous	1 05	
" Prof. Angelo Heilprin. Lecture Fees	62 50	
" Benj. Sharp, M. D. " "	15 00	
" D. G. Brinton, M. D. " "	38 00	
" Wilson Fund. Toward Salary of Librarian	300 00	
" Publication Fund. Interest on Investments	340 00	
" Barton Fund. " " "	240 00	
" Life Membership Fund. " " "	165 00	
" Maintenance Fund. " " "	205 00	
" Eckfeldt Fund. " " "	125 00	
" Stott Legacy Fund. " " "	100 00	
		6222 81
Balance overdrawn		$1237 92

LIFE MEMBERSHIP FUND. (For Maintenance.)

Income from Investments		$ 165 00
Life Membership transferred from General Account		150 00
		$315 00
Balance overdrawn last statement	$100 00	
Transferred to General Account	165 00	
		265 00
Balance		$50 00

BARTON FUND.

Interest from Investments	$ 240 00
Transferred to General Account	240 00

JESSUP FUND. (For Assistance of Students.)

Disbursements		$ 795 00
Balance per last statement	$234 01	
Interest from Investments	560 00	
		794 01
Balance overdrawn		99

MAINTENANCE FUND.

Income from Investments	$ 205 00
Legacy of Jno. L. Neill, deceased, on account	5100 00
	$5305 00
Transferred to General Account	205 00
Balance for Investment	$5100 00

ECKFELDT FUND.

Income from Investments	$ 125 00
Transferred to General Account	125 00

MUSEUM FUND.

Balance per last statement	$ 55 00
Income from Investments	50 00
	$105 00

I. V. WILLIAMSON LIBRARY FUND.

Balance last statement		$2016 50
Rents collected		1013 92
Ground-rents collected		841 55
		$3871 97
Books	$1192 12	
Repairs to Houses	241 09	
Taxes and Water-rents	202 01	
Binding	120 40	
Collecting	92 77	
		1848 39
Balance (Principal, awaiting investment, $1750.00)		$2023 58

THOMAS B. WILSON LIBRARY FUND.

Balance overdrawn as per last statement		$ 272 33
Cash paid George N. Lawrence, New York		96 40
Cash paid B. Westermann & Co., New York, Books		100 04
Cash transferred to General Account toward Salary of Librarian,		300 00
		$768 77
Less Henry Sothern & Co., London	$ 96 69	
Interest on Investments	525 00	
		621 69
Balance overdrawn		$147 08

PUBLICATION FUND.

Balance per last statement	$ 225 00
City of Philadelphia Loan, July 10, 1868, No. 2945 paid off	500 00
Interest from Investments	340 00
	$1065 00
Transferred to General Account	340 00
Balance for investment	$725 00

STOTT LEGACY FUND.

Income from Investments	$100 00
Transferred to General Account	100 00

WM. S. VAUX FUND.

Balance per last statement	$512 08
Interest on Investments	600 00
	$1,112 08
Cash paid for Minerals	599 54
Balance	$512 54

H. N. JOHNSON FUND.

Balance overdrawn last statement		$ 221 81
Disbursements		1800 85
		$2022 66
Interest on Mortgage	$ 26 84	
Cash received, to entering satisfaction on Mortgage	50	
Rents Collected	1441 96	
Ground Rents Collected	189 00	
		$1658 30
Balance overdrawn		$364 36

The H. N. Johnson Estate was indebted for $\frac{4}{15}$ of a mortgage of $6000 to Charles J. Wister, the proportion being $1600, which was settled by W. N. Johnson's mortgage to Academy, $1500, and the payment of $100 in cash, and both mortgages were satisfied of Record.

The election of Officers, Councillors and Members of the Finance Committee, to serve during 1887, 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, . . .	William 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	George Y. Shoemaker,
years, ...	Aubrey H. Smith,
	George A. Koenig, Ph. D.
	George A. Rex, M. D.
Finance Committee, .	Isaac C. Martindale,
	Aubrey H. Smith,
	S. Fisher Corlies,
	George Y. Shoemaker,
	Wm. W. Jefferis.

ELECTIONS DURING 1886.

MEMBERS.

January 25.—Roland D. Jones, M. D.

February 23.—Miss Mary A. Campbell, F. L. Harvey.

April 27.—Calvin McCormick, Samuel Wagner.

May 25.—Charles P. Sherman.

June 29.—Christian E. Metzler, Charles H. Marot.

August 31.—C. L. Kilburn.

September 28.—Richard H. Day.

November 30.—George McClellan, M. D., George L. English.

CORRESPONDENTS.

January 26.—Alfred M. Mayer of Hoboken, N. J.; Charles Wachsmuth of Burlington, Iowa.

March 30.—J. C. Arthur of Geneva, N. Y.

November 30.—Emil Selenka of Erlangen.

ADDITIONS TO THE MUSEUM.

ARCHÆOLOGY AND ETHNOLOGY.—Stuart Wood. Lapp baby-basket.
W. S. W. Ruschenberger. Spear-head from Zanzibar, obtained in 1835.
Adele M. Fielde. Product from the silk-gland of *Cecropia*, Swatow, China.
W. H. Jones. Collections of Peruvian pottery, Esquimaux implements, shoes, fur suit, etc. Indian mask and figure-head, Alaska.
J. Collins. Shells from Indian mound, Tennessee.

MAMMALIA.—W. P. Gibbons. *Sciurus fossor*, *Thomomys talpoides* from California.
M. Mattson. Lynx, Colorado.

BIRDS.—S. M. Brice. 81 North American birds, principally from the neighborhood of Philadelphia.
W. P. Gibbons. 5 species of California birds.
A. J. Garrett. *Crex Tabuensis* (?), Pacific Islands.

REPTILES.—W. W. Jefferis. Vertebræ of snake.
H. C. Chapman. *Bothrops atrox*, Martinique.

FISHES (Recent and Fossil).—A. S. Rowan. Vertebræ of *Portheus* (?), Cretaceous of Fort Randall, Dakotah.
A. M. Smith. *Dicerobatis Japonica*.
W. E. Meek. *Petromyzon* (male and female), from Cayuga Lake, N. Y.
W. P. Gibbons. Two uteri of viviparous fishes.
J. D. Casey. *Carcharias Americanus*, Townsend's Inlet, N. J.

MOLLUSCA.—Wm. G. Binney. *Helix Hemphilli*, Oregon; *Planorbis bicarinatus*, N. Mexico; *Helix Cantiana*, Quebec; three species of Land Shells from the New Hebrides, Tennessee and Lower California; *Pompholix costata*, Oregon.
John Brazier. Twenty-eight trays of Land Shells from Australia and New Guinea.
C. Conemenos. 497 trays of land, fresh-water and marine shells from Greece and the Mediterranean Sea. (Purchased by the Conchological Section.)
William H. Dall. Operculum of *Fasciolaria princeps*.
M. Dollfus. 277 trays, Mediterranean shells, principally from the coast of France, at Roussillon, etc. (Purchased by the Conchological Section.)
Harry E. Dore. 26 species California marine shells.
John Ford. 3 marine species, Atlantic City, N. J.; *Ostrea borealis*, Lam., Greenwich Bay, R. I.; *Arca pexata*, Say, Atlantic City, N. J.; *Ostrea Virginica*, *Arca pexata* and *Modiola tulipa*, from Cape May, N. J.; nidus of Natica, and variety of *Mactra solidissima*, Atlantic City, N. J.; *Helix hyroides* and *Succinea obliqua*, Wissahickon Creek, Philadelphia; *Arca pexata*, Greenwich Bay, R. I.
Andrew Garrett. 96 trays of land, fresh-water and marine shells, mostly of the Society Islands; 69 trays of Polynesian shells, 228 specimens. (The above both purchased by the Conchological Section.)
Wm. D. Hartman. Photographs of three new species of *Partula*; *Veronicella Floridana*, in alcohol.
Theodore Hermann. Five specimens of *Spondylus princeps* and *S. leucacantha* from the Gulf of California; *Eburna lutosa*, China.
Angelo Heilprin. *Spondylus princeps*, Var.
W. W. Jefferis. *Vermetus lumbricoides*, Florida.
Joseph Leidy. *Modiola modiola*, Kennebunkport, Me.
Wm. G. Mazyck. *Helix terrestris*, Charleston, S. C. (naturalized).

Prof. J. H. Morrison. *Helix nemoralis*, Lexington, Va. (introduced).
S. R. Morse. 9 marine species, Atlantic City, N. J.
C. R. Orcutt. *Chlamydoconcha Orcutti* and three other marine species, San Diego, Cal.
W. T. Pettard. 21 species land and fresh-water shells, Tasmania.
H. A. Pilsbry. 7 species land and fresh-water shells, Louisiana and Texas.
J. B. Quintard. 27 trays fresh-water shells, from Kansas.
John H. Redfield. *Pecten Magellanicus*, Mt. Desert Isl., Me.
Wm. H. Rush. 2 species of Nudibranchs, from Florida and the Bahamas.
Benj. Sharp. Dry preparation of *Limax agrestis*, Philadelphia.
J. A. Singley. 27 species of land and fresh-water shells from Texas. (Purchased by the Conchological Section.)
R. E. C. Stearns. 3 species of marine shells from the W. Coast of America.
Rev. J. M. Thompson. *Bulimus scalariformis*.
Geo. W. Tryon, Jr. 115 species marine, land and fresh-water shells, new to the collection.

INVERTEBRATES (recent) generally, excluding Mollusca.—J. Ford. *Microsciona prolifera*, Atlantic City, N. J.
P. C. Tucker, Jr. *Renilla Danæ*, Galveston Beach, Texas.
G. H. Parker. *Tubularia indivisa*, Atlantic City, N. J.
H. M. Smith. *Mithrax spinosissimus*, West Indies.
B. Sharp. *Cymothoa* (from *Crenilabrus*), Villefranche, France.
A. Orr. *Gecarcinus lateralis*, Jamaica.
W. A. Stewart. *Libinia canaliculata*, Arkadelphia, Arkansas.

INVERTEBRATE FOSSILS.—A. D. Durbishire. 30 species of British Pliocene and Post-Pliocene fossils (in exchange).
T. H. Aldrich. 23 trays Eocene and Oligocene fossils, from Alabama and Mississippi; 9 species of Alabama Eocene fossils.
E. T. Dumble. 15 trays Eocene fossils from Texas.
A. G. Wetherby. 9 trays Oligocene fossils from Florida.
F. L. Harvey. *Anthracomartus trilobitus*, Subcarboniferous of Arkansas; *Ostrea larva*, Cretaceous of Arkansas.
G. W. Tryon, Jr. 95 species of Eocene fossils from the Paris Basin, collected by M. Antheaume; 46 species of Tertiary fossils from the same region; 5 species of French Cretaceous fossils.
A. Heilprin. Pygidium of *Phacops*, Upper Silurian of Walpack Bend, Pa.
J. M. Hodgin. *Calymene Blumenbachii*, Easton, O.
H. B. Abbott. Collection of Miocene fossils from Southern New Jersey.
A. F. Gentry. 4 trays Miocene fossils from Southern New Jersey.

PLANTS (Recent).—Aubrey H. Smith. 156 species of plants collected chiefly by himself in Colorado, New Mexico, and California, in May and June, 1884.
J. Bernard Brinton. 4 species of plants from Louisiana and Lower California.
J. H. Sandberg, Red Wing, Minnesota. 22 species of plants collected by him in Nez Percé Co., Idaho, in 1885.
Chas. S. Sargent, of the Arnold Arboretum, Mass. 21 species of trees and shrubs, mostly from the Southern United States. *Shortia galacifolia* Gr., from Michaux's original locality, Toxanay R., S. Carolina.
Horace J. Smith. *Pinus Tæda* L., from Aiken, S. C.
Frank Tweedy, through F. L. Scribner of the Agricultural Department, Washington, D. C. 54 species of grasses collected in the Yellowstone Park in 1885.
Wm. M. Canby. 255 species of plants from Southern Europe and Northern Africa, mostly from the herbarium of John Ball, London.

Asa Gray. 43 species of plants collected in British America by J. M. Macoun; 65 species collected by Gaumer at Cozumel I., on the coast of Yucatan; 88 species from Northern, Western, and Central Asia and Japan, by various collectors; 76 species, mostly from Northern Africa and Asia; 52 species, mostly from Porto Rico.

Isaac C. Martindale. *Dalea plumosa* Wats., new species from Chihuahua, Mexico.

Geo. Vasey.—U. S. Department of Agriculture. 232 species of North American grasses, many of them new.

Thomas Meehan. 55 species of plants, mostly cultivated, and many of them new to the collection.

Thomas Meehan and John H. Redfield. 308 species of plants collected by Dr. E. Palmer, in S. W. Chihuahua, Mexico, Aug.–Nov, 1885; 315 species of South African plants, collected by Miss M. E. Cummings.

Helen C. De S. Abbott. Trunk of *Fouquiera splendens*, from Lake Valley, New Mexico.

Mrs. E. H. Williams. 18 species of Chilian plants.

F. W. Harvey. 18 species of plants from S. W. Arkansas.

Thos. C. Porter. 24 species of plants from New Jersey and Pennsylvania.

Joseph Leidy. *Ornithogalum nutans*, Wissahickon, Phila., Garden scape.

John W. Eckfeldt. 19 species of N. American Lichens.

Miss Harrison, through Mrs. M. L. Owen, Springfield, Mass., *Myriophyllum hippuroides* Nutt., from California.

Isaac Burk. 4 species of New Jersey plants.

H. C. McCook. *Agave Sisalana*, fine living plant in flower, from Florida.

Josiah Hoopes. Flowers, leaves, and ascidia of *Nepenthes distillatoria.*

Miss Fisher. *Polygala incarnata*, near Charleston, S. C.

John H. Redfield. 402 species of plants collected by C. G. Pringle in 1885 in the border provinces of Mexico, mostly in Chihuahua; 55 species, mostly from Washington Territory and California; 76 species from the coast of New England; 86 species, mostly southern and western, to supply desiderata in the collection.

Plants (Fossil).—W. D. Hartmann. Fern (?) stems from the Triassic of Pennsylvania.

F. L. Harvey. *Whittleseya microphylla*, sub-Carboniferous of Arkansas.

A. F. Gentry. Quatenary leaf impressions, Bridgeton, N. J.

S. D. Button. Plant impressions (*Vexillum?*), from the Devonian of the Catskill Mountains, N. Y.

Minerals and Rocks.—H. N. Dubois. Gibbesite, Poughkeepsie, N. Y.; Slickensided Medina sandstone, Delaware Water Gap, Pa.

C. H. McCormick. Zoisite, Leiperville, Pa.; kyanite, Chester Co., Pa.; peacock-coal, Philadelphia, Pa.

J. D. Button. Siderite nodule, Sligo Junction, Pa.

W. W. Jefferis. Smithsonite, Mineral Point, Wis.; sphalerite, Joplin, Mo.; biotite, Delaware Co., Pa.; phlogopite, Burgess, Can.; moonstone, Delaware Co., Pa.; euphyllite, Unionville, Chester Co., Pa.; selenite, Lebanon Co., Pa.; aurichalcite, Laurium (?), Greece; chestertite, Chester Co., Pa.; siderite and hematite, Antwerp, N. Y.

J. T. Morris. Boulders from the Muir Glacier, Alaska; garnet schist, Stickeen River, Alaska.

T. D. Rand. Concretionary weathering in gneiss, Radnor, Pa.; trap, Radnor, Pa.

S. Durborow. Ferruginous earth, Bartram, Fla.

H. Derousse. Rock from McElwain's oil well, Duke Centre, Pa.

M. Hannah. Irish turf.

W. B. Eltonhead. Limestone, N. C.

F. L. Harvey. Carboniferous rock, Siloam Springs, Ark.
C. S. Bement. Meteorite, Alfianello, Italy; garnet crystal, Colorado.
G. F. Kunz. Meteorite, Jenny's Creek, W. Va.
C. U. Shepard. Meteorite, Dalton, Ga.
E. J. Nolan. Hematite ore, Bessemer, Mich.
M. Russell. Concretionary nodule, Woodbury, N. J.
J. Edgerton. Stalactitic quartz, Belmont Creek, O.
L. Woolman. Fossiliferous boulder, Tacony, Pa.
A. Heilprin. Cambrian pebble, Glassboro, N. J.
D. Mickle. Boiler incrustation.
A. Brezina. Glorietta meteorite (fragment).
D. P. Williams. Gneiss, with enclosure of feldspar, Aldham, Chester Co., Pa.
E. C. Hine. Magnetic iron and iron ore, fragment of trap-dike, Potsdam sandstone, and glaciated boulder, from Chateaugay, N. Y.
C. P. Perot. Ferro-manganese, Edgar Thompson Steel Works, Pittsburg, Pa.; coke, same locality.
W. H. Jones. Silver ore, Oroya, Peru; silver ore (no loc.); silver ore, Triumfu Mines, L. California; cinnabar, St. John's Mine, California; cinnabar, New Almaden, California; copper ore, Coquimbo, Chili.
J. Ruther. Devonian shale, Lycoming Co., Pa.
J. M. Birkey. Carnelian (no loc.).
Editor *Philadelphia Public Ledger.* Fissure products from the Carolina earthquake.
U. S. National Museum. Meteorite, Grand Rapids, Mich.

Additions to the Wm. S. Vaux Collection.—Turquoise, New Mexico; Molybdenite, Canada; 3 Spinel Ruby, St. Petersburg; 2 Sphalerite, Missouri; 2 Calcite on Sphalerite, Missouri; 2 Astrophyllite, Colorado; 2 Topaz, Colorado; Sphalerite, Missouri; Orthoclase, Missouri; 3 Azurite, Arizona; 2 Malachite, Arizona; 2 Malachite and Cuprite; 3 Ouvarovite, Canada; 3 Prehnite, Hartz; 2 Rutile and Mica, North Carolina; 2 Vanadinite, Arizona; 2 Cut Aqua-marine, Brazil; 2 Garnet, Ceylon; 2 Wulfenite, Arizona; 2 Opal, Mexico; 2 Yellow garnet, Siberia; 2 Calcite, Chihuahua; 2 Rhodochrosite, Colorado; Gypsum, Chihuahua; Quartz; 2 Amethyst, Germany; Celestite, Lake Erie; 2 Celestite, Texas; 4 Marcasite, Missouri; Sphalerite, Missouri; 3 Obsidian, Mexico; Opal, Mexico; Tridymite, Mexico; Valentinite, Mexico; Quartz, Mexico; Calcite, Mexico; 6 Geodes, Florida; Diamond in Bort, Brazil; Quartz, New Jersey; Silver Amalgam, Peru; Garnet, cut spe.; 4 Phlogopite, New York; 2 Phlogopite, Canada; 3 Muscovite; Apophyllite, Pennsylvania; Emerald, North Carolina; Microcline, Colorado; Silicified Wood, Colorado; Five-pound Garnet, Colorado; Stromyerite, Mexico; 3 Topaz, Siberia; Kyanite, Pennsylvania; Dog Tooth Spar, New York; Corundum, North Carolina; Pyrargyrite, Saxony; Celestite, Tumerlee; Cairngorm; Specular Iron, Elba; Smoky Quartz, Colorado; Witherite, England; Aragonite, Pennsylvania; Milarite, Tavetch; 2 Hyalosiderite, Germany; Steatite; 3 Chalcopyrite, Pennsylvania; Tetrahedrite, Pennsylvania; Magnetite, Pennsylvania; Crystal of Limonite, Pennsylvania; 3 Calcite, England; 3 Tourmaline, New Jersey; Rhodochrosite, New Jersey; Fossil Coral, Iowa; Hiddenite, North Carolina; Alabandite, Mexico; Iridescent Blende, Mexico.

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