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PROCEEDINGS

OF THE

ACADEMY OF NATURAL SCIENCES

OF

PHILADELPHIA.

1881.

PUBLICATION COMMITTEE:

JOSEPH LEIDY, M.D., GEO. H. HORN, M.D.
WILLIAM S. VAUX, THOMAS MEEHAN,
JOHN H. REDFIELD.

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1882.

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February, 1882.

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"	25 to 56	May	31, 1881.
"	57 to 88	June	14, 1881.
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"	113 to 144	August	2, 1881.
"	145 to 160	August	18, 1881.
"	161 to 176	September	13, 1881.
"	177 to 208	September	27, 1881.
"	209 to 256	October	18, 1881.
"	257 to 304	November	8, 1881.
"	305 to 384	November	22, 1881.
"	385 to 414	December	6, 1881.
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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.

1881.

January 4, 1881.

Dr. Jos. Leidy in the chair.

Twenty persons present.

Rhizopods as Food for Young Fishes.—Prof. Leidy remarked that last September he had received a letter from Mr. S. A. Forbes, of the Illinois State Laboratory of Natural History, Normal, Illinois, stating that the young of some of the suckers (*Catastomidæ*), *Hypentelium*, *Myxostoma*, etc., "have the intestines packed with tests of *Difflugia* and *Arcella*." Later, Mr. Forbes sent two slides, with some of the intestinal contents, for examination.

The slide with food from the intestine of the large-scaled Mullet, *Myxostoma macrolepidotum*, from Macinaw Creek, contained the following species:

Difflugia globulosa. Shell of rather coarse sand, with larger grains around the mouth; mostly in the shape of the segment of an oval, with the oral pole truncated. Most numerous form.

Measurements of a number were as follows:

1.	Shell	0.18	mm.	long;	0.162	broad;	oral end,	0.102	broad.
2.	"	0.18	"	"	0.156	"	"	0.102	"
3.	"	0.156	"	"	0.15	"	"	0.072	"
4.	"	0.174	"	"	0.156	"	"	0.09	"
5.	"	0.198	"	"	0.168	"	"	0.096	"
6.	"	0.198	"	"	0.21	"	"	0 108	"

Difflugia acuminata. Shell mostly slightly unsymmetrical; some with a slight neck, straight or slightly everted at the mouth; a few with two points to the summit; usually of minute sand and comparatively smooth. One oblique form noticed (No. 6), approaching *D. constricta.*

1. Shell 0.18 mm. long; 0.108 broad; oral end 0.06 broad.
2. Shell of same size, but with a short neck, slightly erected and undulant at the border.

3. Shell	0.18	mm. long;	0.114	broad;	oral end	0.048 broad.
4. "	0.198	" "	0.102	"	"	0.06 "
5. "	0.18	" "	0.114	"	"	0.06 "
6. "	0.162	" "	0.09	"	"	0.06 "

Nos. 1–3 of fine sand, and smooth; Nos. 4–6 of coarser sand.

The slide with food of *Eremyzon succetta.* The material apparently consisted of the superficial sediment of the water, and contained entomostracans, rotifers, dipterous larvæ, desmids, diatoms, etc., together with the following:

Difflugia globulosa. Shell 0.15 mm. long, 0.138 broad; oral end 0.078 broad.

Difflugia lobostoma. Shell with trilobed mouth, 0.09 mm. long, 0.078 broad; mouth 0.03 wide. Several measured of the same size; others slightly smaller. The most common species present.

Difflugia pyriformis. Shell 0.42 mm. long, 0.21 broad, at mouth 0.09 broad.

Arcella vulgaris. Variety with pitted shell.

Arcella discoides. Shell 0.18 mm. broad, mouth 0 026 wide. Another specimen 0.15 broad, with mouth 0.054 wide.

Another rhizopod shell observed, was different from any previously noticed. The shell had the form of that of *Arcella discoides*, with no trace of the structure characteristic of that of *Arcella*, but composed of a nearly colorless or pale yellowish chitinoid substance, incorporated with minute spherical granules of uniform size, darkly outlined, scattered irregularly, isolated, or in little groups or chains, straight or irregular, and in pairs, or up to five in number. The specimens measured about 0.105 mm. broad, with the mouth 0.03 wide. A chain of five granules of the shell measured 0.009 mm. long.

It is certainly an interesting observation of Mr. Forbes, to discover that the young suckers should use the rhizopod shells to obtain as nutriment their little stores of delicate protoplasm.

January 11.

Dr. John L. Le Conte in the chair.

Eighteen persons present.

A paper entitled "Descriptions of new species of Terrestrial Mollusca of Cuba," by Rafael Arango, was presented for publication.

JANUARY 18.

The President, DR. RUSCHENBERGER, in the chair.

Twenty persons present.

JANUARY 25.

The President, Dr. RUSCHENBERGER, in the chair.

Twenty-one persons present.

Jos. J. Knox and Geo. H. Rex, M. D., were elected members.
Chas. Velain, of Paris, was elected a correspondent.

FEBRUARY 1.

Mr. GEO. W. TRYON, JR. in the chair.

Ten persons present.

FEBRUARY 8.

The President, Dr. RUSCHENBERGER, in the chair.

Twenty-seven persons present.

Note on Treeless Prairies.—Mr. THOMAS MEEHAN remarked that the absence of timber or arborescent growth on the grassy prairies of America, still continued to be a matter of controversy, but he believed that in the light of accumulating evidence, we might now come to a positive decision in regard to the question. The most prevalent belief had been that trees would not grow on these prairies,—and we have had theories relating to soil or climate, to show why they could not grow. Then there were others who believed that trees did grow there in ancient times, but had been burnt off, and kept burnt off by annual fires.

Mr. Meehan considered in detail, the authors who had propounded various theories, and the distinguished men who had advocated them, and said that it was evident climate could have nothing to do with the question, because in these prairie regions there were often large belts of timber lands, projected like huge arms into the grassy regions, with precisely the same climatal conditions over both. That the soil was not unfavorable, was proved now by the artificial plantations everywhere successful, and that the soil was unfavorable to the germination of tree seed, as suggested by Prof. Whitney, was on the face of it untenable from the fact that it required but the same conditions for the seeds of trees as for those of herbaceous plants, the number of species of which on the prairies was well known to be very large. Another great gain to our present knowledge, was that since the annual firing of the grassy prairies had been discontinued by the advance of civilization, the timber was everywhere encroaching on them. Among the facts which he offered in proof of this, was a reference to p. 505 of the 7th Report of the Geological Survey of Indiana, where Dr. Schneck shows how land which was once grassy prairie, is now covered with a luxuriant growth of forest trees; to the evidence of Major Hotchkiss, Geologist of Staunton, Virginia, that the Shenandoah Valley, now heavily timbered, was clear of trees in the early history of Virginia; to the discovery of buffalo bones, in caves near Stroudsburg, Pa., by Dr. Joseph Leidy,—now a timbered region, the buffalo only existing in open, grassy countries;[1] and to various traditions of settlers in some valleys now timbered, that the land was originally clear of trees. He pointed out that in all known parts of the United States at the present time, except the arid regions, where only drought-loving plants could exist, the natural result of freedom was the succession of forest growth. Seeds were scattered by winds or animals over acres of cleared land; if such land became neglected, these, again seeding in time, extended the forest area continually. The tallest growing vegetation, like trees, crowded out the weaker, and the forest naturally crowded out the lower growing and weaker herbaceous plants. He illustrated this by reference to the neglected cotton-fields of the Southern States.

From all this, the speaker said that it was evident that there was nothing in Nature either now or in the past, to prevent the gradual encroachment of the forest over the grassy plains, till long before the white man came here, the whole would have been completely covered by arborescent growth. Were there any artificial causes equal to the exclusion of trees, and yet permitting an herbaceous growth? If we were to sow a piece of land in the autumn with some tree seed and some seeds of annuals, the latter would be up, flower, mature and scatter their seed to the ground before the next autumn, and many of these seeds would be washed into the earth, or drawn into the earth by insects or small animals. But tree seed would make young trees, which would not again produce seed for ten or more years. If now, at the end of this first season, a fire swept over the tract, the seeds of the annuals which had found a slight earthy protection, would come up again the next summer, again seeding and extending the area. The trees would be burned down, and though perhaps many would sprout, successive burnings would keep them confined to one place. In short, under annual burnings, herbaceous plants could

[1] Since the reading of the paper, it has been brought to the attention of the author, that the bones may have belonged to the Wood Buffalo.

still increase their area annually, but trees could never get far beyond the line they had reached when the annual fire first commenced. There could be no doubt that an annual burning in a tract destitute of forest growth, would certainly prevent the spread of timber, or of any plant that required more than a year to mature seed from the time of sowing. Now, if we look at the actual facts, we find that the Indians did annually fire the prairies.

Father Hennepin, the earliest writer on Indian habits, noted that it was the practice in his time. There is little doubt but this practice of annual burning has been one extending long into the past. What object had they in these annual burnings? They must have known that the buffalo and other animals on which they were largely dependent for a living, throve only on huge grassy plains, and that it was to their interest to preserve these plains by every means in their power. Low as their power of reasoning may be, they could not but have perceived that while grassy herbage throve in spite of fires, perhaps improved under the fiery ordeal, trees could not follow on burned land. What could be more natural than that they would burn the prairies with the object of retaining food for their wild animals? If we have no difficulty in reaching a positive conclusion so far, we may now take a glance at the early geological times. Mr. Meehan then referred to the researches of Worthen, Whittlesley and others in Ohio, Illinois and other prairie regions. On the retreat of the great glacier, the higher lands and drift formation were probably high and dry long before the immense lakes formed from the melting and turbid waters ceased to be.

It was tolerably well understood that many species of trees and other plants which required a temperate atmosphere, retreated southwardly with the advance of the glacier, and advanced to higher latitudes on the glacier's retreat. Thus these higher ridges would become timbered long before the lower lands became dry. Evidence accumulates that man existed on this continent, in the far west, not long after the glacier retreated, though "not long," in a geological sense, may mean many hundreds of years. The lakes of glacial water would gradually become shallower from the deposit of the highly comminuted material brought down from higher land, from the wearing away of rocky breastworks as in South Pass, Illinois, as well as from the openings which would continually occur from nature's ever varying plan of streams under ground. In all events, the drying of these lakes would be from their outward edges first. Aquatics would give way to marsh grasses, and these to vegetation such as we now find generally spread over the prairie region. If now we can conceive of human beings such as we know the Indian races to be, already in more southern latitudes—having learned the fact that firing would keep down trees and aid in the preservation of the chase—following the retreat of the glacier to the higher lands, and still as they advanced northwardly, firing the plains up to the water's edge, it would certainly account for the absence of arboreal vegetation from these immense lacustrine lands from the very beginning of their formation. Of course with this view we should have to look for some evidences of man's existence, both on the lands which were once under water, as well as those which were timber lands at his first appearance there. He did not know how many such evidences have been or may be found. Man's traces in the past are at best but rare, and they would naturally be much more scarce in the lacustrine regions than in lands dry at the same epoch. At any rate, this part of his remarks he said, must be taken as mere speculation; but, as we could see on the basis of sound scientific investigation why there could be no trees on these grassy prairies within the range of indubitable history, it was a fair inference that some such cause had continued from the beginning; namely, that annual fires had ever been the reason why arborescent vegetation had never had an existence there.

The resignation of Mr. Edw. S. Whelen, as a member of the Council and Finance Committee, was read and accepted.

February 15.

The President, Dr. Ruschenberger, in the chair.

Nineteen persons present.

A paper entitled "The Honey Ants of the Garden of the Gods," by Rev. Henry C. McCook, D. D., was presented for publication.

February 22.

The President, Dr. Ruschenberger, in the chair.

Thirty-six persons present.

The death of Harry C. Hart, M. D., a member, was announced.

Mr. Isaac C. Martindale was elected a member of the Finance Committee, to fill a vacancy caused by the resignation of Mr. Edw. S. Whelen.

Mr. Charles P. Perot was elected a member of the Council for the unexpired term of Mr. Whelen.

Robert P. Field was elected a member.

John Brazier, of Sydney, N. S. W.; Rafael Arango, of Habana, and Chas. Mohr, of Mobile, Ala., were elected correspondents.

The following were ordered to be printed:—

DESCRIPTIONS OF NEW SPECIES OF TERRESTRIAL MOLLUSCA OF CUBA.

BY RAFAEL ARANGO.

Choanopoma acervatum Arango.

Testa obtecte-umbilicata, ovato-oblonga, plerumque decollata, tenuis, plicis transversis irregulariter et costulis spiralibus distantibus undulatim et acervatim interruptis lamellata,

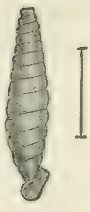
albida, anfractus 6 (superstites $3\frac{1}{2}$–4) convexi, lente acrescentes ad suturam canaliculatam (ob plicarum extremitatem) denticulati, ultimus anfractui contigui callo adnatus; apertura circularis, peritrema duplicatum, internum rectum, externum patens, concentrice striatum et ob costulas spirales testæ undulatum, ad anfractum contiguum callum formans, tum umbilicum lamina lata fornicata tegens. Long. $8\frac{1}{2}$–$9\frac{1}{2}$; diam. $4\frac{1}{2}$–5 mill.

Differt ab *Choan. Tryoni* Arango primo visu costulis spiralibus, ab sordido imprimis plicis testæ undulata interrupta.

Habitat.—Las Lagunitas prope Pinar del Rio partis occidentalis in plantatione dicta "Vega de D. Manuel de Jesus Hernandez."

Cylindrella paradoxa Arango.

Testa sine umbilico, fusiformi-turrita, solidula, albida, costis



subrectis confertis munita, integra, apice obtusiuscula, anfractus 12–13 convexi, penultimus longitudinaliter in medio canaliculatus, ejusdem pars superior reliquis anfractibus ignalis quoad sculpturam, inferior angustior, reducta, costulis magis aproximatis, dein dilatata et umbilicum tegens. Apertura piriformis, obliqua, superne angustior ob carinam salientem partis superioris anfractus. Peritrema continuum, undique æqualiter expansum. Columna interna simplex. Long. $12\frac{1}{2}$; diam. $2\frac{1}{4}$ mill.

Habitat.—Guane in loco "Puerta de la Muralla" dicto.

Cylindrella incerta Arango.

Testa quoad sculpturam et columnam internam simillima *Cylindrellæ cærulans* Poey, sed forma ventroso-cylindracea et anfr. superst. 8 (in testa integra 14).

Long. 18 ; diam. $4\frac{1}{2}$, testa integra.

Long. $14\frac{1}{2}$; diam. $4\frac{1}{2}$, testa fracta.

Habitat.—Guane in loco "Puerta de la Muralla" dicto.

Ctenopoma nodiferum Arango n. sp.

Testa clauso-perforata, cylindraceo-turrita, decollata, tenuis, plicis æqualiter distantibus et liris debilibus decussata, cineracenti-albida, anfr. 3½–4 superstites convexi, lente accrescentes, ad suturam canaliculatam subdenticulati; ultimus subdisjunctis pone aperturam callo lato cum penultimo anfractu junctus; apertura verticalis, obliqua, ovalis; peritrema duplicatum, internum rectum, externum subæqualiter patens, sed superne dilatatum, anfractum contiguum attingens et umbilicum claudens. Operculum typicum generis. Long. testæ truncatæ 8; diam. 3; apert. 2 mill.

Simile *Ctenopomati nodulato;* sed differt testa plicis æqualiter distantibus (nec acervatim approximatis et liras decussata).

Habitat.—Sub lapidibus circa oppitum *Santo Cristo de la Salud* prope Bejucal.

Ctenopoma Wrightianum Gundl. n. sp.

Testa subperforata, cylindraceo-turrita, decollata, costis æqualiter distantibus obtusis et liris subtilissimis decussata, cineracenti-albida, anfr. de superstites, convexi, lente accrescentes, ad suturam canaliculatam denticulati; ultimus subdisjunctus pone aperturam callo lato cum penultimo anfractu junctus; apertura verticalis, oblique ovali-rotundato; peritrema duplicatum internum rectum, externum subæqualiter patens, sed superne non dilatatum itaque anfractum penultimum non attingens. Operculum typicum generis. Long. testæ truncatæ 11; diam. 5; apert. 2½ mill.

Proximum *Ctenopomati ruguloso* sed distinctum costis testæ obtusis (nec acutis) et liris decussata.

Habitat.—Sub lapidibus loci *Punta de la Jaula* dicti in Provincia Pinar del Rio, partis occidentalis.

THE HONEY ANTS OF THE GARDEN OF THE GODS.

BY REV. HENRY C. McCOOK, D. D.

I.—GEOGRAPHICAL DISTRIBUTION.

The peculiarity in the Honey Ants (*Myrmecocystus melliger*) which has attracted the especial attention of naturalists is that one of the castes or worker forms has the abdomen distended to the size and form of a currant or small grape, and entirely filled with grape-sugar or "honey."

Very little of their habits has heretofore been known, and only the forms of the honey-bearer and worker-major. In order, if possible, to remove this reproach from Entomology, I started in the early part of July, A. D. 1879, for New Mexico, as the honey-ants have been found in the neighborhood of Santa Fe, and even as far north as Abiquiu, on the Big Chama River.[1]

During a brief visit at the cottage of Gen. Charles Adams,[2] of Manitou, Colorado, which is located in the mouth of the Garden of the gods, in the course of some observations made upon the ants of the vicinity, a nest was discovered whose external architecture was new to me. The sentinels were called out by the application of a straw, and their general appearance raised the suspicion that they might be Honey Ants, which, as I had never seen specimens, were known to me only by description. The nest was opened, and the delightful fact revealed that the objects of my search were before me. I thereupon made an exploration of the vicinity, and found that the nests were present in sufficient numbers for purposes of study; whereupon I abandoned my New Mexico outfit, encamped in the Garden of the gods, and began the observations of which the following paper is the record.

Up to the time of my discovery, it had not been known that the Honey Ants were distributed as far north as Colorado. I found no formicaries at any other point in the State, although the opportunity to search for them was limited. There is little doubt,

[1] At the latter point Prof. Edward D. Cope informed me that he had seen them. Dr. Loew and Mr. Krummeck saw them near Santa Fe.

[2] Gen. Adams has recently been widely known by his intrepid venture among the hostile White River Ute Indians, and rescue of their unhappy prisoners, Mrs. Meeker and others, at the risk of his own life. As a recognition of this service he has been appointed Minister Plenipotentiary for the United States to the Republic of Bolivia.

however, that they may be found in favorable locations in the entire southern portion of the state, and perhaps also north of the latitude of Pike's Peak.[1] Mexico, New Mexico and southern Colorado, may certainly be designated as the natural habitat of the Honey Ants. It is probable, however, that they may be found throughout the entire south-western portions of North America, especially the uplands. They will doubtless be found west of the Rocky Mountains, as I have recently found one female of this species among a collection of Hymenoptera sent to Mr. Cresson from southern California.

The following facts can be presented concerning the *vertical* distribution:—

Locality.	Elevation.	Observer.
City of Mexico, ...	7482 feet,	Llave.
[2] Matamoras, Mex., Brownsville, U. S., . .	50 "	Langstroth.
Santa Fe, ...	7047 "	Loew, Kummeck.
Abiquiu, ...	5930 "	Cope.
Garden of the gods, . .	6181 "	McCook.

It will thus be seen that the points at which these insects have heretofore been found, lie for the most part upon uplands, ranging from 6000 to 7500 feet in height above sea level. Mr. Langstroth's find is recorded as "in the vicinity of Matamoras."[3] If this means the near vicinity, the fact prevents the generalization which one might otherwise have been tempted to form, limiting the ants to the upland, for Matamoras has but a slight elevation.

II.—Nest Sites and Exterior Architecture.

The Honey Ants are domiciled in large numbers throughout the section of country known as the Garden of the gods.

The conformation of the surface here appears to be an important element in determining the habitat of the insects, and deserves a brief notice. The Garden of the gods embraces a

[1] The matter of their distribution is a point to which the attention of entomologists and other naturalists is called, and any information bearing thereupon will be of value.

[2] I could not lay hands upon the elevations of Matamoras, which cannot vary much from that of Brownsville, Texas, on the opposite side of the river.

[3] "Proceed. Acad. Nat. Sci. Phila.," vol. vi, 1852, p. 71.

space of about two miles in length by one in width, the surface of which is broken into ridges crossing each other at various angles, and crowned or bordered at the top by the red sandstone and conglomerate rocks, whose peculiar shapes and likenesses to heathen deities have probably suggested the name given to this bit of landscape. A rude idea of the topography may be had by drawing a horse-shoe, the toe toward the north; within the mouth of this let a second horse-shoe be described, occupying about one-half the space in width and one-third in length. Unite the toes of

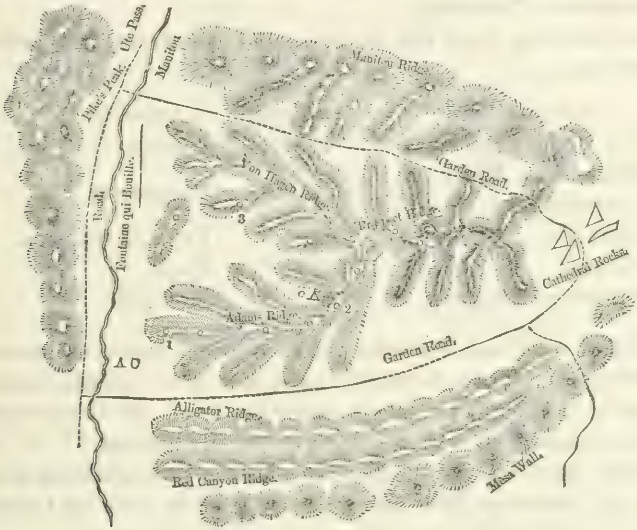


FIG. 1.—Sketch-map of the Garden of the gods.

the two shoes by a zig-zag line, and draw lines east and west, on either side from the interior figure. The western line of the outside shoe will represent the Manitou ridge, which starts at the base of Pike's Peak. The eastern line will indicate the cretaceous wall of the table-land known as the Mèsa, and the two walls of the Red Canyon. The inner shoe has for its western line the Von Hagen ridge, for its eastern the Adams ridge; the east and west lines will represent the general course of the ridges which drop down from these two, from the broken central ridge, Prospect ridge, represented by the zig-zag line, and from the eastern face of Manitou ridge. These ridges are composed of red sandstone, which crops out freely, forming vast ledges and cliffs. The top soil, where the rock is not exposed, is a heavy gravel, upon which grow tufts of gramma grass, straggling bunches of grease wood, Spanish bayonet, low cedars and pine, and in the little vales or nooks wild sunflowers, wild roses, and numerous small thickets and clusters of a scrub oak (*Quercus undulata*). These localities are indicated diagramatically in the sketch-map at Fig. 1.

All along the tops of these ridges, and on the eastern and south-eastern slopes, the nests of the Honey Ants are located (Pl. I, fig. 2[1]). About ninety per cent. of those found were on the tops of the ridges, and every one on or near the summit or central line of the top. The choosing of such a site may, therefore, be inferred to be a fixed habit of the ant.

The advantage of this location is apparent, at least in the points of dryness and warmth. I made several observations of the effects of the heavy July and August rain storms upon the exterior architecture, which is a low, gravel-covered moundlet, penetrated at the centre by a tubular gallery or gate three-fourths of an inch in diameter (Pl. II, figs. 3, 4). The large gravel-covered mounds of the Occidental Ant (*Pogonomyrmex occidentalis*, Cresson), numbers of which were built in the valley of the Boiling Fountain Creek, and in the nooks between the ridges, were more or less damaged by the wash of the water. Some were seriously injured, one wholly swept away. The only damage wrought upon the Honey Ant nests was a little beating down of the pellets of gravel within the gate. There was no injury from the wash of the water, and apparently no likelihood of any beyond that which the momentum of the rain-drops could inflict as they dashed upon the nest and within the gate. Throughout one storm, during the entire progress of which a nest was watched, several ants were stationed like sentinels within the gate around the upper margin (Pl. V, fig. 25). They were evidently on the look out for any damages to their home. The disarrangement of a few pellets moved two of these sentinels to bring up bits of gravel and attempt repairs. But there was little occasion for this, although the force of the rain was great enough to cause a good deal of discomfort to the observer. In half an hour the rain ceased, the sun came out over Pike's Peak, and a rainbow girdled the Mèsa. One worker-major crawled upon the crest of the nest, stretched herself, reared her head as though to snuff the fresh air, then

[1] This is a sketch of my camp, from the point at which the Adams and Von Hagen ridges meet. One of the ant-nests is seen in the foreground; others are indicated by the white circles on the crests of the ridges.

hurried down the gravel side and started at a swinging pace along the trail to a neighboring oak copse. An hour afterward she had not returned, and not another ant had left the nest. Several, however, came out, but apparently were disturbed by a gale which followed the rain, and returned.

On another occasion, the slight disarrangement of the nest made by the rain was repaired immediately after the storm. It amounted to a closing up of the greater part of the entrance by some of the displaced gravel-stones along the crater.

The exterior architecture has been referred to as a small moundlet of gravel.[1] The largest seen was one on one of the ridges quite within the Garden; it measured around the base thirty-two inches, in height three and one-half inches, length of northern slope four and one-half inches (Pl. II, fig. 3). The average dimension of the nests is something less than this. The base diameter varies from ten to three and one-third inches, the greatest number of nests measuring six and seven inches.[2] The ordinary height is from two to three inches. The shape of the nests is a truncated cone. The section across the top is about two inches in diameter. In the centre is a tubular opening or gate, from three-fourths to seven-eighths inch in diameter.[3]

III.—Position of Honey-Bearers in the Nest.

Leaving the details of the architecture to a later period, that habit which attaches the greatest interest to this insect, viz., the storing of honey, may be considered. The first nest that was opened, and called the "Bessie" nest,[4] for convenience of notation, is on the terminal slope of Adams' ridge, looking due south, and quite near to the valley of the creek Fontaine qui Bouille. The gravel had

[1] Dr. Oscar Loew, "American Naturalist," 1874, says of Melligera collected near Santa Fe, that "they make no hills, like other ants." "A structure like a crater indicates where they live underground." Every formicary seen by me had a decided elevation.

[2] I succeeded in bringing one of these mounds home nearly entire, having fixed the gravel contents by liquid cement.

[3] Dr. Loew says of the nests near Santa Fe, that the openings were the size of a quill. It seems strange that such a difference should exist within localities so near each other.

[4] A little girl, Bessie Root, a guest in Gen. Adams' cottage, whom I had enlisted in the search for ant-hills, first reported to me the nest in which I found the Melligers.

not been penetrated to a depth of more than six inches before a honey-chamber was uncovered, and the presence of the honey-bearers indicated that a home of the true Honey Ant had been found (Pl. III, fig. 5). Within a dome-roofed vault, about three inches in width and three-quarters to one inch in height, hung the honey-bearers, clinging by their feet to the roof. Their yellow bodies stretched along the ceiling, but the rotund abdomens hung down, almost perfect globules of transparent tissue, through which the amber-colored honey showed. They looked like a cluster of small Delaware grapes or large currants. Most of the abdomens were quite round, but they were in various stages of fullness. Upon some the external membrane of the abdomen was gathered in folds. A few of the abdomens, and especially those but little distended, were of a white instead of amber color.

I have observed that the honey-bearers in my artificial nests show the honey, which has been gathered from white sugar, quite white and translucent. It is probable that the color becomes amber, and even a wine color, with age. When the abdomen is full it fairly shines, reflecting the light that falls upon it from the lamp. With most of the honey-bearers the abdomens hang downward without touching the ceiling, except at the rotundity near the base, and often not even at that point. With some, however, the whole lower part of the abdomen rests against the roof (Pl. IV, fig. 13). This appears to depend chiefly upon the contour of the perch, and not upon the relative degree of comfort to the ant in the two positions.

The roof of the honey-chamber is different in structure from the floor, the latter being comparatively smooth, while the former is rough, being the natural granulated surface left after the picking away of the sandy soil. This character, of course, enables the honey-bearer to cling more easily and securely to her perch. This position is not held by the mandibles clasping the rugose dome with their sharp teeth, but almost exclusively by the feet, whose claws, hairs and pulvuli all doubtless contribute to the effect.

Judging from observations upon artificial nests and from the utter unwieldiness and helplessness of the fully charged bearers, they are not much disposed to change their roost after once taking it, at least after they have reached a considerable degree of rotundity. But the statements generally made by writers, that they are wholly unable to move, and never change position, are inferences without the facts. They are not unable to move, and in point of fact do occasionally move their positions. Those whose abdomens are but half or even two-thirds the full globose, I have frequently seen coming out of their chambers, ascending the galleries and moving freely about the surface. Those with full globes can move about with no little agility when placed upon a table, or when exposed in their nests to some unusual danger or alarm. In the nests they slide along from point to point, moving their feet sidewise, and so make changes of position.

Fallen Honey-bearers Helpless.—If once they loosen their hold, however, and fall to the floor, they seem ordinarily helpless to recover. Numbers of my full honey-bearers dropping from various causes, or shaken down by thoughtless visitors, laid upon the floor helpless, resting upon the rotund abdomen, bodies up, antennæ and feet in motion, and seeming exceedingly uncomfortable. Those who so fell as to have some object upon which to lay their feet, as a clod or the surface of the jar, fared better. In very favorable positions a few recovered their roost. But as a rule they were helpless, remained stationary, and so passed their lives, which were evidently shortened by their position, although some of them lived thus several months (see Pl. VI, fig. 32).

IV.—Source of Honey-Supply.

The rotunds do not elaborate the honey, as has frequently been asserted. I was not for a moment misled by this fancy, being satisfied that, in the nature of things they were sedentary, and that their immense abdomens were charged by regurgitation from the workers who were the honey gatherers. But whence do they obtain their supplies?

Not from Aphides, at this season of the year at least. I searched every bush and shrub in the vicinity, including large numbers of wild rose bushes, but failed to find any of these familiar and useful Emmet "herds." Certainly, at least, the honey ants were not there drawing supplies from them. It was not possible to trace the ants to these or other sources of food supply during the day, for I found very soon that they were nocturnal insects. Their nests were as silent, and to all appearance empty, as an abandoned habitation, during the daytime. I accordingly stationed myself beside a nest to await the nightfall. This nest was located upon the summit of a ridge which from a peculiar formation of a rock upon it I named Eagle-head ridge, and the nest Eagle-head nest. At 7.30 P. M., the sun was set, and darkness had begun to gather. A few ants appeared within the gate. They advanced to the top, followed by others; they pushed out upon the gravelled sides of the mound, over which a goodly swarm of yellow insects was soon gathered. There were no rotunds or semi-rotunds among these mustering squadrons; all were workers, with normal abdomens.

Presently an ant left the mound and started over the ridge northward. Another—several—a score followed, until within a brief time a vast column was seen trailed along the ridge, all moving in the same direction. The evening had now become so far advanced that it was difficult to trace the column, but by stooping down close to the earth and using care not to alarm the ants, I was able to do so. The trail was somewhat winding, but on the whole seemed to be chosen with some regard to avoiding the inequalities of the ridge. I was not impressed, however, with the engineering skill of the insects in this matter.

At the distance of about fifty feet from the nest, the column turned down the slope and entered a copse of scrub oak (*Quercus undulata*, var.). I traced a number of ants to a bush several feet within the thicket, but failed to unravel the secret that night. The next night a similar experience awaited me. After a long, careful, but vain search, I retired to my tent baffled. The third night (July 29), the ants of Eagle head nest came out at 7.23 P. M. Those on Toad-stone ridge, to which I had assigned my assistant, Johnson, came out at 7.25 P. M., but did not begin to move until 7.44. Johnson followed them, but failed to find their feeding ground. They moved north and eastward, as did those of the Eagle head. These latter began to move almost as soon as they came out. They followed the same trail as on the previous evening, the track having beem marked by me. The movement was somewhat slower than before, perhaps because the trail had been washed by a heavy rain during the afternoon. There was no leader. A dwarf worker kept in advance over the greater part of the track, then a worker minor took the head of the column. The two were separated from each other, and the van of the column about eight to ten inches. There was, however, not the slightest evidence of any leadership at any time, in any part of the moving line, although I carefully looked for such.

The ants directed their movements to the same tree as on former forays, reaching it in seventeen minutes, at 7.40 P. M. They distributed themselves along the tree, hunting trunk, branches, leaves. I could trace their forms, but when it is remembered that I was wedged in among the thick, low branches of this dwarf oak, holding up a lantern with one hand, and using the other to clear space for it; that the necessity to avoid alarming the timid insects compelled me to retain very inconvenient positions for a long time, it will not seem strange that I could find nothing satisfactory until between nine and ten o'clock. At last, in course of the slow investigations, I reached the extreme end of a branch on the south side of the tree, and found a number of ants engaged upon clusters of brownish-red galls. The ants were moving from gall to gall, not tarrying for any length of time upon any. They applied their mouth organs to the galls frequently. The dimness of the light, and the distance which I was compelled to keep, prevented me from seeing anything more than this. But it was plain that they were obtaining honey stores, for in the lantern light it could be seen that their abdomens were already much distended by the sweets which they had lapped.

The branch was carefully cut off without disturbing the ants, taken to my tent, and the movements of the insects observed during the remainder of the night, the branch having been so placed as to prevent the escape of the ants, who were yet easily under view. They, however, were so preoccupied with their honey gathering, that they made little effort to escape.

Directing attention to the galls, it was seen that some of them were gradually exuding minute globules of a white transparent liquid, which the ants greedily licked. I tasted the liquor, and found that it was very sweet and pleasant. The object of the nocturnal expedition of the ants, and the source of their honey supply, were thus revealed. These galls are of various sizes, from that of a currant downward. Most of them were of a Turk's-head shape, some flattened spheres. They are placed in groups of two and more along the stems of the branches; they are commonly of reddish-brown color, marked with black patches, but some of them are of a brighter tint, almost rose-color, some of a livid yellow marked with black, some almost green. By cutting off a few of the clusters and removing them from the ants, I saw that the sugary sap issued from several points upon the gall, which in some cases became beaded with six or more globules, several times larger than a pin-head. By removing these beads successively, I found that during the night one gall gave out at least three series. The continual flitting of the ants from branch to branch and gall to gall, was thus explained: the successive exudations invited their frequent return to the galls from which they had formerly fed. When the branch had first been brought to the tent, some of the gall-bearing twigs had been clipped off and placed within the artificial nests, but received no attention from the ants. Some of the bleeding galls were now introduced, which were instantly covered by the ants, and soon cleaned of their beaded sweets. An examination of the first galls explained the reason for their neglect—they were sapless.

Nectar-producing Galls.—A number of galls of various sorts and sizes, was collected for dissection. They were readily divided into two classes (1), the livid and greenish galls which were soft and entire: (2) the darker colored ones which were hard, unyielding to the touch, and pierced at one side by a small, smooth, regular, cylindrical cavity. It soon appeared that the bleeding of honey-sap was confined to the first class. Upon cutting away the soft pulpy fruit (if it may be so termed), a hard whitish-green ovoid cell, not unlike a cherry seed, was found at the centre. It was about one-eighth inch in diameter. Lying outside of and against this, in a little cavity, I found in one gall a minute, living grub (Pl. III, fig. 12). The body was white, of eleven segments, the head tipped with a brownish hue. The inner cell when opened, showed a spherical cavity in which was a very minute gelatinous pyriform object, which adhered to the side of the cavity. I had no microscope with me, and in lieu of facts, can only conjecture that this may have been an embryonic form of an insect, which matures later in the season.

The hard galls were next dissected. They are all pierced on one side, invariably near the base (figs. 10, 11), by a circular opening made by the matured gall-insect in its escape. Fig. 11 represents one of these, a turban-shaped gall, magnified about three times the natural size. A section view of the gall (fig. 10) shows that the exit hole (*eh*) penetrates the interior cell-case, which must therefore serve as the cocoon in which the pupa transforms. Inside of some of these cells I found traces of a flossy texture. The cells are commonly spherical, but (as in fig. 10) sometimes egg-shaped. They are separate from the rest of the gall, from which they quite differ in appearance, and are of a firmer substance. In fig. 10, the gall is three-sixteenths of an inch in length, of which the cell occupies two-thirds, that is, one-eighth of an inch. The largest gall observed had an outside measurement of three-eights inch long and the same across the top. In one of the galls opened, I found an imperfect insect (imago), which is identified by Mr. E. T. Cresson as of the genus Cynips, a true gall-fly. The specimen would not permit further identifitification.

At the meeting of the American Association for the Advancement of Science, held in 1880, at Boston, I had the pleasure of presenting the substance of this paper to the Entomological Section. My account of the extravasation of the galls, as above, caused much comment, the result of which was to confirm the accuracy of the observation which had been challenged. Prof. C. V. Riley, well known as an entomologist, declared upon his own observations, that many galls exude saccharine matter, citing among others, those of certain Phylloxeræ on Hickory, one of which he had named *carya-gummosa* on account of the abundance and stickiness of the exudation. Mr. H. F. Bassett, who has made extensive and careful studies of galls, said that he had found many species of galls visited by ants [1]

Specimens of the oak-gall visited by Melliger were sent to Mr. Riley, concerning which he says: The gall is one that is found quite commonly in the Rocky Mountain region on *Quercus undu-*

[1] American Entomologist, Dec., 1880. The following additional remarks will be interesting in this connection: Mr. E. P. Austin remarked that the chemical composition of sugar and woody fibre are the same, and that sugar could be produced by conversion from woody fibre in the plant. Dr. J. L. Le Conte said that he understood tannin to be a conjugation of gallic acid and sugar. Mr. B. P. Mann suggested that some light might be thrown upon this food-supply of the ants, by the nature of much of the moisture which appears occasionally at night in great abundance on the leaves and other portions of plants, and which is usually mistaken for dew. This moisture, it is said, differs from dew in being produced under circumstances which would not account for the formation of dew, and in containing a perceptible quantity of sugar. It is the ordinary watery excretion from the surface of the plant, which, under favorable conditions of the atmosphere, collects in beads or in drops, instead of evaporating as rapidly as it is formed.

lata, as determined by Dr. Engelmann, who sent me the same gall in 1874, though I had previously collected it myself. It is, undoubtedly, an undescribed gall, and a very similar one occurs on the *Quercus macrocarpa* in the Mississippi valley. It has the ordinary woody texture that belongs to so many Cynipidous oak-stem galls, and the architect develops in a paler cell that occupies a large part of the interior of the gall. When fresh, the gall is quite bright-colored, inclining to crimson or scarlet. It seldom attains a larger size than an ordinary pea, and differs from similar galls in my cabinet by having frequently a rather broad, flattened crown, though this character is by no means constant.[1]

Nocturnal Habits.—It has already been said that the ants collect the oak-gall nectar by night. Observations daily repeated upon a number of nests, determined that they leave their nests for the oak thickets at or near 7.30 o'clock P. M., and between that hour and 8 o'clock, which is about the time of sunset in July and August. Previous to the departure, the crater, gate and exterior of the mound become gradually covered with swarms of insects whose yellow bodies quite hide the red gravel surface of the nest. The marching of the honey-gatherers has already been described, but always there remained a very numerous force at home, who were seen at all hours of the night on guard within and around the gate. (Pl. V, fig. 25.) The return home began about or a little before midnight, and continued until between four and five, which was near daylight at that season. One or two extracts from my field notes will indicate the facts on this point. "11.30 P. M. Some ants returning home; the movement very slow and deliberate. . . . 12.30. Quite a number are now returning. Some are also still going outward. Numbers of workers patrol the mound and vicinity challenging nearly all incomers, who have to stand the test and give the required satisfaction. What is the antennal password? None of the returning repletes are tolled by the home sentries. . . . This morning at 4.10 A. M. the ants were seen coming in from the oak bushes, most of them well laden, but others not so full. There are evidently degrees of success in honey-gathering among them. Some of the dwarfs had very full abdomens. . . . 4.30 A. M.

[1] He suggests for the gall the name *Cynips quercus-mellaria*. Am. Ento, Dec. 1880.

The ants are returning in numbers and rapidly moving from the brush to the nest. It is about daylight."

In these night observations the light of the lantern seemed to cause the ants in column no little disturbance. They would go toward the lantern as it sat on the ground near the trail, appear to examine it, then move away. It really seemed to confuse their ideas of locality, and shake their confidence as to the site of the trail, although no one was finally thrown off the track thereby. The sentries at home were always more or less excited by the light, and delicate manipulation was everywhere required in order to preserve the natural conditions and get the natural behavior.

At no time were the ants seen during the day except when it rained, and then only a few sentinels appeared at the gate. Ordinarily the entrance, as far as the eye could see, was entirely abandoned. It is doubtful if Melliger can endure a great amount of sunlight and heat. While excavating a nest, a number of specimens were collected in a large empty glass bottle, which was set aside for further use. Not more than three minutes afterward when I took up the vessel to insert more specimens, those already collected were dead. The sun had killed them. I was surprised at this quick fatal issue, and tried to revive the insects; but no, they were quite dead. The sun was of the usual August temperature, but the bottle was large, and such a result in so brief a time argues extreme sensitiveness to the heat. I have observed that the agricultural ants[1] always avoided the noonday heats of Texas, which are certainly intense; and indeed all ants appear to me to shun, more or less, the midday fervor of the sun. But Melliger doubtless is more susceptible to solar influences than most of her fellows. It cannot therefore be wondered at that she seeks her food under the shelter of night.

V. Quality of the Ant Honey.

A number of the honey-bearers were unavoidably injured and their abdomens broken during the excavations of the nests, and I observed from these the quality of the honey. It is very pleasant, with a peculiar aromatic flavor, suggestive of bee-honey, and quite agreeable to me. Dr. Loew describes it as having "an agreeable taste, slightly acid in summer from a trace of formic acid, but perfectly neutral in autumn and winter." It contains, according

[1] Op. cit., p. 18.

to this writer, a little more water than the honey of bees, and has therefore somewhat greater limpidity.

Fortunately, the composition of this ant-honey has been subjected to a thorough chemical analysis by a competent authority, Dr. Chas. M. Wetherill.[1] The experiments were made at the request of Dr. Leidy, from specimens of *M. melliger-mexicanus* collected by Mr. Langstroth at Matamoras, Mexico.[2] These ants showed the variations observed by me in the distension of the abdomen, and the amount and color of the honey. Six of the average-sized honey-bearers were weighed, and showed the average weight of the honey-bearer's body alone (without honey) to be 0·048 grammes, and the average of honey in a single ant 0·3942 grammes. The amount of honey was therefore 8·2 times greater in weight than the body without the honey. The density calculated for the ants filled with honey was 1·28, and for the bodies alone 1·05. Dr. Wetherill's calculations expressed in English Troy weight would allow about six grains for the weight of each honey-bearer. It would thus require about one thousand (960) honey-bearers to yield one pound of honey (Troy weight), or about twelve hundred (1166) to yield a market or avoirdupois pound.

The syrup extracted from the ants had an agreeable sweet taste, and an odor like that of the syrup of squills. When set aside as removed it showed no trace of crystallization to the naked eye or under the microscope. Under high powers fragments of organic tissue were seen. When evaporated by the heat of steam, it dried to a gummy mass, which did not exhibit traces of crystallization after standing for a couple of weeks.

This mass was very hydroscopic, becoming quickly soft from the absorption of water from the atmosphere. It dissolved without residue in ordinary alcohol, leaving a residue in nearly absolute alcohol. These solutions did not crystallize when set aside. They had exactly the smell of perfumed bay rum. After various tests, which are described, Dr. Wetherill analyzed by combustion with oxide of copper and chlorate of potassa a portion of the gum-like substance which resulted after the ant-honey had been left in vacuo for two weeks. As this was not perfectly hard, but of a sticky nature, it was necessary to introduce it into the combustion

[1] Proc. Acad. Nat. Sci. Philad., Vol. VI, pp. 111, 112, 1852.

[2] I have some of these still in good condition after twenty-nine years' preservation in alcohol.

tube upon a piece of glass. 0·497 of honey gave 0.306 of water, and 0.684 of carbonic acid, corresponding to a percentage of C = 37·535, H = 6.841, O by loss =55·634. This corresponds, as nearly as could be expected under the circumstances of the analysis, with the formula of crystallized grape sugar, $C_{12}\ H_{14}\ O_{14}$.

Dr. Wetherill, who in this analysis was especially seeking light upon the origin of the ant-honey, thus announces his conclusion: "It results, I think, from these experiments, that the honey contained in the Mexican ant is a nearly pure solution of the sugar, so called, of fruits, which is in a state of hydration, isomeric with grape-sugar, $C_{12}\ H_{14}\ O_{14}$, and differing from grape-sugar in not crystallizing." It is certainly an interesting confirmation of the value of this reasoning from analysis, that the ants have been proved by field observations to have collected their honey-dew as Dr. Wetherill concluded, from the nectar of plants. Thus the methods of cabinet and laboratory, and the objective studies of the field, confirm and complete each other.

With regard to the acidity of the ant-honey, which has been referred to, Dr. Wetherill found that it reacted slightly acid to blue litmus paper, but want of material prevented satisfactory experiments. He was in doubt as to whether it was formic acid, or acetic from the oxidation of the alcohol in which the ants were preserved. A portion of the alcohol (reacting acid like the honey) neutralized by caustic potassa, when distilled with sulphuric acid, gave an aqueous acid liquid, which, on addition of nitrate of silver, gave a whitish precipitate, becoming black on boiling, rendering the supposition of formic acid probable.

The uses to which the Mexicans and Indians put this ant-honey are various. That they eat it freely, and regard it as a delicate morsel is beyond doubt. Prof. Cope, when in New Mexico, had the ants offered to him upon a dish as a dainty relish. The Mexicans (Loew) press the insects, and use the gathered honey at their meals. They also are said to prepare from it by fermentation an alcoholic liquor. Again, they are said (Edwards) to apply the honey to bruised and swollen limbs, ascribing to it great healing properties. Dr. Loew's suggestion to bee-keepers to test the commercial value of these ants as honey producers is wholly impracticable. The difficulties of farming the colonies, gathering the supply, and the limited quantity of the product, would prevent a profitable industry. The greatest number of honey-bearers in a large colony, taking my observations as a standard, will not exceed six hundred, which, counting six grains of honey to the ant, would be little more than one-half pound avoirdupois. Besides, the sentiment against the use of honey thus taken from living insects, which is worthy of all respect, would not be overcome. The Mexicans and Indians will therefore probably not be disturbed in their monopoly of the honey-product of the nests of Melliger.

VI. Interior Architecture.

Gate Architecture.—In order to determine the gate architecture—a term by which I characterize the structure of the nest nearest to the entrance—several formicaries were carefully opened and studied. Four of these are here given as fair types of all. It will be seen from these that a general similarity of plan prevails. The gate itself is a single tubular opening in the centre of the mound, from three-fourths to seven-eighths of an inch in diameter. It is smooth within, and penetrates the mound and the earth perpendicularly to a depth varying from three and one-half to six inches. This gate is funnel-shaped at the top, and the funnel (Pl. IV, fig. 14, F) is gravel-lined, differing therein from the lower part or nozzle of the gate (fig. 18, N). The nozzle descends perpendicularly, or with a slight slope, for three inches, more or less, and then deflects at an angle more or less abrupt, forming an arm (A) usually shorter than the nozzle. This leads into a series of radiating galleries and rooms, and the point of deflection may be called the vestibule, V. These galleries and rooms appear to extend quite habitually beneath and chiefly in one direction from the gate. There are indeed galleries immediately surrounding the gate on every side; but these appear to be limited except in the one direction, within a radius of about eight to ten inches, and to the same distance in depth.

These general statements may be illustrated and expanded by the following details of particular nests.

1. Nest No. 7, fig. 19, was a small nest three and one-third inches in diameter. The gate had a perpendicular depth from the surface of three inches. Thence at nearly a right angle it bent south-east for two and one-half inches, forming the arm, A, and meeting at V a series of branching galleries, *a*, *b*, *c*, *d*. Gallery *a*, bore westward, terminating under the gate; *b*, bore southwest, appearing to run upward toward the surface; *c*, extended down-

ward and southward at a sharp inclination, entering a long room. E, was a small circular chamber, at one end of which was a beautiful gallery, *f*, running deep downward and inclining slightly west. It was entered near by and above by another gallery, *d*, running toward the surface.

2. Nest No. 6, fig. 18. The depth of the gate, G, was three inches; the length of the arm, A, two inches. The gallery into which A opened toward *b*, divided at one end with two branches separated at their mouths by a little column of two stones resting one upon the other. The gallery, *c*, could be traced at least six inches downward, and a gallery opened directly downward at *a*.

3. Nest on Eaglehead Ridge, Pl. V, fig. 20. This nest, from which many of my night studies were made, was finally opened, and the section view, fig. 20, taken. The vestibule, as in the above examples, also opened into a main gallery, *b*, which led to the northeast, and joined a circular gallery which passed around the vestibule and terminated in an oval room, A. At the other end it entered a circle, which widened upon one side into a bay-room, and sent off a couple of branches, one of which, *c*, was a chamber. Two galleries, *g g*, opened downward. Beyond this, southward, was a long waved gallery, D D, which ended at *e e*, and branched at *h*. Galleries, *g g*, in this series, also led downward.

No. 4. Fig. 23, Nest No. 4, on Adams Ridge. The diameter of this mound was three and one-half inches at the top and seven inches at the bottom. The vestibule sloped eastward from the summit, downward three inches to the main gallery, which had three branches, *x*, *y* and *z*; *x* was followed six inches northeast and upward; *y*, extended southwest and downward; *z*, southeast and downward. A gallery, 1, ran upward from *z*, and connected with *x*. Another, 2, opened on the southwest into a room, A, six inches long and three inches wide, at the west end of which were galleries dividing north and south. A third gallery separated from *z* at 3, and bent northward, apparently uniting with a room, A, five inches long. This room was entered again by a widened mouth, B*e*, about one-half inch above *z*. At the vestibule and upper part of *z* were a number of cocoons. The room, *A*, was five inches below the surface of the ground at G.

Galleries and Honey-Rooms.—The last figure gives an idea of the relation of some of the honey-rooms to the gate and the upper series of galleries. These rooms lie at least as near to the surface as six and eight inches. They vary in size, but for the most part, are about five or six inches in length and three or four in width. They are irregular in their outlines, but have a general tendency toward the oval. One of the most irregular is figured at Pl. V, fig. 21, HR, a large chamber which lay nearly underneath the gate. The gallery, *g g*, into which the vestibule opened, debouched into this room, and a portion of the gallery roof unbroken is shown at *ug*. At B, appeared a bay-room, or enlargement of a gallery, which penetrated the earth horizontally at one end and at the other seemed to wind into the vestibule. The height of the rooms at the walls or sides is from one-half to three-fourths of an inch. The roof is vaulted, thus causing the height to increase gradually until at the centre it is one and one-half inches, which is the greatest distance that I measured.

Floors and Roof.—The floors and walls are well nigh invariably smooth, quite smooth some of them. The roof, on the contrary, is rough, presenting the natural condition after the sandy pellets of earth and the little pebbles had been picked out by the workers. This can hardly be otherwise than by purpose, precisely as with the smoothness of the floors. The roughness of the roof evidently greatly favors the use to which the honey-bearers put it as a perch. So the smoothness of the floor and walls much better adapts them for the use of gangways. The amount of travel to and fro must be enormous, it is true, in a large formicary; but I cannot think that the resulting friction will account for the smoothness, independently of the purposed masonry of the ants. In the galleries the entire surface, above and below, is smooth, a condition which might be anticipated on the ground of adaptation.

Galleries and Rooms.—The galleries are tubular openings, varying somewhat in size, from one-half to three-fourths of an inch, and even more, in diameter. A vertical section, however, uniformly shows a quite perfect circle. The underground formicary may be described in general terms as a system of galleries and rooms, arranged in several horizontal series, one above another, approximating the order of "stories" in a house, and intercommunicating at many points by vertical galleries. The character of the interior architecture can, perhaps, be best shown further by giving somewhat in detail my studies of one nest.

The nest selected for exhaustive exploration was situated upon the summit of Adams Ridge, just above the nook within which my camp was located. Three entire days, besides other portions of time, were spent in this work by myself and assistant. The nest interior sloped eastward, and toward the base of the hill, and occupied a space (in round numbers) eight feet long, three feet high and one and one-half feet wide, the whole tunneled through the soft red sandstone rock of which the ridge consists. This rock is much of it quite friable, crumbling readily under the pressure of the hand, but packs tightly under the stroke of mallet and chisel, thus making difficult mining for men if not for ants. Most of our work was done with the chisel, and the galleries and rooms had to be worked out with knives.[1] These thirty-six cubic feet of rock were fairly honeycombed by the series of galleries and chambers above referred to.

The dimensions of the exterior nest are as follows (see Pl. IV, fig. 15): Height, north side, $2\frac{1}{2}$ inches; west side, $1\frac{5}{8}$ inches; east side, $1\frac{7}{8}$ inches; south side, $1\frac{7}{8}$ inches; distance across the top, $a\ c = 10$ inches; distance around the base, $a\ i\ e\ c = 29$ inches; distance around the crater, $m\ o\ n\ r = 8$ inches; eastern ridge of the crater, $v\ n = 1\frac{1}{8}$ inches; western ridge of crater, $m\ s = \frac{1}{2}$ inch; distance across the gate at $x\ z = 1$ inch, at $s\ v = \frac{7}{8}$ inch; depth of the gate before bending, 4 inches. The mouth, as appears from measurement, was ovate (Pl. IV, fig. 14), but the entrance beyond was a circular tube.

The mound was removed and the soil carefully scraped away. Close to the surface, at the distance of one-half to three-fourths of an inch, openings were found of various sizes, from one-fourth to one inch in diameter. These openings occurred at various distances from the gate, on all sides, four and one-half, five, five and one-half, eight, eight and one-half inches and upwards to ten inches on the northwest side, eighteen inches on the south side, and eighty-two inches on the southeast, in which direction the formicary extended. Toward the termination of the nest, however, they did not appear so near to the surface.

Section views were next had by cutting across the nest. On the north side I found no galleries at a greater depth than eight inches. On the south side, the first cutting was made east and

[1] While engaged upon this part of my work, I was pleasantly surprised by a brief visit of Prof. A. S. Packard. I am glad to be able thus to refer to his valuable testimony in confirmation of some of the statements of this paper.

west, and thereafter the rock cleared away outwardly, until the end of the nest, when the cutting was made inwardly from the starting point toward the gate. The character of the architecture is the same throughout the entire nest, so that the following views will suffice to typify all the interior. The figures Pl. VI, fig. 35, and Pl. V, figs. 16, 17, give views of vertical and horizontal sections made from the gate (southeast), the bottom of the section being twenty-one inches below the surface and the distance of the furthest point from the gate twenty-three and one-half inches. Fig. 35, Pl. VI, is a front view of galleries looking south, and exhibits a surface about seventeen inches in length by seven in height.[1] The main series of galleries within this area are accurately shown, but the connecting vertical galleries were broken away in the excavation, and are not figured.

Fig. 16 is a vertical section showing the southwest and southeast sides of the excavation at the same point as the preceding figure, part of which is included in this view.[2] There are here shown the general tendency of the galleries (*g*, *g*, *g*) toward stories, arranged one above another; the relative position of the honey-rooms (R, R), and the relation of the series to the large honey-rooms, C, D, E, shown fully at fig. 17.

The broken lines, *c l d*, and *e h k*, show a series of rooms, some of which were occupied by larvæ and some by honey-bearers. The large rooms, C D E, Fig. 17, belong to the lowest series, and are figured and described as fairly typical of all the honey-rooms and other chambers. They were carefully uncovered by chisel and knife, and after being sketched, a plaster cast was taken of them, which is preserved in my collection.[3] These rooms were of

[1] Detailed measurements.—*a* to G = 5½ inches; G to *d* = 11 inches; *e* to *f* = 10 inches; *h* to *i* = 11 inches; *k* to *l* = 11 inches; *m* to *n* = 3 inches; *b* to *e* = 2⅝ inches; *o* to *f* = 3½ inches; *p* to *q* = 1½ inches; *q* to *k* = 2⅓ inches; *i* to *l* = 2¼ inches; *o* to *r* = 3¼ inches: *l* to *s* = 6¼ inches.

[2] Fig. 16 measurements.—*a* to *b* = 4½ inches; *c* to *d* = 10 inches; *e* to *f* = 4 inches; *h* to *i* = 4⅛ inches; *i* to *k* = 4⅝ inches; *c* to *j* = 10 inches. The gallery, *j*, appeared to connect upward with the lowest series of rooms, *e f h k*.

[3] I succeeded by vast painstaking and labor in securing a number of fine specimens of the architecture, which were carefully packed in boxes and committed to the Express Company at Colorado Springs. The company received a heavy bill for transportation, and delivered my beautiful and

an irregular oval shape; in length five, three and one-half, and six inches successively (C, D, E), and were of an average width of about four inches. They were not built upon a level, the origin of C, at *b*, being three and one-half inches above the middle point of D, and six inches above the termination of E. A side gallery, *g g*, skirted two of the rooms, and appeared to open upon a fourth chamber at F, which, however, was too much broken in the digging to be identified. Of course, only the floor and part of the side walls of the rooms are shown, but the roofs were vaulted and rough, as already described, and rose to the height of three-fourths to one and one-fourth inches. Within them, clinging to the roofs, were packed the rotunds. The number in each room averaged about thirty; and as there were at least ten chambers thus occupied, the number of rotunds in the nest was certainly not less than three hundred. Of far the greater proportion of these the abdomens were distended to a perfect sphere.

THE QUEEN ROOM.—I had the good fortune to capture the fertile queen of this colony. She was found quite near the extreme end of the formicary, in a nearly circular room four inches in diameter. The series of galleries and honey-rooms which composed the formicary terminated in a single gallery (fig. 22, *g g g*), about eighteen inches long, three-fourths inch wide and one-fourth inch deep. The gallery sloped sharply with the slope of the hill-side on which the nest was made. Near the middle part thereof was the queen-room (C), being seventy-two inches from the central gate and twenty-eight and one-half inches below the surface of the hill. Besides the queen the room contained a large number of naked grubs, callows, honey-bearers and workers. It is not improbable that the queen habitually dwelt in or near this room; but it may be that during the successive attacks upon the nest, the workers bore their queen still further and further from the point of danger until the limit was reached.

Ten inches below the queen-room, the gallery, *g g g*, was continued until it finally terminated in a small circular chamber (E) or bay on the one side, and on the opposite side a narrow gallery (*t g*), which curved upward. This was the end of the formicary.

costly specimens at the Academy broken in pieces! It was an act of gross carelessness, which merits this notice, as some specimens brought home in my trunk survived even the "baggage smashers."

It was eighty-two inches from the central gate, forty and one-half inches below the level of the main nest gate, and twenty-nine and one-half inches below the level of the hill-side. The entire length of the formicary from northwest to southeast was thus seven feet eight inches.[1]

VII. Queen Life.

The captured queen of the large excavated nest was transported to Philadelphia, placed in one of my artificial nests, a large glass globe, and afforded several interesting observations upon her habits.

Her Body-Guard.—After the usual custom of ants, she was continually surrounded by a guard of workers (Pl. VI, fig. 29) varying in number, but usually as many as twelve or twenty. These attendants quite enclosed her, and restricted her movements, apparently watching and guarding her with great carefulness. On one occasion when she escaped to the upper surface of the nest, she was followed and seized by a worker-major, who interlocked her mandibles with the queen's (Pl. VI, fig. 26) and dragged her down the gateway into the interior. The royal lady gave only a passive resistance, holding back somewhat heavily.

Depositing Eggs.—I quote from my notes the desoription of this process, the various stages of which I was also able to sketch. "The queen has been laying a small heap of eggs. She is now on a little elevation of earth, surrounded by a number of workers of all castes, some of whom lick her abdomen, especially beneath and at the apex. One, meanwhile, gives her food in the usual way, by regurgitation. I see the tongues of the two insects overlap in the

[1] While preparing clay models of some of the above examples of ant architecture for my cabinet of Insect Architecture in the Academy of Natural Sciences, it was suggested that moulds be made, from which plaster casts could be taken, for the benefit of such other scientific collections and public museums as they might be wished for. This I had done, and the moulds are now in the hands of the Curator in charge of the Academy, by whom they will be furnished, upon proper order, at the cost of reproduction and packing, as nearly as may be. Five specimens are cast, viz., those figured at Pl. II, fig. 4, and Pl. V, figs. 16, 17, 22 and 23. They are cast natural size, except fig. 16, which is half size. The cost, painted natural color, will be $10 for the set, unpainted $6. Orders should be sent to Charles F. Parker, Curator in charge Academy of Natural Sciences, Philadelphia, Pa., U. S. A.

act. The queen's abdomen is raised high, her head is stooped, she lifts the abdomen up and down. The workers have clustered under her body, giving her somewhat the appearance of a successful candidate undergoing 'a chairing.' She has changed her position; the workers follow, quite surrounding her. Two are beneath the abdomen, which is depressed now, the head being elevated. The attendants sit down patiently to watch. They keep their antennæ moving continually, while they amuse themselves by cleansing their persons. The queen moves; a dwarf seizes a fore-foot and attempts to control her course. This and "nipping" with the mandibles, is the common mode by which the guard directs the queen's motions. The eggs laid are in an irregular mass about one-eighth of an inch thick. There are twenty to thirty minute yellowish, ovoid objects, which adhere to each other. The workers surround the mass, some appeared to lick it. The queen straggles over the eggs, places a foot upon the mass. A dwarf seizes the foot hastily and draws it back, while another worker catches up the egg-mass and draws it aside." The observation was made at 11.20 P. M.; at 1 A. M., when I retired, no change had occurred. This is as much of this interesting behavior as I was able to observe in this female. I have, however, seen the actual deposition of the eggs by a queen of *Camponotus pennsylvanicus*.[1]

VIII. Acts of Beneficence.

In the natural sites the workers showed great interest in the preservation and removal of the rotunds, dealing with them very much as with the larvæ. As the honey-rooms were opened and the rotunds disturbed from their roosts, the workers of all castes rushed eagerly to them, and dragged them into the unbroken interiors. Sometimes several ants would join in removing one rotund, pushing and pulling her along. One sketch (Pl. VI, fig. 27) made in my notes, represents a major pulling a rotund, whom she has seized with her mandibles by the outer abdominal wall, while a dwarf-worker is mounted upon the globe, standing upon her hind legs "a-tip-toe," as it were, pushing lustily. Another sketch (Pl. VI, fig. 36), caught on the spot, represents a worker-major dragging a rotund honey-bearer up the perpendicular face

[1] See a note in "Proceed. Acad. Nat. Sci. of Phila.," 1879, p. 140.

of a cutting made in the excavation of the nest. The mandibles of the two insects were interlocked, and the worker *backed* up the steep, successfully drawing her protégé.

This interest is maintained in the daily life of the formicary. The workers were continually seen hovering about the rotunds as they hung from the roof of my nests, or as they lay upon the floor cleansing their bodies. It is evident that these creatures are regarded as dependents, and, as with the queen, virgin females, males and larvæ, are fed and tended by the active members of the community. In all these cases the same communal instinct would of course control action, giving at least the semblance of beneficence.

Lack of Individual Beneficence.—But a great number of examples fell under notice which go to throw doubt upon the possession of any personal or individual sentiment as towards special cases of need, outside of the above limit. Some of these may deserve permanent record.

1. In making up my artificial nests, I placed in the natural soil, which was closely packed down, and then introduced the ants, knowing that they would work out their own habitations. The honey-bearers were thus mingled upon the surface with the workers, upon whom fell the entire task of digging galleries. In this work, and in the distribution of the excavated pellets, there was much room for the exhibition of individual carefulness and tenderness toward the honey-bearers. Not a single such instance was noted, although I watched closely and with some anxiety to discover such excellencies in my little friends. On the contrary, the exhibitions of an apparent cruel neglect and positive cruelty were many. The grains of sand and soil were heaped around the rotunds (Pl. VI, fig. 31) until the poor creatures were literally buried alive. It would have been easy for the busy masons to draw their fellows aside and thus carry on their work. But it either never occurred to them to do so, or the disposition was wanting.

2. Again, as the openings were made into the earth, most of the rotunds, not prevented as above, managed to roll down the galleries and secure a place in the honey-rooms. They were not observed to be aided in this by the workers, and I believe that they attained their perches unaided. Some of them, on the route, became fastened in the gang-way in most uncomfortable positions,

heads downwards, bodies awry, etc. The workers passed by and over them continually, for many days, without the slightest apparent concern, and certainly without a single observed effort to relieve their comrades, who could readily have been extricated and drawn into the chambers.

3. It frequently happened that the rotunds dropped or were shaken down from their perch against the roof to the floor. These creatures remained in the positions in which they fell, except when they chanced to so fall as to be able to clasp with their claws some clod of earth, or bit of gravel, or the rough surface of the projecting walls or roof. In such case, they either recovered their perch, or placed themselves in comparatively comfortable postures. The greater number, however, fell upon the round abdomen in such wise that the body stood up quite erect (Pl. VI, fig. 32), leaving the legs thrust out unsupported. These unfortunates were faithfully attended, often cleansed and caressed, but in no single instance did the workers attempt to right them and restore them to the roof. Yet they were abundantly able to do so, with little effort, and the fallen rotunds were in sore need of help. Some of these lived for two months and longer in this awkward position, but it was very evident that they were extremely uncomfortable.

When it was practicable to extend my help to those near the surface it was eagerly accepted, the offered stick or quill clasped by the mandibles, sometimes assisted by the feet, so firmly as to enable me to transfer the heavy creatures to any point, even to lift them out of the nest. Here again the idea or at least the act of helpfulness was lacking. If we are to suppose the power of communicating their distress and desires to have been possessed by the bearers, we must think the workers even yet more lacking in feeling and intelligence.

4. One honey-bearer was partly buried under her perch, that portion of the roof having fallen. Her abdomen was quite covered by the fine sandy particles at the margin of the little landslide. The task of rescuing her would have been easy to the workers, but it was never undertaken. A sketch (Pl. VI, fig. 28) was made, shortly after the occurrence, which shows one worker-minor standing before the rotund with head and body erect, antennæ atent, with every mark of curious interest in her deportment. She watched the struggles and mute appeals (as it seemed to me) of her unhappy comrade, who by great exertion had suc-

ceeded in heaving up the clod, and then "passed by on the other side." Meanwhile a second worker was perched atop of the clod, coolly and cosily combing her back-hair and antennæ! This tableau is simply characteristic of the ordinary behavior of the workers.

An apparent exception was noted in the case of a semi-rotund who was overtaken in a gangway by water with which I was supplying the community, and stuck fast in a bed of mud. For a long time the workers, who were incited to masonry, as usual, by the water supply, dug and traveled around and over the imbedded ant without notice of any sort. Finally one stopped and licked the antennæ and head of the prisoner, who began to struggle, and so dropped down a little into the gangway. Meanwhile the first-comer had left. A second ant stopped, applied the tongue a moment, gave a little tug at the unfortunate, and was off. Still the stream of workers passed on. Finally, an additional pull from below was given by a concealed worker, but when I closed the observation the ant was still imbedded in the mud within the gangway. It was impossible to decide in this case whether the helpers noted were moved by personal kindness, or rather (as is most likely), by the same impulse which directs them in ordinary mason operations and toward supposed dead comrades.

Sir John Lubbock, who has made interesting experiments and observations with a view to testing the presence of benevolent feeling in ants,[1] does not have a very high opinion of emmet charity, but concludes that there are "individual differences," and that among ants, as with men, there are Priests and Levites, as well as Good Samaritans. I am much inclined to the view that anything like individual benevolence, as distinguished from tribal or communal benevolence, does not exist. The apparent special cases of beneficence, outside the instinctive actions which lie within the line of formicary routine, are so rare and so doubtful as to their cause, that (however loth), I must decide against anything like a personal benevolent character on the part of my honey-ants.

Such an example, indeed, as one of those cited by Lubbock,[2] viz., the neglect on the part of co-formicarians to remove the decapitated heads of enemies from the limbs to which they are firmly clasped, does not seem to me as remarkable as it does to

[1] Journal of the Linnæan Society, Zoology, Vol. XII, p. 497.

[2] Op. cit. p. 492.

Sir John. I have often observed the same fact among various species, and, knowing by experience, the difficulty of unloosing those formidable jaws, clasped by their immense muscles in the rigor of death, would charge it to inability rather than indisposition, that these adhering death's-heads are not removed by kindly offices of comrades. But such examples as are here recorded, together with kindred ones given by Lubbock, may fairly be quoted against the existence of a personal benevolent character in ants. However, the question can by no means be regarded as settled.

Cleansing and Feeding Larvæ.—One or two miscellaneous observations may, perhaps, be allowed a place in this connection. The solicitude of the workers for the helpless larvæ was a matter for continual admiration. The offices of nurse do not seem to be confined to any one caste, but the burden of duty appeared to be assumed by the dwarfs, and next to them the minors.

When the grub is to be cleansed it is taken in the mouth, turned by the fore pair of legs, the antennæ meanwhile touching and apparently aiding, while the mandibles are applied over the grub, their teeth apparently working chiefly within the annular divisions of the several joints. Doubtless this motion is accompanied by a free use of the tongue, but this I did not observe.

When the grubs are to be fed, the workers pass from one to another, striding over them, and standing among them (Pl. VI, fig. 34) as they lie in little groups. The wee white things perk up their brownish yellow heads, which they stretch out and move around, evidently soliciting food. Their nurses move from one to another, apply the mouth for a moment, and pass on.

At the slightest alarm the grubs are seized and hurried into the recesses of the nest. Their position is frequently changed, from higher to lower, from outer to inner rooms, and the reverse, without any purpose which I could discover or imagine. When this sort of transfer was not going on, the nurses would often be engaged in shifting the position of their charges, flitting restlessly among them, picking them up, turning them around, putting them down again, with an aimless uneasiness that bore an amusing likeness to the dandling which human infants undergo at the hands of certain young mothers.

Toilet Habits.—It has been said that the honey-bearers are cleansed by the workers. This is the rule; but the rotunds are not wholly dependent for this upon their fellows. In one of my formicaries, the rotunds when placed within the light, began to cleanse themselves, without leaving their perch. They held on to the roof by the two hind legs and one of the middle pair, and used the other middle and the two fore legs in the usual manner of ants.[1] They were quite able thus to draw a leg through the spur-comb of one of the fore-feet; to brush the head, etc.

In one case I even saw a honey-bearer performing the offices of the toilet upon a worker. The latter held her mandibles apart, while the rotund licked the mouth parts; and from thence proceeded to the vertex of the head. Both insects were in a semi-rampant posture the meanwhile.

FRATERNAL RELATIONS WITH SISTER COLONIES.—A few experiments upon several nests quite widely separated, showed that as in the case of some other ants,[2] the inmates (of the same species) fraternized completely, and engaged within the artificial nests, in the care of the larvæ, cocoons, honey-bearers, and in all other formicary duties.

IX. ECONOMY OF THE HONEY-BEARERS.

What is the economy of the remarkable structure and habit presented in the honey-bearer? The naturalist is shut out from all observations in natural site that might give answer to this question. But from studies thus far made upon my artificial formicaries, from structure, and from reasonable analogy, I have little hesitation in saying that the economy is precisely that of the bee in storing honey within the comb. The difference lies in the fact that the bee puts her store within inorganic, the ant within organic matter; the bee within the waxen cell which her industry constructs, the ant within the living tissue of her sister formicarian, provided to her hands by the Creator. The honey is held in reserve within its globular store-room of animal tissue for times when the workers fail to gather food, or the supply fails in Nature. The queen, the virgin females, the males, the teeming nursery of white grubs, are all and always altogether dependent upon others for nurture. During the winter months and in seasons when the honey supply is scant or wholly fails,

[1] See Toilet Habits of Ants, in Agricultural Ants of Texas, Ch. VIII, p. 125.

[2] Mound-Making Ants of the Alleghenies, p. 281.

perhaps during the long rainy seasons, the entire family must have food. Precisely as the bee goes to the honey-comb in such emergencies, the honey-ant goes to the honey-bearer.

There is, to be sure, a corresponding difference in the mode of eliciting the stored sweets. The bee breaks the cell and laps the honey. The hungry ant places her mouth to that of the bearer, from whose mouth it is received as it is regurgitated from the honey crop. The muscles of the abdomen act upon that organ as does the pressure of a lady's hand upon the eau-de-cologne within the elastic bulb of a toilet jet or spraying bottle. It is forced up, gathers in a little globule, a honey-dewdrop, upon the filament-like maxillæ under the jaw, whence it is lapped off by the waiting pensioners. The admirable adaptation by which the ant's structure is fitted for this function, will be noted further on. It may be well to state such facts as appeared in various efforts to arrive at the truth of the above opinion, viz., that the honey-bearers serve as store-houses of food for the inmates of the nest. If these facts fall short of a complete demonstration, they at least form a chain of evidence which creates a very strong probability.

1. Regurgitation of Honey.—On the occasion of the discovery that the ants collected nectar from the oak-galls, a branch upon which the foragers were at work was removed to my tent for study. First, however, it was taken to the home site, and a dwarf worker coaxed upon a leaf and laid on the nest. She seemed much confused, and evidently did not at first recognize the fact that she was at home. The workers around the gall, who were quite easily distinguished by the smaller size of their abdomens, also showed marks of surprise at this unexpected arrival. However, two dwarfs and a minor soon sufficiently recovered their equanimity to arrest their fellow and "take toll" from her mouth of the syrup with which her crop was well charged. (Pl. V, fig. 24.) The mode was that which is common among ants, and has been fully described.[1] A worker major was next transferred from the bush to the nest, and showed the same confusion at this unexpected "railroading" home. She also was tolled by the ants clustering upon the mound. In both cases I saw the drop of liquid honey sparkling as it passed, a lantern having been placed on each side, thus throwing light fully upon

[1] See Mound-Making Ants, p. 275.

the group. The major, after her first confused hesitation, seemed inclined to start again on the trail, but after being tolled entered the gate. It thus appeared at the outset, that the honey collected by the foraging parties is served out to the sentinels, working parties and others at the nest, precisely as has been fully shown in the case of the mound-making ants of the Alleghenies.[1]

2. The act of receiving supplies from the honey-bearer was observed by me soon after the transfer of the ants to an artificial nest. The rotund threw her head up, raised her thorax, and regurgitated a large drop of amber liquid, which hung upon the mouth and palps. At first two ants were feeding—a major, who was in a position similar to that of the rotund, and a dwarf who stood upon her hind legs and reached up from below. During the feeding another major was attracted to the banquet, and obtained her share by reaching over the back of the first worker, indeed, partly standing upon her, and thrusting her mouth into the common "dish." (Pl. V, fig. 24.) The mandibles and maxillæ of the pensioners serve as a sort of dish, upon which a particle of honey is taken and afterward is licked off more at leisure.

3. Workers fond of the stored Honey.—The fondness of the workers for the store within the rotunds was strikingly shown during the excavation of a nest. Necessarily, in breaking down the rooms, the distended abdomens of some of the honey-bearers were ruptured. The high state of excitement which pervaded the colony, the ordinary instinct to defend the nest and preserve the larvæ, cocoons and other dependents, were at once suspended in the presence of this delicious temptation, and amid the ruins of their home the workers paused, clustered in large groups around the unfortunate comrade, and greedily lapped the sweets from the honey-moistened spot. It was a pitiful sight to see, and was noted with a mild sort of indignation, and to the disparagement of the ants, until I remembered that history has often recorded, and, indeed, I myself have seen, the humiliating fact that human beings have exhibited a like greed and ignoble self-gratification amid the perils and threatened wreck of their country and homes.

Treatment of Dead Rotunds.—Over against this fact may be placed one seemingly more to the credit of our Melligera. From time to time the honey-bearers died. The bodies of those who perished upon their perch would hang to the roof for days before

[1] Op. cit., p. 277.

the death-grip finally relaxed and they fell. It happened more than once that the workers failed to perceive the change, and for some time, a day or more, after death, continued to cleanse and tend them with the accustomed solicitude. When the fact was at last perceived, and the dead removed, the round abdomen was first severed from the thorax by clipping the petiole, then the parts were separately removed to the "cemetery," that common dumping-ground for the dead, which these ants, like all others whom I have observed, invariably maintained. In view of the fact last recorded, it seemed curious that the stored treasures of these "honey-pots" were not secured by cutting the sealing tissue. In point of fact, this was never seen to be done, and the amber globes were pulled up galleries, rolled along rooms, and bowled into the graveyard along with the juiceless legs, heads and other members. I verily believe that they were never once deliberately opened, in spite of their tempting contents. If this act were the result of an instinctive sentiment by which Nature guarantees protection to the living honey-bearer (and this, indeed, is likely), it must seem to us very beautiful and praiseworthy. But what if it were only the consequence of a mentalism so low and fixed within its instinctive ruts as to hinder even a suggestion of utilizing the wasting store by opening the abdomen?

4. Effects of Withholding Food.—In order to determine beyond doubt the relations of the honey-bearers to the other ants, I made a number of experiments, which, I regret to say, led to no decided conclusion.[1] One or two of them, however, gave results of some value. A number of rotunds and workers were placed in a nest, and denied all food. A little water was allowed them, but for more than four months their fast was not otherwise broken.

[1] An unusual press of professional and domestic duties during the winter of '79-80 absorbed even my evenings and those leisure hours which I feel at liberty to devote to natural history. I was thus unable to give to my little friends that attention which might have assured a complete success. On one occasion, just as a long series of preparations promised satisfactory results, a family bereavement intervened, and when it was possible to resume observations, the hour of advantage had passed. Then followed the untimely destruction of my captives, as will be related hereafter, and the estopment of all study. Naturalists, at least, will know how to estimate the various ordinary as well as extraordinary interruptions and hindrances with which the observer has to contend, and which often prevent the most satisfactory results.

It was my hope that this prolonged separation from external food supplies would compel the workers to resort to the honey-bearers for food, and thus afford the positive proof that the latter were the natural storehouses of the colony. Most provokingly, the perverse Melligers made the room of the honey-bearers within the very heart of the nest, and no strategy of mine could tempt more than one or two of the rotunds into a position under my eyes. I was therefore limited to such inferences as might be drawn from the general condition of the inmates during and at the close of the fast.

During the entire four months, the workers, whose movements were of course observable, were in perfect health and good condition. Indeed, it was very evident that they were in a more healthy state, more vigorous and active than the inmates of the other nests. When the nest was finally opened the remaining workers had well-filled abdomens, all of them looking more like foragers freshly returned from a banquet of nectar among the oak galls, than like the victims of a four-months' seige. The abdomens of the honey-bearers were undoubtedly diminished, but presented little appearance of having been largely drawn upon by hungry workers.

The complement of this experiment over a nest of workers who were wholly separated from honey-bearers, and denied food, came to an untimely end. The purpose had been to make such a comparison between the two sets of workers as would have shown what effect the presence of honey-bearers had upon the abdomens.

5. Covering obnoxious matter.—Two other formicaries were established with the special purpose of determining whether the workers habitually transferred food to the sedentary insects upon the roof. One colony was fed syrup mixed with carmine; the expectation being that if the ants ate this and fed it to the honey-bearers, the color would show through their abdomens, or be discovered by dissection. The experiment failed, as to its main purpose, but was the occasion of uncovering an interesting trait. The carmine-syrup was obnoxious to the ants. Some tasted it, turned away, and rubbed their mouth parts upon the earth, with evident tokens of dislike. Others tested it with their antennæ, and although they had been prepared for a banquet by previous fasting, refused to eat. Moreover, they instantly, deliberately, and with one accord set to work to cover up the offensive material.

The syrup had been placed upon large corks, hollowed out atop into little dishes, and set in the soil. One cork projected an inch above the surface, and up this the workers climbed, carrying pellets of earth and gravel, from the very bottom of the nest, four inches below the surface. These pellets they dropped into the syrup, until the dish was filled and heaped up high. Some of the bits of gravel were quite large, of greater bulk, and several times heavier than the ants. As the nests were made of their native soil, I thus saw the ease with which the workers carry up the gravel stones, that cover their mounds (Pl. VI, fig, 30).

A broad trail of syrup was forced down one side of the cork, and it also was covered. This required more delicate management, as the ants were forced to support themselves upon the perpendicular surface of the cork, and, working side-wise, daub the dirt into the syrup, and fix it there! The whole trail was thus covered from top to bottom, The syrup was fed to another formicary with precisely the same results.

This was not the only occasion on which food given the ants was thus served. A crushed grape, and a juicy bit of a pear were covered in the same way in four of the nests. The fruit did not seem to be relished by the ants, yet I am not sure that the juice may not afterwards have been lapped from the soil which absorbed it. White sugar the ants took freely; bees' honey was not so much relished.

In the meanwhile, during the progress of these observations, I found that the semi-rotunds, at least were not wholly dependent for food upon the workers, as they partook freely of the sugar. But I never saw a honey-bearer, one of full rotundity, taking food or drink.[1] One might imagine that they are quite independent of outside supplies after they have once reached that state, and could spend the remainder of their lives, unless greatly prolonged, without eating. The question of chief interest here is: are they brought to that state by the deliberate action of workers in feeding them? I believe that after a certain point of distension this is the case. But the belief does not yet rest upon positive demonstration. We now proceed to the anatomy of the creature, which may afford some additional light upon this question.

[1] I substituted for carmine Prussian blue, which Dr. Forel had used for staining living ants (Fourmis de la Suisse, p. 110), but had no better success, although some of the ants fed upcn the colored sweets.

X. Anatomy of the Alimentary Canal in the Honey-Ant.

These questions, closely related, required answer:

I. Are the honey-bearers a distinct caste?

II. How is the peculiar dilated condition of the abdomen to be accounted for?

III. What is the condition of the digestive organs in the abdomen of the honey-bearer?

There are some field observations that have a bearing upon these questions:

1. The workers observed returning from foraging excursions had largely inflated abdomens. This is an ordinary experience with ants; the workers of *Formica exsectöides*, our mountain mound-builders, for example, returning from attendance upon the Aphides with their crops very much swollen. The workers of Melliger. however, seem to have an especial elasticity of the crop, which gave the abdomens of some of the returning repletes a nearly semi-rotundity.

2. These repletes and semi-rotunds in my artificial nests adopted in a measure the sedentary habits of the honey-bearers, and perched upon the roofs, where they hung quite persistently. They were often very sluggish, but more ready to move than the rotunds, and at times showed much activity, though not greatly disposed to work. (See Pl. III, fig. 6.)

3. In the formicaries opened in natural site, I observed, what Llave had seen from his specimens, that there were several degrees in the sizes of the honey-bearers in the honey-rooms.

4. There was an apparent growth in the abdomens of the sedentary workers in the artificial nests. As early as September 7th, 1879, I made this record in my note-book: "It begins to dawn upon me that the worker majors become honey-bearers. Many of them hang in the nests to the honey-rooms. In 'B' nest the entire line along the upper margin of the large room is composed of this rank." Honey-bearers with abdomens distended from one-half to two-thirds the full size were continually noted, and I could only infer that they were recruited from the number of the sedentary majors. In fact it became difficult to mark the individuals in whom the sedentary major ceased and the honey-bearer began.

5. A series of experiments was attempted to solve this point. Semi-rotunds or sedentary majors were separated, freely fed, and their growth noted. They never exceeded the condition of about

two-thirds the usual spherical abdomen. What the result would have been had they lived the entire year, and how long it would have taken them to attain the rotund condition can only be guessed.[1]

6. Among the callows, or young ants, collected, I could find no evidence at all of a separate honey-bearer caste. Among the larvæ there were some large, broad grubs, that differed much from the others, which I supposed to be queen-grubs. I was not able to hatch these and the cocoons, and observe results, a process which would probably determine the whole inquiry. The cocoons collected were all of three sizes, corresponding in length to the workers, major, minor and dwarf or *minim* as this smallest caste might perhaps be called.

7. A comparison of the workers with the honey-bearer shows that there is absolutely no difference between them except in the distended condition of the abdomen. The measurements as to length and size of head, length of legs and thorax are precisely the same. This appears to be true also, of some of the smaller rotunds and the minors.

My conclusion from the above facts is that the worker majors, for the most part, and sometimes the minors, are transformed by the gradual distention of the crop, and expansion of the abdomen, into the honey-bearers, and that the latter do not compose a distinct caste.[2] It is probable, however, that some of the majors have a special tendency to this change by reason of some peculiar structure or form of the intestine and abdominal walls.

8. Finally I undertook an anatomical comparison of the honey-bearers and workers. I made a large number of dissections, which were carefully studied and compared, and these observations

[1] Some observer upon the field might readily take up these and other experiments and carry them to a satisfactory conclusion. There are invalids at Colorado Springs and Manitou, who might follow the admirable example of the late Mr. Moggridge at Mentone, and find both enjoyment and prolonged life in some such studies.

[2] I am glad to be confirmed in this opinion by Dr. Aug. Forel, to whom I early sent specimens and notes, and who has shown a gratifying interest in these studies, and has cordially aided them by valuable suggestions. See a communication to the Morphologico-Physiological Society of Munich, in *Aerztlichen Intelligenz-Blatte*, Jan'y, 1880.

strengthened, I might almost say entirely confirmed my opinion.[1] Some of the results thus obtained will have value to many students, and they are therefore briefly presented here. Without entering fully into anatomical and histological details, enough will be given to confirm and explain the facts related and opinions stated above.

THE ALIMENTARY OR INTESTINAL CANAL.—The whole course of the alimentary tract from the mouth to the anus was carefully worked out in many dissections. Less attention was given to the head; the pharynx and mouth parts were, however, worked out. Attention was, of course, chiefly directed to the abdomen and contents.

The intestinal canal is composed of the following parts:

I. Within the head there are:

§ 1. The mouth and the mouth-parts, viz.: the mandibles (Plate VII, figs. 37, 38) *mb.*,[2] which are armed with teeth of irregular size; the maxillæ, *mx.* and maxillary palps, *mx. p*; the labium, *lb.*, and lower lip, the labial palps, *lb. p.*, and the tongue, *to.*

§ 2. The buccal sac (fig. 51, *bc.s*), a spherical expansion at the anterior part of the pharynx, in the middle of the front part of the head. Its function is not determined.[3] It is frequently found filled or partly filled with various, amorphous particles, the debris of food, etc. Brants, who first discovered it in the wasps, supposes that it may serve those insects in the preparation of their paper-nests. Forel conjectures that it may serve the purpose of a special digestion for the anterior part of the body. Lubbock once found in it an entire worm. It would appear to be a sort of anatomical "Botany bay" for the temporary seclusion of such food material as may not be prepared to yield the juices which alone pass into the crop.

[1] I mounted many of my preparations for more leisurely study under the microscope, and they have been submitted to the Academy of Natural Sciences of Philadelphia. I acknowledge here the assistance and advice of Prof. J. Gibbons Hunt, M. D., in these studies, whose unrivaled skill as a microscopist was cordially placed at my disposal.

[2] The reference-symbols are uniform in all the figures, and are for the most part such abbreviations of the names of the parts as may aid the memory in studying the plates. See the key to reference symbols.

[3] See Forel Swiss Ants, p. 109; Lubbock, Microscop. Jour., London, 1877, p. 139; Agricultural Ants of Texas, p. 119.

§ 3. The pharynx (fig. 51, *px.*) a strongly muscular wall situated within the head in front of the neck, *nk.*

II. Within the body there is the œsophagus (*œ.* fig 52), a muscular tube[1] or canal which passes through the neck and petiole, and connects the head with the abdomen.

III. The parts within the abdomen, which most concern us are

§ 1. SEGMENTAL PLATES OF ABDOMEN.—It is first necessary to understand the structure of the wall of the abdomen. This consists of ten strongly chitinous segmental plates, five dorsal and five ventral (Pl. VII, figs. 53, 54). These overlap one another, like scales, from the base toward the apex, and the dorsal plates overlap the ventral. The last plates which guard the cloacal cavity, are known as the pygidium (*py.*) and the hypopygium (*hy.*) The anus, in Melliger is surrounded by a circle of strong bristle-like hairs.

These plates, in the normal condition of the abdomen, are set upon (if I may so say) a strongly muscular inner wall, which is highly elastic in all ants, particularly of the Formicidæ. This elasticity appears to reach its extreme point in Melliger. In ordinary excessive feeding, the distension of the crop causes the expansion of the muscular coat between the plates which are thus forced apart, at various degrees of separation, according to the amount of food taken, until in the case of the honey-bearer of Melliger the three middle plates (Nos. 2, 3, 4) are wholly isolated, appearing, as Forel has well said, like little islands on the tersely stretched, light colored abdominal membrane. (Plate VII, fig. 54, D2, 3, V2, 3), (Plate X, figs. 72, 73). Plates D1, V1, retain their normal position, and plates D4, V4, are not so widely separated from D5, V5, as from their next anterior plates.

We may now view the abdominal portion of the intestinal tract, in order to understand what happens in the growth of the honey-bearer.

§ 2. THE CROP OR INGLUVIES.—The crop is the anterior and superior sub-division of the abdominal portion of the alimentary canal. It is simply an expansion of the œsophagus within the abdomen. The normal condition of the crop was determined by examination of the workers with undistended abdomens, and more readily from the study of a virgin queen (Pl. VIII, fig. 59).

[1]Forel, quoting Meinert, speaks of the muscularization as feeble; but in Melliger, at least, the muscles appear to be sufficiently strong.

The œsphagus *œ*, is there seen passing through and bent over the hard ring (*Jn*) which forms the junction of the petiole and abdomen. The œsophagus is seen as continued (*œ c*) within the abdomen, where it has precisely the same structure as within the thorax. The crop or ingluvies contains a moderate amount of food and is fairly distended. The exterior coat of the crop is a net-work of muscles which present the branched character sometimes found in insects (Pl. VII, fig. 45). Another section of the crop showing the character of this muscularization is given at Fig. 46. This enlarged view is taken from the object shown at Pl. VIII, fig. 55, and is made at the margin. The spherical crop is thus seen to be hung within the muscular netting, something like an inflated balloon within its net bag.

Forel thinks[1] that the muscles of the segmental walls of the abdomen alone are concerned in the act of regurgitation; but I see no ground for this opinion, except possibly with the honey-bearers, whose abdominal muscles alone might suffice to expel the contents of the crop. Such a remarkably efficient structure as is here demonstrated and illustrated, can hardly be without its proper function.

Before proceeding to demonstrate the main point in hand, it will be well to follow the alimentary canal to its termination.

§ 3. THE GIZZARD OR PROVENTRICULUS.—The crop is continued posteriorly by the gizzard, *gz* (Pl. VIII, figs. 55, 56, 57, 59), a singular and complicated organ in ants which has given rise to conjectures the most diverse. Meinert regards it as serving to regulate the movement of the aliments. Forel thinks it certain that it serves above all to close, and for the most part hermetically, the digestive canal between the crop and the stomach.[2] The gizzard properly belongs to the anterior part of the intestinal canal its internal cuticle (*tunica intima*) being a direct continuation of the crop, œsophagus, pharynx and mouth. It consists in Myrmecocystus (and the entire sub-family Camponotidæ) of three parts.

[1] Swiss Ants, p. 111.

[2] The gizzard varies largely among ants, and the variations form generic characters of great value, which Dr. Forel has shown, first in his "Fourmis de la Suisse," p. 112, seq., and afterward, more fully and clearly, in his "Études Myrmécologiques," *Bulletin de la Soc. Vaudois d. Sci. Nat.*, Vol. XV, 1878, pp. 337, 392. This last study of this organ is one of the most admirable contributions yet made to myrmecological histology.

1. The anterior part, or gizzard proper, a lily-shaped organ composed of a spherical bowl (*b.gz*) and four blades or sepals, *s.gz*. It is strongly chitinous, appears intact in all dissections, and is easily seen. The crop contracts at the posterior end within the four sepals of the gizzard, which thus appear to act as valves to regulate or moderate the flow of aliment from the crop to the stomach. What, if any, action it may have upon the food is not known; it can hardly have the usual function of trituration, as ants do not receive solid food into the crop.[1]

2. The middle part of the gizzard, or cylinder, *cy.gz*, is a straight cylinder, with a fine, transparent internal cuticle whose matrix is surrounded by a compact coat of transverse striated muscles. Exteriorly the cylinder appears to merge directly into the stomach. Only the muscular coat, however, is thus directly continued and expanded into the fine muscular bag-net of the stomach (Pl. VIII, fig. 57).

3. The internal cuticle of the gizzard traverses the walls of the stomach accompanied by its matrix, and projects within the cavity of the stomach, terminating in an elongated bulb, which is the button, *bn.gz*. (fig. 57), *bn*. (fig. 59), or posterior part of the gizzard. The anterior and posterior parts of the gizzard are always found in ants, the first varying greatly, the latter scarcely at all. The cylinder, on the contrary, is wholly wanting in many genera, and in others undergoes great variations of length. The entire organ is united to the crop externally by a strong muscular netting, so that the two might be compared to a balloon (crop) and the car (gizzard) and the enfolding muscles to the network swinging between the two.

§ 4. The Stomach.—The stomach, *stm* (Pl. VIII, figs. 55, 56), like the gizzard is always easily discernible, inasmuch as a quantity of solid amorphous matter within it, of a dark brown or blackish color, betrays its presence even through the segmental plates. It is commonly spherical or ovate in shape.

§ 5. Malpighian Tubes.—Around the posterior pole of the stomach are grouped the Malpighian vessels, *mpg* (figs. 56, 60), twelve in number.

[1] The various sections of the bowl appeared to me to have upon their interior edges certain tooth-like inequalities, which suggested at least the office of triturating or *agitating* the passing food. These may be, however, nothing more than longitudinal flutings upon the external surface.

§ 6. The Intestine.—The location and appearance of the intestine, is seen in fig. 56, more clearly in fig. 60. The ileum (*il*) passes from the posterior pole of the abdomen, and appears to be united to the colon (*col*) by a fold which I have ventured to refer to as the ileo-secal valve (*il.v*). The rectal glands (*re.gl*) appear upon the colon, and the rectum (*re*), a strongly chitinous and muscular structure, terminates in the ciliated anus (*an*).

Finally, Pl. VIII, fig. 58 [1] will show the relative positions of all the organs opening into the cloaca. See Explanation of Plates, fig. 58.

We may now construct for further illustration the synthetic figure, Pl. IX, fig. 61, giving a side view of the entire intestinal canal *in situ*. This will indicate the normal position of the crop relative to the abdomen and the other alimentary organs. It will be seen that it occupies a position anterior and superior to these. The natural tendency of the pressure caused by the expansion of the crop, as it fills the abdominal cavity, would be to force the remainder of the tract backward and downward. In point of fact it is so found. A number of workers, with abdomens in various degrees of distension were examined, and the condition and site of the digestive organs noted. A few outlines of these abdomens are given:

The series begins with Fig. 63 (Pl. IX), where the crop is shown in nearly normal site, and well filled.

The same condition is indicated at Fig. 66, except that the crop shows marks of having once been quite distended and afterward emptied.

Fig. 64 shows a worker, whose crop about half fills the abdomen. The gizzard, *gz*, is forced downward (ventral) and has the anterior poles of the sepals turned upward (dorsad). The effect of subsequent pressure (should the crop have expanded), in forcing the stomach, etc., backward and downward into the cloacal cavity, can readily be predicted from the figure.

In Figs. 62 and 65, the abdomens of workers in the semi-rotund state, the distension has advanced a little further so as to push the stomach in one case (62) as far as, in the other (65) partly beyond, the fourth segmental plates, compressing the intestine proportionately.

[1] Adapted from Forel, "Der Giftapparat und die Analdrüsen der Ameisen," *Zeitschrift f. wiss. Zool., Bd. XXX.*

That the same results follow in all the worker castes may be seen in Fig. 67, the abdomen of a minim or dwarf worker.

Turning to the honey-bearers, we find precisely the same condition of the abdomen, except that the distention of the crop has greatly increased, pushing its walls in all directions quite up against the inner walls of the abdomen, forcing the latter into rotundity, and compressing the other organs into the smaller space.

Fig. 69 is the abdomen of a honey-bearer, which appeared to be a little short of the full rotundity. The crop filled the entire cavity, but the gizzard, stomach and intestine, instead of being crowded together upon each other, were in their normal relations, and appeared to be in an entirely healthy state. The aspect of many of the bearers raised the query, whether the anus might not be sealed by the organs forced against it, thus stopping all excretion, and making the animal simply a vital honey-pot. The above individual, at least, had every appearance of normal condition and action of all the organs.

In the next example (fig. 70), the gizzard, stomach, malpighian vessels and intestine are forced down quite within the compass of the fourth pairs of segmental plates, and directly over the cloacal vent. For the most part these organs are situated ventral, but here they are partly dorsal of this cleft. The most usual position of the stomach in the honey-bearers is between and quite close to the fifth and fourth ventral plates. The gizzard is a little anterior of this, the sepals, which mark the posterior pole, or entrance of the crop within the gizzard, being directed downward, upward, downward and backward, upward and backward, or forward, at hap-hazard.

Another illustration is given (fig. 68), in which the crop of a honey-bearer is seen in the act of contraction, after having been punctured through a slit (*s*) in the abdomen. When one holds a rotund up to the light, and looks into the semi-transparent abdomen, it is not possible to distinguish the crop from the abdominal membrane. But in the example here figured, as the honey flowed out from the pierced crop, the slowly contracting and thickening folds of the partly emptied organ were thus revealed. Nothing could demonstrate more clearly than this experiment and figure, that it is *the crop alone* which fills the distended abdomen.

I venture to add a final illustration to this series. I was enabled to separate a crop *entire* from the abdomen, and mount it for microscopic examination. In this delicate work, which could not otherwise have been done, I was aided by some morbid condition of the abdomen. I occasionally noticed, both in the natural and artificial nests, honey-bearers whose abdomens had the appearance of cones (Pl. VI, fig. 33) and the outer membrane hung in folds.[1] They seemed to have suffered some injury, which apparently had affected the crop. It was from one of these that the crop (Pl. VIII, fig. 55) was taken.

These studies point to the following conclusions :

I. *First*, and absolutely, that it is the *crop alone* which contains the nectar received at the mouth, which, immensely distended thereby, fills the rounded abdomen of the honey-bearer.

II. *Second*, and absolutely, the organs of the abdominal portion of the alimentary canal in the honey-brearers are ordinarily in a natural state, except in so far as their position has been changed by the downward and backward pressure of the expanding crop. This condition of the abdomen is frequent, in a greater or less degree, among ants.

There has been much error and loose statement on this point among authors. So eminent an anatomist as Dr. Joseph Leidy supposed that the honey was contained within the stomach; that all the other viscera of the stomach were obliterated, and that even the tracheal vessels had entirely disappeared.[2] Dr. Oscar Loew[3] makes some correct notices of the honey-ant, as seen at Santa Fé, New Mexico, but permits himself to recognize "the intestine . . as a narrow canal winding through the rounded and puffed up abdomen." This could only, in any sense, be affirmed of a small part of the abdomen, the posterior portion into which, as we have seen, the intestine is crowded. It is possible that the dorsal ves-

[1] I do not credit the statement (Loew) that many of the rotunds burst by force of the pressure upon the crop. Probably this never occurs in nature. The spots of moistened clay seen by observers rather mark the wreck of ants crushed by pressure upon the chambers and galleries during excavation, or ruptured by falling from the roosts.

[2] Proceedings Academy Natural Science, Vol. VI, 1852, p. 72. This, however, was twenty-nine years ago.

[3] Chemist and mineralogist to Lieut. Wheeler's Exploring Expedition, *American Naturalist*, Vol. VIII, 1874, p. 365-6.

sel may have been mistaken for the intestine, as this may be seen in some specimens very plainly.

Dr. James Blake[1] has published a brief report in which he falls upon an error quite the reverse of Dr Loew.[2] "The intestine of the insect," he says, "is not continued beyond the thorax, so that there is no way in which the remains of the food can be expelled from the body, except by the mouth." It follows, of course, that with this view, he should further err in supposing the honey-bag to be formed simply by the expansion of the abdominal segments.

The illustrations above figured, on the contrary, show that the intestinal canal has neither been ruptured, nor resorbed, nor otherwise disposed of than is quite natural.[3]

III. *Third*, it is seen that the process by which the rotundity of the honey-bearers has probably been produced, has its exact counterpart in the ordinary distension of the crop in over-fed ants; that, at least, the condition of the alimentary canal, in all the castes is the same, differing only in degree, and therefore, the probability is very great that *the honey-bearer is simply a worker with an overgrown abdomen.*

If this last conclusion has not been fully demonstrated, it has at least been shown that there is no anatomical or physiological obstacle thereto, but very much confirmatory thereof.

The Australian Honey-Ant.—An exceedingly interesting discovery of a new species of honey-ant, adds to the probability of this last conclusion. Sir John Lubbock has described this species as *Camponotus inflatus*,[4] from specimens collected at Adelaide, Australia. I received examples through the courtesy of Mr. Gerald Waller, last summer, which enabled me even in advance of Lubbock's admirable description, to note that a con-

[1] Proceedings California Academy Science, 1873, part II, page 98.

[2] Dr. Forel, in the communication to the Morphologico physiological Society of Munich, already alluded to, appears to me to have misunderstood Dr. Loew's *published* statement. Dr. L. erred in seeing *too much* intestine, instead of none at all.

[3] It is not worth while to more than mention here the opinion which has been largely circulated, that the workers *bite and wound* the ends of the abdomens, producing thereby an inflammation which seals up the anus, stops all excretion, and so causes the repletion of the abdomen.

[4] Journal Linn. Soc. Zoology, 1880, Vol. XV, p. 185, seq.

dition supposed to be peculiar to our American Melliger, obtained in an Australian species belonging to a genus quite removed from *Myrmecocystus*. Mr. Waller could tell me nothing of the habits or habitat of *C. inflatus*, and Lubbock has no account of any. But the congeners of the Australian insect are "Carpenter ants," quite generally making their formicaries in the roots and trunks of trees, and thus in economy as well as structure differ from *M. hortus-deorum*. This widening of the range within which this hitherto phenomenonal condition of the abdomen is found, not only raises the suggestion which Sir John makes of an independent origin of the modification in the two species, but also adds to the probability that the modification may have originated in the natural mode which I have described.

It is to be regretted that Lubbock did not make an examination of the alimentary canal of his species, which, with the material and resources at his command, would doubtless have been highly satisfactory. However, I undertook from my limited material, to make at least so much of a study of the digestive organs as would permit some comparison with results obtained from Hortus-deorum. I had but one perfect specimen, which is figured Plate X, fig. 74. The abdomen of this example was removed and carefully mounted without rupturing the abdominal walls. The result is shown at Plate IX, fig. 71, and as will at once be seen, corresponds with those obtained fully from Hortus-deorum, and as far as pursued, from Mexicanus also. The crop (fig. 71) fills the cavity of the abdomen, and the rest of the digestive organs are seen crowded into the anal region. The gizzard has the general features of that of Hortus-deorum, but has marked characteristics, quite identical with those of the genus *Camponotus* as pointed out by Forel.[1] The sepals are not deflected at the anterior pole, as in the lily-shaped sepals of Hortus-deorum, but are clavate and straight.

This fact certainly strengthens the conclusion arrived at concerning the American species of honey-bearer, viz., that the rotund has been developed by natural habit from the ordinary worker, and that the possibilities of such a condition exist in the structure and functions of all nectar-feeding ants. Why the extraordinarily distended crop seen in the honey-ant should be limited to two

[1] Etudes Myrmecologiques, Bull. Soc. Vaud. de Sci. Nat. 1878. Pl XXIII, fig. 1.

species (so far as known), and why so limited a number of workers in the formicaries of these two species should develop the round abdomen, are questions that provoke sufficient wonder, but yield scant satisfaction.

XI. Possible Organs of Stridulation in Ants.

The segmental plates of the abdomen are composed of numerous hexagonal epithelial scales, Pl. VII, fig. 48, which present a very beautiful appearance, as of delicate mosaics, when viewed through a microscope. When a profile view of one of these plates is exposed to the lens, as at fig. 49, the scales are seen to be imbricated, that is, to overlap each other like tiles on a house roof, and show the serrate edge figured in the cuts, figs. 49 and 50. The former (49) is drawn from a section of *Camponotus inflatus*, and the latter (50) from *Hortus-deorum*. This serrate edge not only shows upon the external part of the plate *e. ab. pl.*, but upon the imbricated portion, *i. ab. pl.* By referring to the manner in which the one part overlaps the other shown at figs. 53, 54, it may be seen that a backward and forward motion of the plates upon each other might produce a faint rasping sound. That this motion is entirely possible can hardly be doubted. The abdominal plates are continually, though gradually, sliding out and in, like the parts of a telescope, under the expansion and contraction of the crop, as the ant feeds or regurgitates the contained nectar. All that is required to have the complete conditions for stridulation seems, therefore, to be the muscular ability to perform this action rapidly; which, it appears to me, ants certainly possess.

I have often noticed the peculiar *hiss-z-z-z!* which arises from an excited colony or column of ants, a sound which grows in intensity according to the degree of excitement. I have also met an opinion prevalent among ordinary observers, that the ants produce this sound by some organ analogous to some one of those by which other insects produce musical notes or noises—in short (to use the popular phrase), that "ants sing." But I have heretofore been disposed to consider the noise referred to simply as the result of friction of a great multitude of insects moving rapidly over the surface of the earth, the litter of leaves, twigs, etc., and against the hard, shell-like bodies of their fellows, or possibly (also) by the gratings of the hard tooth-like mandibles upon each other.

I am not yet prepared to abandon this opinion, nor to affirm that ants do produce audible sounds by proper stridulating organs; but simply record the structural possibility of such behavior.

Since making the above note, Mr. Swinton's work on "Insect Variety"[1] has reached me. The author records an example of what seemed to be an act of stridulation by a small yellow ant, *Myrmica ruginodis.*

This insect was observed stationed near the edge of an inverted wine glass, underneath which it had been confined, its head downward, rapidly vibrating its abdomen vertically from the pedicle, and simultaneously giving out a continuous singing sound, in color and intensity resembling the sharp whining of the little dipteron *Syrilla pipens.*

Concluding that the rhythmical motion accompanying the music indicated this ant as a stridulator, the author undertook a microscopic study of its anatomy, from which the following facts appear:[2] The ant belongs to the family Myrmicidæ, which are distinguished from the Formicidæ, to which our honey ant belongs, by having two knots or nodes to the petiole. The second or posterior knot is commonly the larger, and is placed quite near to the anterior pole of the abdomen. Upon the insertion of the abdomen into this node, were observed twelve minute yet regular annular striæ. (Pl. X, fig. 81.) This striation was produced, but less distinctly, upon the articulation of this (the second) node with the first (anterior) node. It was conjectured that the rapid movement of these joints of the petiole, back and forward upon each other and upon the abdomen (like the jointed tubes of a telescope), produced the sound above described. As the nodes are to be regarded as abbreviated segments of the abdomen, and as the abdominal segments have already been shown to be capable of movement one upon another, Mr. Swinton's interesting observation gives new value to the suggestion above made concerning the structural possibility of stridulation in the honey ant and others of like organism.

[1] "Insect Variety, its Propagation and Distribution," by A. H. Swinton, member of the Entomological Society of London, p. 106, and Pl. VI, fig. 7.

[2] The writer's account is somewhat confused by false punctuation, and he falls into the error of conjecturing that the small worker may have been a male. I have given my understanding of the structure as derived chiefly from the figure, which I reproduce with some alteration.

XII. Destruction of the Ants by Mites.

The untimely end of my artificial colonies is worthy of a passing note. The ants were brought from Colorado in large jars, domiciled in their native soil. Every precaution which circumstances would allow was taken to preserve their health, but after a confinement of over seven months, during which many of the observations noted above were made, they became infested with mites. These parasites, or their germs, were probably brought from Colorado with the insects, although I did not observe them until late in their imprisoment. However, I have seen the same or similar parasites upon other ants while in their home-nest, and more than once have suffered the loss of colonized formicaries from their inroads.

In the case of the honey ants I was powerless to give relief of any kind, and witnessed with real grief the helpless little sufferers in their struggles to free themselves from their destroyers. I have figured the head of an ant thus infested, at Pl. VII, fig. 39. where the mites may be seen clinging to the cheek, mandibles and antennæ. I have spared the feelings of my readers so far as to figure but a few of the pests. In point of fact they literally covered the mouth parts, where they were chiefly congregated, although they were attached to other parts of the body. The poor "host," although so admirably provided with implements for cleansing her person—such as the mandibles, mouth and tarsal comb—found all efforts to rid herself of her "guests" futile. Even that friendly aid in toilet service which one emmet is wont to extend to another, was vain. Gradually the poor victim yielded life to the parasitic swarm that sucked at her vital juices. The charnel-house—the little cemetery centre at one side of the formicary—gained many inmates daily; the galleries and chambers thinned of their busy populace and grew lonely; at last, as in some plague-stricken human commonwealth, the dead were suffered to lie where they fell, for the living were themselves sealed to death, and unable to give their comrades sepulture. So my nests faded away, until, unwilling longer to witness their sufferings, I gave them all a painless death.

My studies were seriously interfered with by this calamity, as many of my well-nigh ripened experiments thus came to nought. But one cannot complain, for Nature and Destiny pursue ants also, and that this particular form of insect doom is unhappily not rare has long ago been voiced in the familiar couplet:—

> "Great fleas have little fleas, they smaller fleas to bite 'em;
> Smaller fleas have lesser fleas, and so *ad infinitum.*"

One might pass to the opposite pole of the zoological series—Man—and add the reflection of Quintus Serenus upon the death of the Dictator Sylla:—

> "Great Sylla, too, the fatal scourge hath known,
> Slain by a host far mightier than his own."

It might be supposed, at least I had so thought, that the presence of these parasites would greatly irritate the ants, and produce an excited behavior, and animated struggles to be rid of their guests. On the contrary, they endured the affliction with wonderful patience. It seemed to me, although one must allow in such cases for the anthropomorphic color upon his observations, that the unfortunate creatures were quite conscious of their doom, of the hopelessness of contending against it, and had yielded themselves in a philosophic resignation.

The mites are, in color, white, almost transparent, and are about one millimetre in length. I am not certain as to the species, but present correct drawings of the animals, from which they may be determined by a competent authority. (See Pl. VII, figs. 40, 41). Greatly magnified views, in several degrees of expansion, of the sucking organs, by which the mites cling to their host, are shown at figs. 42, 43, 44.

XIII. Previous Accounts of the Honey-Ant.

The first account of the Honey-ant was given to the world by Dr. Pablo de Llave, in the year A. D. 1832, in a Mexican journal.[1] A translation into French of the substance of this paper was given by Monsieur H. Lucas in the French Review and Magazine of Zoology, June, 1860.[2] Meanwhile (1838), M. Wesmael had published a description of the ant, with figures, without knowledge of the above paper of Llave, establishing for it the Genus Myrmecocystus. Wesmael's generic name remains, but his specific name

[1] Registro trimestre o colleccion de Memorias de Historia literatura ciencias y Artes, 1832.

[2] Revue et Magazin de Zoologie, Tome XII, 1860, p. 271.

(*Mexicanus*) has of course yielded to that of Llave, modified, however, from *Melligera* to *Melliger*. The Colorado insects, upon which the studies of this paper are based, I have ventured to regard as a new variety, and have named *Myrmecocystus hortus-deorum*, and thus have retained Wesmael's name as a variety name.

It will be well to state briefly the facts in the economy of these insects indicated in the foregoing and other papers, in order to mark precisely the new facts which have now been communicated here.

Llave's information was all at second hand, he having made no personal observations of the habits of Melliger. From a person living at Dolores, a village in the vicinity of the city of Mexico, he learned :

1. That the ants were popularly known under the name of *Busileras;*

2. That they do not erect heaps of earth at the entrance to their nests;

3. That on opening the nest, a species of gallery is reached, to the roof of which certain ants are suspended, packed one against the other;

4. That these ants cover the roof as well as the wall of the gallery.

5. The women and children of the valley know these nests perfectly well, and frequently open them for the sake of the honey-bearers, or rotunds. The honey is sucked from the abdomen of the rotunds, with great relish, at the nests; or, if it is wished to preserve them, they are lifted by the head and thorax and placed upon plates, in which they grace the village feasts, and are eaten as delicacies.

6. The rotunds when thus placed together, stir around, lay hold of and tear one another, and finally end life by bursting.

7. The skin of the abdomen, which binds the segments together, is so thin, and the upper coat so distended, on account of the quantity of honey which it encloses, that the least pressure suffices to cause the ants to disgorge.

8. When they do not so disgorge, that is, by elevating the head and thorax, the honey diminishes, and the ants eat it.

9. Dr. Llave observed, moreover, from specimens of the ants sent to him, that there were different castes of workers and degrees of distension in the abdomens, and

10. That the honey in the rotunds varied in color from a crystal whiteness to a wine-color.

Several of the above statements, as has been seen, are without foundation, but the majority of them are confirmed in whole or part by my observations.

Wesmael,[1] who made his study from specimens sent him from Mexico by the Belgian Envoy, Baron Normann, records his credence of the theory announced by that gentleman, viz., that the honey-bearer elaborates the honey and deposits it in certain reservoirs, analogous to the cells of bees, for the nurture of the formicary. Baron Normann was unable to obtain examples of these reservoirs to send to Europe, or rather failed to do so under the conviction that they would be destroyed during shipment. In point of fact, such reservoirs exist only in imagination.

One of the most perplexing accounts of the honey-ant is that of Mr. Henry Edwards.[2] The statements recorded are made at second hand from the verbal narrative of a Capt. W. B. Fleeson, whose observations were made at or near Santa Fè. They are so extraordinary and contradictory of my own experiences, that I am compelled to withhold credence, until some experienced observer shall have corroborated them, a result of which I have little expectation. According to this account, no exterior moundlet surmounts the formicary, but simply two openings into the earth. Within the nest, at a depth of about three feet, "a small excavation is reached, across which is spread, in the form of a spider's web, a network of squares spread by the insects, the squares being about one-quarter inch across, and the ends of the web[3] fastened firmly to the earth at the sides of the hollowed space which forms the bottom of the excavation. In each one of the squares, supported by the web, sits one of the honey-making workers, apparently in the condition of a prisoner, as it does not appear that these creatures ever quit the nest."

But the marvels of this strange story are not exhausted. "The

[1] Bulletin de l' Acad. Roy. des Sci. et Belles lettre de Bruxelles, Tome V p. 770. Pl. XIX, figs. 1–4.

[2] Proceed. California Acad. of Sciences, Vol. V. 1873, p. 72 ; "Notes on the Honey-making Ants of Texas and New Mexico."

[3] Of course, this is pure fiction, as no ant makes a web, or anything that could well suggest one. The cutting ant does make out of fragments of leaves a "comb" of more or less regular cells, resembling the nests of the paper-making wasps.

inmates of the formicary are composed of two distinct species, apparently even of different genera, of ants. There are the ordinary yellow workers and honey-bearers of Melliger, and besides, black workers, who act as guards and purveyors. One column of the blacks surrounds the openings on three sides, attacking, driving off or destroying all intruding insects. Another column bears, through the unguarded side of the hollow square, fragments of flowers, aromatic leaves and pollen, which (adds our author), by a process analogous to that of the bee, the honey-makers convert into honey."

One can hardly refrain from the thought that Capt. Fleeson was testing the credulity of the writer by one of those jokes of which naturalists are occasionally the victims. But, if the narrative is to be taken in good faith, I can only explain the facts by supposing, first, that the observer happened upon a nest of cutting-ants (*Atta fervens*), within whose boundaries a nest of Melliger had chanced to be established, and had confounded the habits of the two as those of one formicary; or, second, that the cutting-ant, or some other species of similar economy, has really acquired the habit of kidnapping and domesticating the honey-ant for the sake of its treasured sweets, precisely as many ants domesticate aphides; or, as the slave-making ants, *Formica sanguinea* and *Polyergus lucidus*, domesticate *Formica fusca* and *F. Schauffussi*.[1]

One of the latest accounts of the honey-ant, and so far as it goes, one of the best, is that of Mr. Saunders, the editor of the *Canadian Entomologist*,[2] who communicates to his journal some observations made by Mr. Kummeck, at Santa Fè.[3] According to this observer, considerable numbers of these insects are found in the mountains of that vicinity. He sat by a nest six or seven

[1] One may not be over rash in refusing belief even to facts that go counter to all past experiences, for the marvels of Nature are ever widening within our view. While, therefore, I am inclined to reject the whole story, I await the observation of some trained naturalist, giving the account the benefit of the above possible explanations.

[2] Can. Entom., 1875, Vol. VII, pp. 12–13.

[3] I may be permitted to explain why I did not go to New Mexico, to attempt on the spot a solution of some of the questions raised by these accounts. I had made every arrangement to do so, after my studies in the Garden-of-the-gods were completed, but on the morning that I was to break camp, was taken with a sudden and violent illness which compelled me to abandon my journey.

hours and noticed the workers carry home leaves of different plants to feed, as he supposed, "the others that produce the honey." This would seem to confirm the leaf-bearing habit quoted by Mr. Edwards from Capt. Fleeson. The inference as to the use of these leaves is, however, quite unwarranted, as the portage of leaves, etc., into nests is not an uncommon habit among ants of divers species. Without stopping to discuss the question whether such material may contribute to the food supply of the formicary, it may be remarked that its most probable and ordinary use is for purposes of architecture or nest-building.

Mr. Kummeck also makes the remark, which I had not seen at the time my own conclusions had been reached, that "in early life none of these insects present any unusual distension of the body, but when arrived at a certain period of maturity some individuals begin to show a distended abdomen."

The ant honey has no commercial value among the New Mexicans. It has a place, however, as a remedy in the domestic therapeutics of the native Indians, who compound a drink by mixing three to four drachms of the honey with six ounces of water. The drink is used in cases of fever. The honey is also applied as an unguent in eye diseases, especially cataract.

To the above may properly be added two accounts of my own studies published in the London *Journal of Science.*[1] These are reports made by Mr. Morris, of the verbal communications in which my observations were originally announced to the Academy of Natural Sciences of Philadelphia. They were made and printed without any oversight or responsibility on my part, but are admirably, and in the main, accurately done. They have been reproduced with various degrees of fulness in other journals.

Such other notices of this ant as I have been able to find, and have had occasion to use, will be found properly referred to in the text of this paper, where those who are interested in the literature can readily find them.

[1] Jour. Sci., February, 1880, "Living Honey Comb; a novel phase of Ant Life." By Mr. C. Morris. Ibid. July, 1880, "Habits and Anatomy of the Honey-bearing Ant." By Charles Morris.

XIV. Description of Species.

FORMICARIÆ.

Family FORMICIDÆ.

Subfamily CAMPONOTIDÆ (Forel).

Genus MYRMECOCYSTUS, Wesmael.

Cataglyphis, Fœrster, Verh. d. Nat. Ver. d. Rheinl., 1850; Mayr. Europ. Formic., 1861; Norton, Wheeler's Report, Vol. V, Zool., p. 734.
Monocumbus, Mayr, Verh. d. Zool.-bot. Ver. in Wien, 1855.
Myrmecocystus, Forel, Etudes Myrmecologiques, Bull. Soc. Vaud. de Sci. Nat.

M. melliger, Llave.

1. Var. *mexicanus*, Wesm.
2. Var. *hortus-deorum*, McCook.

Workers.—Three castes, major, minor and minim or dwarf. Color, a uniform light yellow; the body is covered quite thickly, the legs more thickly, with short yellow hairs. The maxillary palps are very long, six-jointed, third joint longest; they are covered, especially beneath, with long hairs, curved backward. Labial palps four joints; mandibles with nine teeth. The head is quadrate, in the worker-major more rounded at the sides than with the minor and dwarf; wider than the thorax. Clypeus smooth, rounded, slightly flattened in front of the frontal area. Frontal area smooth, shining, triangular, somewhat truncated posteriorly. Ocelli sufficiently prominent; a tuft of hairs on the face beneath, directed forward. The body is of good length, narrow and compressed beneath at the mesothorax; metanotum as high as, or slightly higher than the pronotum. The node cordate, cleft at the tip, thickened at the base, set perpendicularly upon the petiole. Anus strongly ciliated. Length, worker-major, 8½ mm.; worker-minor, 7 mm.; worker-minim, 5½ mm.

Honey-bearers.—A sedentary class or caste distinguished by abdomens distended into spherical form by expansion of the crop filled with grape-sugar. The length (including abdomen) is 13 mm. (one-half inch); the proportions and description of the head and body are those of the worker-major, of which it may be a developed form.

Female.—Virgin queen, total length, 13 mm., as follows: Mandibles, 1 m.; head, 2 mm.; body, 5 mm.; abdomen, 5 mm. Width of abdomen, 3 mm.; of prothorax, 2 mm. Color, livid yellow. Fore-wing, 14 mm. long; venation as in Pl. X, fig. 77.

Male.—Length, 5 mm.; length of fore-wing, $5\frac{1}{2}$ mm. Color, livid yellow; the head, upper part of thorax and dorsum of abdomen blackish. The mandible has one feeble tooth at the tip, and two others shorter and feebler.

Habitat.—Southern Colorado, occupying subterranean formicaries with small gravel-covered exterior moundlet, pierced by one central gallery.

ALPHABETICAL KEY TO REFERENCES IN THE PLATES.

The references are uniform in application throughout all the figures. References which occur only once, and are explained in the "Explanation of Plates," are not placed in the Key.

ab., abdomen.
ab. pl, abdominal plate.
ab. pl. d, abdominal plate dorsal.
ab. pl. v, abdominal plate ventral.
an, anus.
an. sp, scape of antenna.
ant, antennæ.

bc. s, buccal or mouth sac.
b. gz, bowl of gizzard.
bn. gz, button of gizzard.
b. ms, branched muscles.

CL, Clypeus.
C. ms, crop muscles.
Col, colon.
Cy. gz, cylinder of gizzard.

D, dorsal.

E, epithelium.
E. i. s, epithelium imbricated, serrate edge.]
E. ab. pl, exterior abdominal plate.
Epc, epicranium.

f. ar, frontal area.
fem, femora.
flg, flagellum of antenna.
fm, foramen.

gz, gizzard.

hy, hypopygium.

i. ab. pl, interior abdominal plate.
il, ileum.
il. v, ileo-secal valve.
in, intestine.

lb, labium.
lb. p, labial palps.
lbm, labrum.

mb, mandibles.
mo, mouth.

mpg, malpighian tubes.
ms, muscles.
m. th, mesothorax.
met. th, metathorax.
m. tr, metatarsus.
mx, maxilla.
mx. p, maxillary palpi.

nd, node of petiole.
nk, neck.

oc p, occiput.
oc, ocelli.
Œ, œsophagus.

p. ms, pharyngeal muscle.
pr. th, prothorax.
py, pygidium.
px, pharynx

re, rectum.
re. gl, rectal glands.

s. gz, sepals of gizzard.
stm, stomach.
str, striæ.
su, sucker.

tib, tibia.
to, tongue.
tr, tarsus.

V, ventral.

EXPLANATION OF PLATES.[1]

Plate I.

Fig. 2. View of my camp in the Garden of the gods, showing the site of some of the nests of the honey ants studied. The view is taken from the rocks at the junction of Adams and Von Hagen ridges (see Fig. 1, p. 19), and looks towards the south, and the eastern face of Pike's Peak. One of the nests is shown in the foreground, and the sites of others are indicated by the white circles on the tops of the ridges. My tent and booth are seen near the centre of the sketch, and just opposite, on the right, is the oak copse in which the ants were discovered feeding on the exudations of galls. Page 19.

Plate II.

Fig. 3. Elevated gravel cone of a honey-ant nest; the gravel is of red sandstone, and the rocks around are bits of quartz of several colors, giving a pretty effect. This nest is the largest seen, and measures three and one-half inches high and thirty-two inches around the base. Page 21

[1] Mr. Joseph Jeanes, a member of the Academy of Natural Sciences of Philadelphia, contributed the money required for the illustration of this paper, and thus has greatly added to whatever value it may possess.

Fig. 4. A nest built partly around a tuft of gramma grass, and less conical in shape than the above.

PLATE III.

Fig. 5. View of honey-bearers as seen in natural site, clinging to the roof of a honey-room. About natural size. Page 22.

Fig. 6. View of honey-bearers in same position, drawn from one of my artificial nests. Mingled with them are seen ordinary workers, and semi-rotunds, or workers apparently in process of transformation into honey-bearers. About natural size.

PLATE IV.

Fig. 7. Sprig of dwarf oak, *Quercus undulata*, with galls of *Cynips quercus-mellaria*, showing the beads of sweet sap. Page 25.

Fig. 8. The same galls enlarged.

Fig. 9. Another cluster of the same galls.

Fig. 10. Section of gall showing the inside cell, *c*, and the exit hole of the gall-fly, *eh*. Page 26.

Fig. 11. Turk's-head gall, showing exit-hole, *eh*.

Fig. 12. View of inside of a gall, showing a globular cell, and a small grub domiciled against it. Page 27.

Fig. 13. A honey-bearer clinging by her feet to the wall of a honey-room. Page 22.

Fig. 14. The crater of a gate to an ant's nest, showing the graveled funnel, F, and the smooth nozzle, N. Page 32.

Fig. 15. Outline of the elevation of a formicary. Page 35.

PLATE V.

Fig. 16. Double section view of the interior of a nest, drawn from a point in the excavation twenty-one inches below the surface. Nest made in soft, red sandstone. *g*, *g*, *g*, galleries arranged in stories. R, R, R, vertical sections through honey-rooms and chambers for nursery purposes. C, D, E, the floors of a suite of honey-rooms, showing their connection with the general system. Page 36.

Fig. 17. The three honey-rooms C, D, E, above referred to, and the indication of a fourth, F. Length of C from a to $b = 5$ inches; D, from c to $d = 3\frac{1}{2}$ inches; E, from e to $h = 4$ inches. Elevation of b above $x = 3\frac{1}{2}$ inches; of b above $e = 6$ inches. A little stairway united D with C and F; g, g, a gallery. Page 36.

Fig. 18. Section through middle of nest, showing the gate architecture. G, gate; N, nozzle; A, arm of the gate gallery terminating in the vestibule V. *a*, *b*, *c*, branching galleries. Page 32.

Fig. 19. A similar section of another nest. Letters as above; E, a small room, with gallery *f*, leading downward.

Fig. 20. Similar section of another nest. The main gallery branches to the right, and passes behind the gate, *b*, *b*. *b*, into room A. E, C, small bays or rooms; D, D, *ee*, curved and branched gallery on the same plane, with openings downward *g*, *g*, *g*. Page 33.

Fig. 21. A honey-room, HR; *g;* gallery leading into the gate gallery, G; *ug*, unbroken part of same; B, small bay-room. Page 34.

Fig. 22. Termination of excavated nest, 6 feet 10 inches from gate. 2 feet 5 inches below surface. *g g*, gallery entrance; C, Queen-room, 4 inches diameter. E, Small bay-room, apparently beginning of a chamber; *t g*, terminal gallery, running upwards as though the ants were in process of excavating a room resembling C. Page 36.

Fig. 23. Sloping section through middle of nest, showing relation of gate to the upper series of galleries and rooms. A, B, honey-rooms; *x*, *y*, *z*, main galleries; 1, 2, 3, side openings. Page 33.

Fig. 24. A honey-bearer regurgitating honey from her crop at the solicitation of hungry workers. Page 46.

Fig. 25. Sentinels on guard at the gate. Page 20.

Plate VI.

Fig. 26. A queen dragged home by a worker. Page 38.

Fig. 27. A honey-bearer dragged and pushed by a worker-major and dwarf from a broken room into a gallery. Page 39.

Fig. 28. A honey-bearer under a "landslide," one worker looking on, curious but inactive, another on the clod at her toilet. Page 41.

Fig. 29. Queen surrounded by her "court" or body-guard of attendant workers. Page 38.

Fig. 30. Workers carrying a pebble up the mound.

Fig. 31. Honey-bearer partly buried alive under pellets brought up by mining workers. Page 40.

Fig. 32. Honey-bearer fallen from her perch, being cleansed by a worker, who reaches down from the wall. Page 40.

Fig. 33. Honey-bearer with (apparently) morbid abdomen. Page 58.

Fig. 34. Worker nurses feeding and cleansing larvæ. Page 43.

Fig. 35. View of vertical section of a nest, showing galleries arranged in stories. See Pl. V, fig. 16. G, location of gate; *a—t*, *e—i*, *k—l*, galleries; R, R, sections of honey-rooms. Page 36, and foot-note.

Fig. 36. A worker dragging a honey-bearer up a perpendicular surface into a gallery. Page 39.

Plate VII.

Fig. 37. View of the under side of the head of *Myrmecocystus hortus-deorum*, showing the mouth organs. × 20, Page 20.

The letter-references in this and subsequent anatomical figures are uniform throughout. The Key to References, therefore (p. 70), will apply to all figures.

Fig. 38. Face sculpture of same. × 20, Page 20.

Fig. 39. Side view of head of worker to show parasitic mites clinging thereto. The mites are about natural size. Page 63.

Fig. 40. Dorsal view of mites greatly enlarged.

Fig. 41. Ventral view of same.

Fig. 42. One of the suckers, *su*, contracted.

Figs. 43 and 44, the same further drawn out.

Fig. 45. Muscles of the honey crop, showing their netted and branched character. × 30, Page 54.

Fig. 46. The same, from margin of the crop. *C. ms*, crop muscles; *b. ms*, branched muscles.

Fig. 47. Third leg of *M. hortus-deorum*, worker-minor. × 10.

Fig. 48. Section of segmental plate of abdomen of honey ant, showing hexagonal cells of epithelium, and a bristle-like hair, or seta, arising therefrom.

Fig. 49. Profile view of segmental plates of *Camponotus inflatus*, showing the overlapping of the same, and the imbricated epithelial cells, forming a rachet-like structure which suggests the possibility of a sound-producing organism. *e. ab. pl*, exterior abdominal plate; *i. ab. pl*, interior ditto. Page 61.

Fig. 50. Profile view of abdominal plate of *M. hortus-deorum*, to show the same.

Fig. 51. After Lubbock. Section through the head of *Lasius niger*, to show site of buccal sac, *bc. s*, the pharynx, *p.r*, and its muscles, *p. ms*. × 36, Page 52.

Fig. 52. View of the œsophagus of a worker of *M. hortus-deorum*. One side of the thorax and petiole are cut away in order to show the œsophagus in site. × 18, Page 53.

Fig. 53. Abdomem of honey ant, showing the segmental plates both dorsal (D) and ventral (V) in normal condition of the crop. × 16, Page 53.

Fig. 54. Same, when separated by partly expanded crop. Page 53.

Plate VIII.

Fig. 55. Entire crop with gizzard and stomach. Dissected from a honey-bearer with morbid abdomen. × 14, Page 53.

Fig. 56. Crop, gizzard, stomach, malpighian tubes and intestine. From honey-bearer. × 14, Page 54.

Fig. 57. Enlarged view of gizzard. × 50, Page 55.

Fig. 58. After Forel. Topographic, somewhat diagrammatic representation of the organs opening into the cloaca of *Bothriomyrmex meridionalis* ☿, enlarged 18 times.

4, 5 and 6, optical section of the tergal chitinous pieces of what are really the 4th, 5th and 6th abdominal segments (nodes of the petiolus reckoned as one segment). Opposite and beneath there are shown the sterna of the corresponding segments. *do*, dorsal vessel; *an. v*, right anal vesicle; *an. gl*, right anal gland; *Can*, intestinal canal (intestine and rectum); *po. v*, poison vesicle with gland; *ac. gl*, accessory gland of the poison apparatus; *Ov*, rudimentary ovaries with vagina; *ab. g*, the last three abdominal ganglia of the ventral cord with their commissures.

Between 6 and the corresponding sternal plate (6′), lies a cleft (shown wide open in the figure) which leads into the cavity of the cloaca. In this cavity one finds, reckoning downwards from 6 to 6′:

1. *O*, the common opening of the anal vesicles. 2. *an*, anus (opening of rectum). 3. *r. st*, rudimentary sting, into which the poison vesicle opens, and then lower down, the accessory gland of the poison apparatus. 4. *o. sa*, opening of the rudimentary female sexual apparatus.

Fig. 59. Crop in normal condition, from a virgin queen. The junction, *jn*, of the abdomen with the petiole is bent over, showing

a part of the œsophagus as drawn from the petiole. The continuation of the same, *œ. c*, within the abdomen is shown; also the relation of gizzard to both crop and stomach. × 14, Page 53.

Fig. 60. View of the intestine from the posterior pole of the abdomen to the anus. × 35, Page 56.

Plate IX.

Fig. 61. Synthetic figure exhibiting the entire course of the alimentary canal, from mouth to anus. Page 56.

Figs. 62–70 compose a series illustrating the progressive distension of the crop from the normal condition to that of the honey-bearer. Page 56.

The series begins with Figs. 63 and 66, where the crop is normal; in fig. 66 the crop has shrunken after distension.

Fig. 64. Worker crop, half filling abdomen.

Figs. 62, 65. Workers-major, or semi-rotunds, with distension of crop still further advanced.

Fig. 67. Abdomen of a worker-minor, showing same process of distension.

Fig. 68. Abdomen of a honey-bearer, opened at the slit, *s*, to puncture the crop and exhibit by its shrinking away the fact that the crop fills the cavity of the abdomen. Page 57.

Fig. 69. Full crop of honey-bearer, with the lower part of the alimentary canal shown through the abdominal wall against which it is pressed, and evidently in healthy condition. Page 57.

Fig. 70. Abdomen of honey-bearer, the full crop pressing the gizzard, stomach, etc., into the cloacal cavity. Page 57–8.

Fig. 71. Abdomen of the Australian carpenter-ant, *Camponotus inflatus*, exhibiting the characteristic distension of *M. hortus-deorum*. Drawn from an alcoholic specimen. The figure is somewhat flattened by pressure; other abdomens in my possession are quite spherical. The gizzard, stomach (ruptured and stretched) and intestine are shown in the same relative position as in the honey ant. Page 58.

Plate X.

Fig. 72. Side view of honey-bearer, *M. hortus-deorum*. × 3.

Fig. 73. Dorsal view of same. × 3, Page 69.

Fig. 74. Honey-bearer of *Camponotus inflatus*, dorsal view × 3, Page 59.

Figs. 75, 76. Male of *M. hortus-deorum*. × 5.

Figs. 77, 78. Winged female, or virgin queen of the same. $\times$ 3.

Fig. 79. Worker-minor of *M. hortus-deorum.* $\times$ 5. The workers-major and minor or dwarf are exactly similar in form, only longer in the proportions given in the description. Page 69.

Figs. 80, 81. Node or scale of the petiole ·queen of honey ant, side and front views. $\times$ 10.

Fig. 82. In part, after Swinton ; to show the striæ, *str*, supposed stidulating organs, upon the junction of the abdomen and second node, 2. *nd*, and also on junction of second node with the first (1. *nd*,) of *Myrmica ruginodis.*

March 1.

The President, Dr. Ruschenberger, in the chair.

Eighteen persons present.

March 8.

The President, Dr. Ruschenberger, in the chair.

Fifty-eight persons present.

A paper entitled "On the Structure, Affinities and Species of Scolopendrella," by J. A. Ryder, was presented for publication.

Prof. Angelo Heilprin delivered the introductory to his course of lectures on Invertebrate Paleontology.

March 15.

The President, Dr. Ruschenberger, in the chair.

Prof. Henry Carvill Lewis delivered the introductory to his course of lectures on Mineralogy.

The following was ordered to be printed:—

THE STRUCTURE, AFFINITIES AND SPECIES OF SCOLOPENDRELLA.

BY JOHN A. RYDER.

Inasmuch as a notice,[1] published by me in the *American Naturalist* for May, 1880, has awakened renewed interest in relation to these singular types, and because the ordinal division proposed by me for their reception has apparently been accepted by Dr. Latzel[2] in his revision of the Austro-Hungarian species of *Myriapoda*, I venture to offer the results of my studies for the use of those interested. Since the publication of my notice above referred to, I have met with a paper unknown to me at the time mine was written, which in many respects anticipates the observations made by the writer, and relied upon as characters of ordinal value. The publication here alluded to is entitled "Myriapoden der Umgegend von Danzig"[3] by Menge, in which the author discusses at length the anatomy of the *Scolopendrella immaculata* Newp. From his plates and text I find that, while he confirms my observations in many respects, in others his interpretations conflict with mine. Not only is this the fact with regard to my observations, but also with those of others who have studied the genus. Taken as a whole, the monograph of Menge is, however, by far the most valuable which has yet appeared.

The following synopsis of Menge's observations will, I think, be found useful. I will preserve as nearly as possible the phraseology of the German text, which has reference to *S. immaculata.*

"Head compressed, ovoid, little longer than wide; . . . . . antennæ 40–42, articulate, inserted immediately behind the labrum, the joints compressed fusiform, urn-shaped, the basal ones thicker than long, becoming gradually longer towards the tip, so that the apical joints are more than twice as long as thick; terminal joint acorn-shaped. Each joint is encircled at its middle by a circlet of outwardly divergent hairs. . . . . Behind the insertion of the antennæ, at the sides, are two little prominences on the epicranium and alongside and above them on each side is placed a round black eye, visible only under the microscope.

[1] "Scolopendrella as the type of a new order of Articulates (Symphyla)."

[2] R. Latzel, "Die Myriapoden der oesterreichisch-ungarisch Monarchie. Erste Hälfte. Die Chilopoden," pp. 228, Pls. 10, 8vo. Vienna, 1880.

[3] Neuste Schriften der naturforschenden Gesellschaft in Danzig, IV, 4tes Heft, 4to. 1851.

"Mouth parts arranged for biting. Labrum forming the anterior portion of the epicranium, and divided into two rounded extremities anteriorly by a mesial emargination, both halves terminated by three pairs of teeth directed towards each other. Mandibles beneath labrum, somewhat exserted, one jointed, elongate, curved inwards, the outer side finely pubescent, the apex armed with four large and five small, hard, brown teeth. Maxillæ two-jointed, basal joint cylindrical, curving slightly inwards, surmounted by two apical pieces, the outer, longest and most slender piece may be regarded as representing a palpus, while the inner one, which is shorter, terminating in a series of bristles, may be regarded as the second joint of the maxillæ. The labium is an oblong plate divided in the middle by a suture. The anterior margin of each half bears three conical teeth.

"The body consists of twenty-three somites; twelve principal ones, to which the legs are attached, and ten smaller intermediate and a caudal somite. Each principal or leg-bearing somite has a quadrate sternum which is divided in the middle into two halves by a median furrow; the narrower intermediate somites have an elongate, undivided sternum, while the sides are covered by a triangular chitinous piece. . . . . Attached to every leg-bearing somite except the first, behind and alongside of the insertion of the legs are a pair of simple, hairy appendages. The anal opening is on the ventral side of the body covered by a rhomboidal almost semicircular plate, the lateral extremities of which extend somewhat beyond the edges of the last dorsal scute. The dorsal surface is covered by fifteen scutes which are slightly imbricated. The hind margins of the scutes are but slightly emarginated. . .

"Legs in twelve pairs, or three less than the number of dorsal scutes; no pairs of legs corresponding to the fifth and eighth dorsal and the caudal scutes. The first pair of legs are the smallest, and including the tarsal joint, are four-jointed. The fourth joint is the longest, the tarsal the shortest. The latter is simply a little conical prominence on the outer face of which there are attached two hooked claws. . . . .

"The conical caudal appendages are simply an efferent apparatus connected with two long caecal pouches which are filled with a viscous spinning material. The efferent duct ends between two terminal bristles.

"Besides the dorsal and sternal scutes there are pairs of ligamentous bands which join the terga and sterna; in the hinder somites these bands are joined together dorsally and form an arch. The anterior ones are joined medially below by lateral processes. They also exist in the head.

"The digestive apparatus consists of a straight canal which extends from the mouth to the anus. The pharynx passes between the ligamentous bands of the upper cephalic plates. The œsophagus is provided with annular folds and longitudinal and annular muscles The stomach is decidedly widened and consists of an elongated cylindrical sac and is covered with brownish hepatic cells; these cells have finely granular contents. There are no cilia on the inner surface of the stomach or alimentary canal. The stomach is usually of a yellowish brown color because of the contained food, which consists of particles of brown mould or humus, which could not be taken in by a sucking apparatus. The cavity of the small intestine is very much more contracted than that of the stomach, and at its commencement four vermicularly coiled malpighian tubules open into it.

"Immediately above the anus lies the opening of the oviduct and ovary, the latter consisting of a simple cylindrical canal with thin transparent walls. Eggs in different stages of development may usually be found therein.

"I did not see the male sexual organs, as all of the specimens dissected were females.

"I was not able to study the nervous system satisfactorily. From the head a simple cord passes backwards, which has scarcely noticeable ganglionic swellings at every somite, from which simple pairs of nerves pass to the legs.

"The vascular system consists of a simple straight canal just below the dorsal scutes beginning just behind the head and passing backwards to the caudal appendages where it divides, each branch ending blindly in the latter. The presence of valves in the dorsal vessel, trachea or tracheal openings was not revealed by an amplification of 450 diameters with a Nobert microscope of fine quality.

"The function of the ventral and caudal appendages is not certainly known. I have on several occasions found specimens of *Machilis* which had eggs attached to the caudal styles, and I have supposed that these appendages in *Scolopendrella* have the same use. If a needle is brought into contact with the tips of either of these appendages at the opening of the spinning organ a long thread may be drawn out. It is believed that this spinning apparatus is used in fixing or attaching the eggs of the animal.

"The pairs of legs and the number of joints in the antennæ are variable. I found but eleven pairs of legs and seventeen joints in a young animal. The first pair of legs was wanting. In other specimens with twelve pairs of feet I found twenty-five, in others thirty-two, and in others still, forty-two joints in the antennæ. the last seems to be the number in full-grown specimens." . . .

In conclusion our author observes that, "It will have been concluded from what has been said, that *Scolopendrella* is distinguished from *Lithobius* as well as from *Geophilus* by the very different manducatory apparatus, the double tarsal claws, the ventral and the caudal appendages with the spinning apparatus, and that it does not naturally fall into the same family with either of those genera. On the contrary the animal agrees in its principal characters (excepting the spinning organs) and especially in its habits with *Campodea*: is distinguished from it, however, by the greater number of pairs of legs and the dorsal scutes. I believe, accordingly, that *Scolopendrella* may be regarded as the type of a genus or family intermediate between the six-footed *Lepismidæ* and the *Scolopendridæ*."

The foregoing paragraph shows how very nearly Menge had concluded thirty years ago that these singular animals should be separated from the Myriapods proper. The parallel between his conclusions and my own are very striking, as will be seen from the following words from my notice already alluded to. "This form, as interpreted above, becomes of the highest interest to the zoologist, and if the writer is not mistaken, the biunguiculate legs and their nearly complete correspondence in number with rudimentary abdominal and functional thoracic limbs of the *Thysanura*, especially *Machilis* and *Lepisma*, which also have basal appendages to the legs, indicate as much affinity with insects as with myriapods, and may indeed be looked upon, perhaps, as representing the last survival of the form from which insects may be supposed to have descended. I name the new group *Symphyla*, in reference to the singular combination of myriapodous, insectean and thysanurous characters which it presents."

Our conclusions as to its zoological position being nearly the same, upon the details of the anatomy we disagree. I stated in my note my interpretation of the ventral openings on the third or fourth body segment. (The first condition occurs in immature specimens with less than twelve pairs of legs, the last in adults). "Genital orifice on the ventral side of the body opening on the third or fourth body-segment in both sexes. In one sex the opening is a simple pore, in the other a longitudinal cleft, closed by means of an oblong chitinous piece on either side, the two together occupying a sub-quadrate space. Heart dorsal; tracheal system represented by a series of simple tubular arches, without a spiral filament, which arise from openings on the ventral surface of the animal, inside the bases of the legs, widening and passing upwards to and apparently in close relation with the dorsal vessel. Intestine straight, with two very long, tortuous Malpighian tubules opening into it at the posterior third (*S. notacantha*)."

The main points of disagreement are in regard to the position of the genital organs and the supposed tracheal arches. Menge states that the oviduct opens posteriorly and above the anus, and claims to have seen the eggs in the latter and the ovary. As to this point, I did not confirm his observations, although I do not deny that he may have seen real ova. Nor do I now affirm positively that the ventral opening seen by me is genital; the only evidence being the circumstance that I found two kinds in different individuals. Its function may be that of the ventral sucker of *Collembola*. Menge also says he saw no males, which is a curious fact. His statement that the caudal stylets will adhere to a sharp point brought into contact with their tips, I can confirm, and I have also seen a thread drawn from them in *S. notacantha*. He is confident that what I took for tracheal arches are simply chitinous rods or ligaments which serve to join the sterna and the scutes. He is mistaken, however, when he affirms that the posterior ones form a continuous arch, since in all the specimens examined by me the arch was broken at the dorsal vessel, the widened ends of the opposite halves of the arches seeming to lie against its sides. The walls of these arched tubes showed double contours under the microscope, which proves them to be hollow.

He also finds four Malpighian tubules in *S. immaculata*, whereas I find but two in *S. notacantha*. He finds as few as seventeen joints in the antennæ to as many as forty-two. I find from fourteen to twenty-eight in two species. Newport,[1] speaking of the species studied by Menge, finds the joints of the antennæ to vary

[1] Monograph of the Class Myriapoda, Order Chilopoda. Trans. Linn. Soc. XIX, pp. 349–439, 1 Pl. 1845.

from twelve to twenty-eight, and finds specimens of different ages with nine, ten, eleven and twelve pairs of legs. This variability in the number of pairs of legs I have noticed in both the American forms studied by myself. Newport also at first thought the creature was nearly related to *Geophilus*, but afterwards placed it between *Lithobius* and *Scolopendra*, but he at last considered it the type of a family, a conclusion which Gervais[1] did not accept. Wood[2] says he never saw any specimens of the family, and gives the characters assigned by Newport.

The first species described was by Gervais in 1839, from specimens found in the environs of Paris. This species was made the type of the genus. In his description he disagrees with Menge in the distribution of the legs. This may however be on account of the difference of the species.

Order SYMPHYLA.

Amer. Nat. XIV, p. 375-6.

Head, antennæ and mouth parts thysanuriform. Trachea as tubular arches without spiral filament. Spiracles within the bases of the legs. An orifice on the ventral side of the body opening on the third (young) or fourth (adult) body-segment; present in some individuals as a pore, in others as a longitudinal cleft, closed by means of an oblong chitinous piece on either side, the two together occupying a subquadrate space. Two Malpighian tubules (four Menge). Legs five-jointed, terminated by a pair of claws. Ventral appendages at the bases of each pair of legs except the first. Caudal stylets containing spinning glands which open at their tips. Ovary lying dorsad of the rectum (Menge).

Family SCOLOPENDRELLIDÆ.

Newp. Transac. Linn. Society, XIX, p. 374.

SCOLOPENDRELLA Gerv.

Comptes Rendus, 1839.

S. notacantha Gerv. Aptères, IV, 301, Pl. 39, fig. 7; Ann. Sci. Nat., Zool. II, 1844, p. 70, Pl. 5, figs. 15-17; Ryder, Am. Nat., p. 375, 1880. Hab. France and ? Pa. and Md.

S. immaculata Newport. Trans. Linn. Soc. XIX, pp. 373-374, Pl. XL, figs. 4, 4a, b, c; Menge, Neuste Schr. d. naturf. Gesell. Danzig, IV, 1851, Pls. 2, Hab. England and Germany.

[1] Aptères. Suite á Buffon, Walckenaer et Gervais, t. IV, p. 301-303. Paris, 1847.

[2] Monogr. North American Myriap., Trans. Am. Philos. Soc., XIII. New Series, 1869.

S. americana Packard. Proc. Bost. Soc. Nat. Hist., XVI, p. 111, 1873. Name only. Hab. Salem, Mass.

S. gratiæ Ryder. Am. Nat., XIV, p. 375, 1880. Name only.

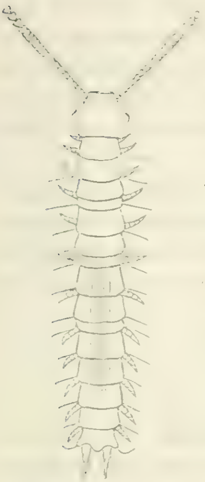


Fig. 1.—*S. gratiæ.* Enlarged 25 times.

This species (Figure 1.), may be distinguished from *S. immaculata* by the presence of a pair of stout hairs which diverge outwards from the sides of the body at each segment. Head wider than body, not cordate but subpentagonal from above. A single pair of eyes on the sides of the head behind the antennæ, not visible from above. Antennæ twenty-one-articulate. Length 2 to 2·5 mm. Habitats: Fairmount Park, Philada; Havre de Grace, Md.; Washington, D. C.; Franklin Co., Pa. Under stones, sticks and in damp mould.

I dedicate this handsome species to my sister.

S. microcolpa Muhr. Zoolog. Anzeiger, IV, 1881, pp. 59–61, figs. 1, 2 and 4.

Is near *S. notacantha*, but is said to have no ventral appendages at the bases of the legs. I would remark, however, that in the specimens thought to be *notacantha*, I find these appendages present, but they are extremely small and may easily be overlooked. Muhr's paper is a valuable contribution however to the anatomy of the mouth parts of a form near the species first described. Habitat, Prague, Bohemia.

Figure 2, representing an American specimen of the same, or nearly the same, as *S. notacantha*, has a very suggestive resemblance to *Japyx* in the shape of the body; whether this is more than a resemblance I forbear to suggest. No doubt now remains in my mind that dissimilar as *Lepisma*, *Machilis*, *Lepismina*, *Nicoletia*, *Campodea* and *Japyx* at first appear upon comparison with each other, their principal characters suggest in

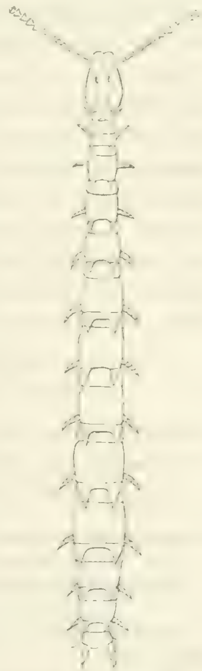


Fig. 2.—*S. notacantha.* Enlarged 25 times.

the most forcible manner, an affiliation with *Scolopendrella*. This is most strongly indicated in the mouth parts, legs, variability in the number of antennal joints and habits of life in all of which *Scolopendrella* exhibits the strongest resemblances to the *Thysanura*, with very marked affinities to the Myriapods as well. The position of the ovary is that in *Geophilus*, but spinning organs are also characteristic of the male *Geophilus* and *Polydesmus*; a female specimen of the latter, while being kept in confinement, spun a web about its eggs in a jar in which I had confined it. I never noticed that any American female *Geophilus* spun webs about their nests, though I have frequently encountered masses of their beautiful amethystine-colored eggs, over which they kept faithful watch.

Whether the proposed order *Symphyla* is sufficiently well characterized may be a matter of doubt; this can only be decided by a more elaborate investigation of its anatomy, which the writer hopes to be able to carry out at no distant day.

MARCH 22.

The President, Dr. RUSCHENBERGER, in the chair.

Twenty-six persons present.

The death of Jos. A. Clay, a member, was announced.

MARCH 29.

The President, DR. RUSCHENBERGER, in the chair.

Twenty persons present.

APRIL 5.

The President, Dr. RUSCHENBERGER, in the chair.

Thirteen persons present.

The deaths of John Gould, of London, a correspondent, and of Thos. W. Starr, a member, were announced.

APRIL 12.

The President, Dr. RUSCHENBERGER, in the chair.

Twenty-four persons present.

The death of Col. T. M. Bryan, of Vincenttown, N. J., a correspondent, was announced.

APRIL 19.

The President, Dr. RUSCHENBERGER, in the chair.

Twenty persons present.

A paper entitled "Observations on Planorbis," by R. E. C. Stearns, was presented for publication.

On the Variations of Acmæa pelta, Escholtz.—Mr. TRYON read a portion of a letter from Mr. Henry Hemphill, of Oakland, California, referring to certain specimens of *Acmæa*, collected by him, and presented to the Academy this evening.

"I will now call your attention to Nos. 457, 458, 459 and 460. I have made two trips to Monterey, Cal., this winter. During my first visit I collected a few specimens of *Acmæa pelta* and its vars., and when I returned home and began to clean the specimens I was very much puzzled over some specimens of No. 458. Several years ago I had collected shells of No. 459 at Monterey, which at that time I called *Nacella instabilis*, but these half and half varieties did not appear at that time. After a little reflection on the matter, I began to suspect the true condition of the subject and became so much interested in it, that I concluded to go to Monterey again and try to work it up, and I think I have done so. It is simply a question of station.

"When the young of *A. pelta* stations itself on the kelp (*Phyllospora Menziesii*, Ag.), it assumes the aspect of *Nacella*, and as long as it remains on the kelp it does not change its color in the least, and only varies its form to suit the shape of the stems of the kelp to which it attaches itself. But when from any cause it leaves the kelp and takes to the rocks, it seems to begin immediately to paint up and ornament itself after the fashion of the specimens I have sent you.

"When it remains on the kelp a long time and completes its growth, we then have *Nacella instabilis*, and if living in an exposed position its apex becomes worn, the sculpture faint, etc. When the young station themselves on the rocks they do not assume the *Nacella* aspect at all, but commence immediately to adorn themselves in gay and beautiful colors as you will see by the fine series of No. 457. Now for the facts and reasons why I came to this conclusion. I collected about 200 living specimens on the kelp in all stages of growth, and out of the 200 I found but two specimens that varied their color at all; one was a very young and small specimen, with a few light dots on or near the apex, and the other was a large specimen with a tesselated border on the inside. I also collected about 200 on the rocks, and every one was more or less variegated with either the square dots or alternate rays of white and black, while those that had evidently been on the kelp had their tesselated borders well advanced. We must also take into consideration the fact that Monterey is the most southern point at which *Nacella instabilis* has been found, and it is quoted by Dall as rare there. The water of the bay where these half and half No. 458 are found, and also others, is comparatively smooth to what it is on the outside where the typical *Nacella* is found, which will account for the preservation of the apex and sculpture and may have something to do with the form, and undoubtedly is the cause why it is rare at Monterey.

"To show the effect of station, with probably other causes, I send you a full series of a very pretty var. of *A. pelta* from Olympia, Puget Sound, W. T., 461 to 466 inclusive, that I collected last summer. Station, on *Mytilus edulis*.

"This very pretty var has almost the exact form and looks like a huge *Nacella peltoides*, Dall, and is a very interesting addition to our limpets."

APRIL 26.

The President, Dr. RUSCHENBERGER, in the chair.

Twenty-six persons present.

A paper entitled "List of Fishes collected by Mr. W. J. Fisher, upon the coasts of Lower California, 1876–77, with descriptions of new species," by W. N. Lockington, was presented for publication.

The death of Dr. J. Dickinson Logan, a member, was announced.

Motility in Plants.—Mr. THOMAS MEEHAN remarked that comparatively little knowledge of motion had been gained since the time of Linnæus. The recent work of Mr. Darwin on the motions of plants, was a valuable contribution to the subject, though confined to motion in roots and leaves. He thought it would serve the cause of science to note that the presence or absence of light in itself could not, as so often assumed, account for all the phenomena of motion. He had made numerous and careful observations, this season, on motility in *Draba verna*, which plant, so far as he knew, had not been observed to have any peculiarities. The petals are usually closed during the early season, though the pedicels are erect in the daytime, drooping so as to form almost a perfect circle at night. These pedicels become erect about three hours after sunrise when there is about twelve hours of sun in the day, commencing to droop at about two o'clock in the afternoon. This diurnal motion in the pedicels continues some days after the petals have fallen, and apparently as long as the silicle continues to grow. Later in the season, on clear days, the petals commence to open early in the morning, contemporaneously with the rising of the pedicel; by the time this was erect, the petals would be nearly expanded. The expansion, when the sun rose at half-past five or six, would be complete by nine A. M. Strange to say, no matter how clearly the sun might continue to shine, the petals commence to close about noon, and by about two P. M., are completely closed.

During the course of his observations, there was a period of four days cloudy, and no attempt at expansion was made. The fourth day, however, was so slightly cloudy, that the eye could scarcely look at the sun through the thin cloudy veil. The amount of absolute light could be little less than on some days earlier in the season, when the sun was wholly unclouded, but still there was no attempt at expansion of the petals. Continued observations seemed to show that not mere light, but clear sunlight, was necessary to the opening of the flower.

One evening there was a heavy thunder shower; the next day was densely cloudy, warm and moist, but the flowers of the *Draba* expanded just as well as under the bright sun of previous days! These facts show that we cannot refer the opening of the flowers either to light or sunlight alone. Mr. Meehan believed that plants not only behaved differently at different times, but in different countries; and as no one, not even Mr. Darwin, seems to have noted the expansion of the petals of the *Draba* in England, it is possible that under those cloudy skies, they do not expand at all. So far as he had noted here, the self-fertilized flowers of the closed Drabas produced seed just as well as the expanded ones, which might possibly be occasionally cross-fertilized by the small sand wasps, which visited the open flowers freely for pollen.

How habits change at times, Mr. Meehan illustrated by specimens of *Lamium amplexicaule*, a common introduced weed in gardens. Dr. Bromfield, in his Flora of the Isle of Wight, notices that the flowers vary in size during the season, but that the earliest ones are the largest. Here it is reversed. The specimens exhibited had already flowered from six verticels, and had mature seeds in many, but the flowers had never expanded in any case. Indeed, very rarely had the closed corollas been produced beyond the calyx. They were essentially cleistogene. As showing how uncertain were the laws influencing this condition, when usually about the end of April, the perfect flowers appeared, some plants would have them a week or more before others alongside produced any. To all appearances, external influences were the same.

As somewhat bearing on the laws of motion, the angle of divergence in branches was referred to. Mr. M. exhibited branches of *Salix caprea*. Normally the branches separated from each other at a very acute angle, but the fertile ament on these branches was pendulous. Under no external influence, so far as we could tell, an individual appears with pendulous branches. This has been increased by grafting, and is known in nurseries as the Kilmarnock weeping willow. But the aments have retained their normal condition as regards the branch. The catkins are erect on the pendulous branches, while pendulous on the erect ones. Morphologically a catkin is but a modified—an arrested—branch, but we see by this that whatever cause induced the change from the normal condition of divergence, it was purely local, and ceased to exist before it reached the arrested branch or ament.

These facts were offered to show that in studying motility in the various parts of plants, it would be well to remember that external causes had but a limited influence, and that in these cases a combination of circumstances often controlled the influences attributed to one. As, therefore, the facts would vary with various observations,—those of one observer sometimes seeming rather to conflict with than to confirm another,—it was too soon to form any just conclusion as to the motive cause. What was desired was not so much these speculations, but an increase in the number of observers, and a correct record of well authenticated facts.

The resignation of Dr. Henry C. Chapman, as a member of the Council was read and accepted.

Jesse S. Walton and Harry Skinner were elected members.

The following was ordered to be published:

OBSERVATIONS ON PLANORBIS.

BY ROBERT E. C. STEARNS.

I. *Are the Shells of Planorbis Dextral or Sinistral?*

Incidental to an investigation into the relations of certain fresh-water snails, upon looking through the books, I find that authorities differ on the point, whether the shells of *Planorbis* are dextral or sinistral.

While Say,[1] Swainson,[2] G. B. Sowerby, Jr.[3] and Reeve[4] regard them as sinistral, or reversed, and properly figure the shells, in their works, in a sinistral position, and not "upside down," as in many of the books, Macgillivray[5] says "the shell is dextral, as several observers have proved; not sinistral, as many have alleged;" and Woodward,[6] H. and A. Adams,[7] W. G. Binney[8] and others also describe it or refer to it as being dextral.

Dall remarks in a foot-note to his paper "On the Genus Pompholyx and its Allies,"[9] "if we consider the shells of this group as dextral, they offer the peculiarity of having the genitalia as in most sinistral shells; *Pompholyx* presents the same conditions and is certainly dextral." Dr. Philip P. Carpenter, referring to *Planorbis*, says, "it lives in a reversed position."[10]

It will be observed from the above that eminent writers are divided, and that we have substantial authority on both sides of the question.

My own observations thus far prove the shells to be generally *sinistral*,[11] but as I have examined but comparatively few of the whole number of species, it may be that the shells in some species are dextral, and in other species sinistral.

[1] Say ex Binney, L. and F. W. Shells of N. A., Part II, p. 103.

[2] Treatise on Malacology, p. 337.

[3] Conchological Manual, p. 245.

[4] Conchologia Systematica, Pl. CXC.

[5] Molluscous Animals of Scotland, p. 114.

[6] Manual of Mollusca, second ed., p. 302.

[7] Genera of Recent Mollusca, Vol. II, p. 260.

[8] Smithsonian Miss. Pub. No. 143, p. 103.

[9] Annals of Lyceum of Nat. History of N. Y., Vol. IX, March, 1870.

[10] Lectures on Mollusca, S. I. Report, 1860.

[11] The figures of Say's larger species in Gould's Invertebrata of Mass., first ed., are most excellent.

G. B. Sowerby, Jr., in comparing *Planorbis* with certain Ampullariæ (*Marisa*), says: "It is further to be remarked that the discoidal Ampullariæ are dextral shells, and the Planorbes are sinistral or reversed; and although the latter are sometimes so flat and orbicular that it is difficult to know which is the spiral side, it may nevertheless always be ascertained by a careful examination."[1]

While the anatomy of *Planorbis* in its principal characters, is presumed to be sinistral, and indicates, with the sum of other characters (including habitat), a most intimate relationship to *Physa*, which has, as is well known, a sinistral shell, yet some of the authors who affirm the sinistral character of the soft parts or body, say also, that the species of this genus (*Planorbis*), have a dextral shell, an inclusive and broad statement which applies to all of the species, and apparently repeat this tradition, or else assume that it is so, because the great majority of gasteropodous mollusks which have shells at all, have dextral shells, the exceptions being comparatively few.

If we consider what are regarded as apical characters in forms about which there is no question, and it is permitted to reason, from analogy in this connection, it will be seen that some species of *Planorbis* have sinistral shells, and I submit as examples sustaining this position, the larger West American forms known as *P. ammon*, (fig. 1) Gould (+ *P. Traskii*, Lea.), *P. trivolvis*, (fig. 2) Say[2] (+ *P.* var. *occidentalis*, Cp. MSS.), *P. tumens*, Cpr., *P. subcrenatus*, (figs. 3–3*a*) Cpr.[3], *P. corpulentus*, (figs. 4–4*a*) Say, and *P. tumidus*, Pfr., from Nicaragua, also *P. corneus*, L., Britain, as shown in authentic specimens received from an experienced and

[1] Conchological Manual, p. 245.

[2] Pacific Coast specimens.

[3] This species more nearly resembles *P. corneus*, than does any other American form. Many of the smaller so-called species (American) are exceedingly close to the smaller forms of Europe, and it is not unlikely a careful investigation would place some of them under the names previously made by the earlier authors. Mr. W. G. Binney writes of *Physa hypnorum*, "it is one of the species common to the three continents;" and of *Limnæa*, he says, "It seems certain that the boreal regions are inhabited by several species common to similar latitudes in Asia and Europe, such as *L. stagnalis* and *L. palustris*." This remark will ultimately be found to apply with equal truth to species of *Planorbis*.

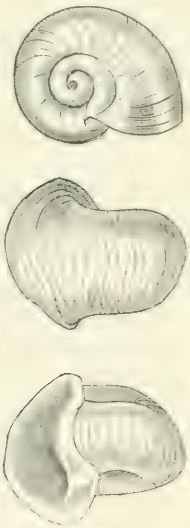
trustworthy correspondent near London. This latter is the only large European species, I am familiar with.

While it is neither proven nor asserted herein, that all species of *Planorbis* have sinistral shells, neither is it known that the anatomy of all the species is sinistral.

The relations of *Planorbis* to *Limnæa* are not so remote as to make it altogether unwarrantable to look for a divergence in that direction.

The extreme variableness of *Planorbis* has undoubtedly led to the making of too many species; specimens which are conceded

FIG. 1.

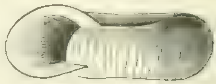


P. ammon, Gld.

FIG. 2.

P. trivolvis, Say.

FIG. 3a.



P. subcrenatus, Cpr.

FIG. 3.

P. subcrenatus, Cpr.

FIG. 4.

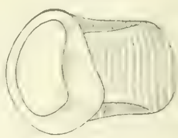
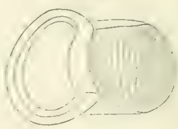


FIG. 4a.



P. corpulentus, Say.

to be of the same species, from different though adjacent ponds, etc., vary more or less, and this is particularly the case with West American forms which are in various degrees affected by the character of the water, temperature, etc. While it is quite certain that the specific names herein given would be reduced by a careful and philosophical comparison, at this time I can only refer to them as they now stand in the books; I may mention *P. tumens* from near Petaluma as a dwarfed variety of *P. corpulentus;* varieties of the latter are frequently confused with *P. ammon*.

It may here be remarked that Macgillivray, an enthusiastic observer, who has described some of the British species with great fidelity, lays much stress on the shape of the *mouth*, comparing it with those of *Helix* and *Zonites*, as conclusive of the dextral character of the shells in *Planorbis*.[1]

If analogies in form of mouth are worthy of consideration, though this point may not have much weight without other and corroborative evidence, we have in this character a stronger argument the other way, by, more properly a comparison between nearer related forms like *Physa* (that is the more globose species), and most of the forms of *Planorbis* I have given, holding the latter in a normal sinistral position, when the tendency to the physoid mouth, the ovate shape and sag of the aperture will be readily noticed.

Frequently, immature, half-grown, and less than half-grown shells of *Planorbis* have been brought to me by collectors who were quite confident they had made new discoveries, and it is not improbable that young shells as above have been described and published as new species of *Physa*.

FIG. 5.

Ameria scalaris, Jay.

FIG. 6.

Physa globosa, Hald.

FIG. 7.

Physa humerosa, Gld.

FIG. 8,

Physa ancillaria, Say.

FIG. 9.

Physa ampullacea, Gld.

I would further suggest a comparison of the apertures of our larger Californian (adult) shells of *Planorbis*, held in a sinistral position with *Ameria scalaris* (fig. 5)[2] (= *Paludina scalaris*, Jay), a curious Florida form; *Physella globosa* (fig. 6), Hald., a Tennessee

[1] It is presumable that the shells of *Planorbis*, by which Macgillivray was impressed and which were the most familiar to him, were the small species of his own country, which are flat, symmetrically coiled, regular in form, and gradual in growth, being in striking contrast with the sturdier, ventricose West American forms I have cited—which also more conspicuously exhibit sinistral characters.

[2] Dall says : "A careful examination of a number of specimens of this singular form, shows that it is distinct, and not a young *Planorbis*, as has

species; also with other species of *Physa*, like *P. humerosa* (fig. 7), *P. ancillaria* (fig. 8), *P. ampullacea* (fig. 9), etc., *et sic de similibus*.

We shall, however, find more satisfactory testimony on the sinistral point by analyzing the apical characters.

If, as in other shells, we consider that to be the upper end or spire in which we can follow the volutions through the entire shell from tip or nucleus to the ultimate or basal whorl and mouth—then it is impossible to avoid the conclusion that some species of *Planorbis* have sinistral shells. In some of the smaller forms, like *P. vortex*, *P. contortus*, *P. glaber*, *P. carinatus*, and *P. spirorbis*, all of which are British species, and in which the whorls are (in comparison with larger American forms) quite evenly coiled and in which also, the increase in size of whorl is quite gradual, the difference between the two sides of the shell, apical and umbilical, is not as readily perceived. The largest British species, *P. corneus*, confirms my view, being sinistral. The rapid enlargement of the whorls in some of the West American species is in marked contrast with even the shells of *P. corneus* of the same diameter; the height of the latter as compared to *P. corpulentus* being as ·31 to ·54, while the length of the aperture is in still greater contrast, being as ·42 to ·76. These measurements were made from average-sized perfect specimens of both species placed apex up, with the mouth to the left,

It is easy to perceive that in those forms where the ratio of increase is great as between the last whorl and the preceding volution and so on, whorl compared with whorl, through the whole, as for instance in *P. ammon*, that the depression of both spire and umbilicus is most marked; but nevertheless the umbilicus is the more profound as may easily be proved by counting the volutions first on one side, and then on the other.

Again, if additional proof is wanted, take any one of the larger forms[1] of the species herein named, and carefully, by degrees, burn off the under side (which can easily be done, by pouring a little

been suspected.—*Annals N. Y. Lyceum Nat. Hist.*, Vol. IX, p. 356; foot-note.

[1] As distorted individuals, with the volutions exceedingly irregular, are of frequent occurrence, in making the test suggested, such monstrosities should be rejected, as they would as often *unduly* favor one side of the question as the other.

acid in a saucer or watch-glass), until the shell is eaten off to a line which obliterates the umbilicus, when the nucleus of the spire, the tip, and half a whorl to a whorl and a-half will be found remaining.

Those who insist on the dextral character of the shells in *Planorbis*, unless they except the species I have named, are thus compelled to demonstrate how in the sequence of growth the umbilicus can precede the nucleus.

Though specimens of the forms under discussion, in various embryonic stages, have frequently excited my attention, yet the material, so far as adolescence is connected with the present line of inquiry, was at the moment, unfortunately, inaccessible. I have therefore been compelled, in order to present such structural features of the shells as are related to the direction (right or left) of the volutions, the form of the aperture, etc., to use adult specimens, and by breaking back, piece by piece, and whorl after whorl, towards the nucleus, until the larger whorls are sufficiently removed, so that the apex or spire ceases to be either concave or depressed, and is simply flat. It would be almost, if not quite impossible to do this with the smaller species, owing to their diminutive size and exceeding fragility, and difficult to obtain the necessary sections for illustration herein, by the use of acid.

The figures (10) are drawn from specimens of *Planorbis corpulentus* collected in Oregon, also in Clear Lake, California, by that indefatigable collector, Mr. C. D. Voy. Before manipulation they measured as follows:

FIG. 10.

Plan. corpulentus—nuclear whorls.

Largest diameter, . .	·94 inch.
Height, ...	·38 inch.
Number of whorls,	four and a-half,

which were broken back to one and a-half whorls, with a diameter of ·10 inch.; height ·15 inch. The umbilicus in one instance was still discernible—in the others, destroyed. This species is widely distributed and occupies an extensive geographical area, on the western side of the continent, from the Columbia River in the north; easterly to Lake Winnipeg; and southerly to Cape St. Lucas.[1] Binney says, "*P. corpulentus* is catalogued from Guatemala by Mr. Tristram."

[1] Prof. Geo. Davidson collected specimens at this place.

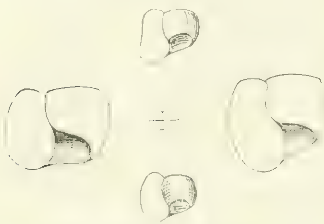
P. Traskii, Lea, which Mr. Binney makes a synonym of *P. ammon*, belongs to the western *corpulentus* form.

While the foregoing figures (10) show the shells of one species reduced to one and a-half whorls, the following figures exhibit the form of *Planorbis tumidus*, Pfr., which measured in

Largest diameter, ... ·68 inch,

with five whorls, reduced by breaking down to two and a-half whorls and a diameter of ·16 inch.

FIG. 11.



Plan. tumidus—nuclear whorls.

This last is a more southern species; numerous specimens were collected by the late Thos. Bridges, who found them abundant in elevated pools, small lakes, etc., amid the forest slopes of Mombacho, in Nicaragua. It closely resembles more northern forms and should hardly be called a species.

It will be observed in the figures (10) that we have in the embryonic shells of *Planorbis corpulentus* a near approach to *Physa*, a close resemblance to a *Physa* with a flattened spire; suggesting such physoid forms as *P. humerosa*, while the adolescent stage of *Planorbis tumidus* (at half its adult size) also suggests an umbilicated *Physa* with a flattened spire, somewhat like (N. W. American) *Physa Lordi* (fig. 12), with the spire cut off, and an umbilicus punched in, back of the mouth.

FIG. 12.

Physa Lordi.

FIG. 13.

Physa planorbula.

The first figures (10) explain De Kay's "*Physa planorbula*" (fig. 13), and also suggestively point towards *Ameria scalaris*. These figures also exhibit the physoid mouth, and show that there is neither necessity nor propriety in leaving closely related forms for more distant analogies. In this connection it should also be kept in mind that certain species of *Physa*, included in Ehrenberg's subgenus *Isidora*, are more or less umbilicated. Of the smaller species of *Planorbis* which have passed under my examination, I have seldom found it difficult to determine the sinistral characters by a comparison of the two sides of the shell.

If we could unroll a specimen of, say, *Planorbis spirorbis*, and then straighten it out, it would resemble, in minature, an acutely elongated conical tube, in a general way like the following figure:

Fig. 14.

of which X represents the nucleus, A the aperture or mouth, and ML a median line. Now it will readily be seen that such a tube, if simply wound up, or made into a flat coil, and during the process of winding, kept horizontally and laterally in plane with the central or median line which divides the tube into equal parts, would, in an exceedingly small shell, make it somewhat difficult to determine which was the apical or the umbilical (that is the upper or under) side of the shell, as the nucleus and nuclear whorls in such a case would be equally as perceptible on one side of the shell as on the other, and the concavity or depression of both sides would be the same, being equal to one-half of the diameter of the tube as seen at X.

Fig. 15.

The Californian species to which I have referred, instead of being represented by an attenuated tube like the preceding figure, which very slowly increases in circumference from nucleus to aperture, would if unwound, give us a more robust form, a more rapidly enlarging, conical tube, like this (fig. 15):

N being the nucleus, A the aperture, and ML the median line.

It will be seen that if this tube, commencing at N the nucleus, was evenly coiled upon the median line, the nucleus as in the first instance, though very much more depressed, owing to the greater diameter of the tube as seen at X, could be equally well seen on the two sides, the umbilical and apical depressions being the same.

When the line of coil is other than median, and the greater portion of the tube or shell is below the line of coil, as is the case with the species I find to be sinistral, then of course the umbilicus is the more and the apex the less depressed, and therefore the latter is more easily discerned. Another point too important to be overlooked, is the form of the tube as exhibited in a transverse or cross section; whether circular, semilunar, or horizontally or perpendicularly ovate.

Some of the larger species have tubes, which, in cross section, are of the latter shape, hence the physoid aspect of the aperture both in adult and embryonic specimens.

Since the foregoing was written, the shells which appear in the list appended hereto as from Lake Simcoe, came to hand. The lot embraced three species of *Planorbis*. Several specimens (of rather small size) of *P. trivolvis*, are of the western *P. corpulentus* character, and *sinistral*. Twenty-five specimens of *P. campanulatus*, Say, are also sinistral as described by that author, and three specimens of *P. bicarinatus* are *dextral*, though described as sinistral by Say. Of the smaller American species glanced at by me in the course of investigation, I find *P. vermicularis*, from Utah Lake, U. T., is sometimes dextral.

From what is presented above it will, I think, be admitted that some species of Planorbes have shells whose structure is in harmony with the sinistral characters of the anatomy, as might reasonably be presumed, and it is not unlikely that such will prove to be the rule and not the exception, when an extended and critical examination of the whole group has been made.

I do not propose, at this time, to inquire into the origin of the related forms referred to in this paper; but the suggestions, which have incidentally occurred in, or grown out of the consideration of the simpler points discussed, impress me as inviting investigation.

The following species of *Planorbis* from the localities stated, have been especially examined in connection herewith.

*	*P. trivolvis*,	Erie Canal, N. Y.
*	"	Tinker's Creek, Lake Co., Willoughby, O
*	"	Foot's Pond, Woodburn, near Cincinnati Ohio.
*	"	Lake Winnebago, Wisconsin.
*	"	Wabash River, Posey Co., Indiana.
*	"	Covington, Kentucky.
†	"	Washoe Lake, Nevada.

NOTE.—I am indebted to the courtesy of the Smithsonian Institution *for all* of the figures herein, *except* 10, 11, 14 and 15, which are original.

‡ *P. trivolvis*,	Near Salt Lake, Utah T.
§ "	Utah Lake, U. T.
* *P.* between *lentus* and *glabratus*,	Carthage, Ohio.
* *P.* approaching *glabratus*.	Cumberland Co., Tennessee.
* *P.* approaching *lentus*.	Cumberland Co., Tennessee.
‡ *P.* near *tumens*,	Tuolumne Meadows, Tuolumne Co., Cal.
* *P.* near *corpulentus*,	Indian River, Texas.
* " "	Bexar County, Texas.
* " "	Miami, Florida.
†† " "	Lake Simcoe, Canada.
‡ *P. corpulentus*,	Near Portland, Oregon.
†† "	Lake Simcoe, Canada.
† " var. *Traskii*,	Clear Lake, Lake Co. Cal.
" "	Oregon, Mus. Stearns.
‡ *P.* var. *occidentalis*, Cp.	Russian River, near Ukiah, Cal.
†† " "	King's River, Cal.
†† " "	Mountain Lake, near San Francisco, Cal.
† " "	Santa Cruz, Cal.
‡ *P. tumens*,	Los Angeles, Cal.
‡‡ *P. tumidus*,	Nicaragua.
* *P. glabratus*,	East Tennessee.
* *P. bicarinata*,	Erie Canal, N. Y.
* "	McHenry County, Ills.
‡ "	Portland, Oregon.
†† "	Lake Simcoe, Canada.
* *P. lentus*,	Clear Lakes of Indian River, Florida.
* *P. campanulatus*,	Orono, Maine.
* "	Henry County, Ills.
‖ *P. ammon*,	Salinas River, Cal.
¶ *P. corneus*,	Great Britain, many localities.

The note marks above refer to the following parties from whom the material examined was received: * Prof. A. G. Wetherby; † C. D. Voy; ‡ Henry Hemphill; †† A. W. Crawford; § Dr. Edward Palmer: ‡‡ the late Thomas Bridges: O. Button; ¶ the late W. W. Walpole, Esq., from all of whom I have received most generous assistance.

As to the validity of the species. or determinations as above, it is not necessary to discuss the matter in this paper, as it is not pertinent to the objective point. but as may naturally be supposed by any one who has had occasion to examine into the literature relating to the group, and to make a critical comparison of material, I have found much that is unsatisfactory, and it is not asserting too much to say, that too many species have been made, and that a careful revision is required; and in this connection, which shows the well-known variability of the group, I may mention the examination of a parcel of specimens from a single "pond back of Covington, Kentucky," kindly furnished by Professor Wetherby, which admits of a separation resulting in three species and a remainder which readily connects all three; for this reason I do not claim that the determinations as given are always consistent, though carefully considered; as before remarked, however, the point I have endeavored to present is not affected thereby.

II. *On certain Aspects of Variation in American Planorbes.*

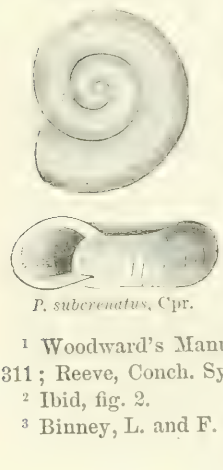
In the course of the preceding inquiry various aspects of variation, as exhibited in the material under examination were constantly recurring.

Without presuming to explain such phenomena, which would quite likely be a difficult matter, even if all the peculiarities of environment in each case, or of each lot of shells examined, were known, and without such data, quite hypothetical, yet a few notes and comments suggested by the forms referred to, may be worth a passing notice.

The larger so-called species of *Planorbis* may for convenience in discussion be grouped as follows:

First. Those in which the whorls are rounded; that is to say if the tube or cone, as represented in the preceding paper, was cut transversely, the section would show a rounded (not round) outline. Examples—The typical *P. corneus*, L.,[1] of Europe; *P. Guadaloupensis*, Sby.;[2] *P. subcrenatus* (figs. 16, 17), Cpr.,[3] and *P. tumidus*, Pfr.,[4] of Nicaragua, a quite persistent form, not, however, quite as rounded as the others.

Figs. 16 and 17.



P. subcrenatus, Cpr.

Second. Those in which the whorls are either planulate, angulated, carinated or subcarinated, which includes most of the larger

[1] Woodward's Manual, Pl. XII, fig. 34; Sby.'s Manual, Pl. XIV, fig. 311; Reeve, Conch. System., Pl. CXC, fig. 1.

[2] Ibid, fig. 2.

[3] Binney, L. and F. W. Shells, N. A., Part II, figs. 176, 178.

North American species. Examples—*P. corpulentus* (figs. 18, 19), Say,[1] *P. Traskii*, Lea., *P. occidentalis*, Cp., and *P. bicarinatus* (fig. 20), Say. In these the tube, if cut transversely, would present an outline more or less angulated.

FIGS. 18 and 19.

P. corpulentus, Say.

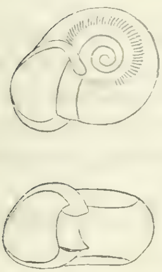
FIG. 20.

P. bicarinatus, Say.

Forms like *P. trivolvis* (fig. 21), Say, connect the two groups; for while in some instances this species exhibits the rounded whorls of the first, it imperceptibly differentiates from the above to obtuse angulation, and thence to the subcarinate forms of the second group.

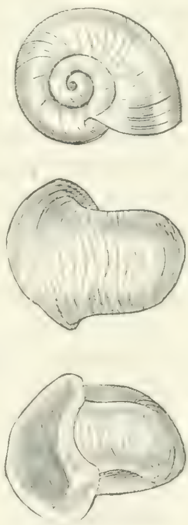
P. ammon (fig 22), Gould, must be mentioned here, as it illustrates another aspect of variation, that of a more rapid enlargement of the whorls, the result of a more obtuse cone than in *trivolvis;* this, when flattened above or angulated, gives us the form *P. Traskii*, the most striking of all the American Planorbes; it is the extreme or culmination of the flattened or planulated aspect in the second group of species, of which *P. corpulentus* is a well known form and more widely distributed than the other; Dr. Cooper's *P. occidentalis* being an intermediate link between typical *P. trivolvis* and ordinary average specimens of *P. corpulentus*.

FIG. 21.



P. trivolvis, Say.

FIG. 22.



P. ammon, Gld.

Southern specimens of *P. trivolvis* seem to be nearer the southern form of *P. lentus* than do average specimens of these alleged species from northern stations: and both of the above from southerly stations approach more closely to the European *corneus* than do northern specimens of the same; the same may be said of the Nicaraguan *P. tumidus*.

[1] Binney's figures, ibid.

P. bicarinatus, the cone of which is less robust than that of *P. ammon* or *P. Traskii*, being in that respect nearer to the typical *trivolvis*, exhibits the culmination of the carinated or keeled character of the second group, and appears to mark the limit in this direction, having reached what may be termed a permanent point. This species is usually quite persistent as to plane of coil; though in Binney it is reported from a single station as far south as "Northern Georgia"—it seems to prefer northerly regions.

It is apparently of rare occurrence west of the Rocky Mountains. Mr. Hemphill informed me that he detected two or three individuals at Antioch, California, a station peculiar in its enviromental characters, being at a point where the Sacramento and San Joaquin Rivers meet and unite the drainage waters of the two great valleys of the same names; mingling in combined volume their fresh water with the salt tidal-water from San Francisco Bay. Other forms are sometimes found at this point; they seem unable to obtain a foothold or to establish a permanent colony or settlement. The region is one of marshes, which sustain a rank growth of coarse vegetation, especially what is known as *tules*, which sift, as it were, the waters, and hold for a time forms which, during the great floods of excessively wet winters, are swept from their native haunts through the submersion or overflow of the ponds, lakes and streams of a vast interior region.

Thus Mr. Carlton[1] found a few juvenile specimens of *Carinifex* here in May, 1869, which, like Mr. Hemphill's specimens of *P. bicarinatus*, had never before nor, so far as I can learn, have never since been reported from this place nor any point in the adjoining region. In fact, the only habitat west of the Rocky Mountains, I believe, from which this *Planorbis* is reported on good authority, is Oregon; I have specimens from Portland, collected by Mr. Hemphill.

A frequent aspect of variation in the forms falling within the first group, is that of occasional bulgings or swellings, as seen in *P. glabratus*, Say, and *P. tumens*, Cpr., suggesting periodicity in growth, or rather periods of hibernation or rest, and periods of activity, at the termination of which a mouth or expansion of the

[1] Proc. Cal. Acad., Vol. IV, p. 50.

aperture, analagous to a varix, is formed—and this repeated as the animal advances towards maturity, imparts to the shell its special feature. It will be readily seen by this, that any of these forms, scattered or distributed over a wide region in northerly or extremely elevated stations, where the season of cold reaches a maximum, against which protection must be sought by hibernation, might in some of their colonies be subjected to such conditions, and hibernation be the only protection, as in the land snails of arid regions, against seasons of excessive drought, and in other regions against the cold of winter; and bulged or varicose variation be produced in a perfectly simple way, that is, in harmony with or through the operation of a general law; and this variation be perpetuated for some time in colonies migrating from such stations to a more genial habitat; until after awhile, some of the descendants of these varicose ancestors reach places where hibernation is unnecessary by reason of a permanency or mean of conditions—temperature, supply and quality of water being in equilibrium with the usual requirements of these animals—and the ordinary smooth, evenly-grown shells again prevail through reversion to the original form.

To return to the groups, as above, the Covington Pond specimens referred to in part first, connect said groups, being what may be called "*trivolvis*, with variations"—that species or general form being, through its plasticity, the connecting link.

Still another aspect of variation is shown in Ingersoll's[1] *P. plexata*, from St. Mary's Lake, Antelope Park, Colorado. Here we have a variation not unusual in the various Planorbes, and not confined to any of the larger species, that of irregularity in winding, as if through extreme torsion the coil cockled; the whorls twisting off the line or plane of volution. *P. plexata* is an eccentrically coiled *trivolvis*, the deviation from plane of volution having somewhat of regularity of occurrence, and not improbably owing to the same cause as that to which I attribute the bulging in the *glabratus* form, namely—to recurring seasons of hibernation and activity, when the new growth hardly makes a "good joint" as a mechanic might say, with the edges of the previous mouth; the heavy water plants at the bottom of the lake described by Mr. Ingersoll, quite likely perform a part, in causing or contributing to the irregular winding of the shell at

[1] See Hayden's Reports Territorial Surveys, 1874, p. 402.

the time when a new growth commences—when the shell *which is to be* is hardly more than plastic membrane, not backed up with a stiffening of lime, as it is after the fabric is perfected.

In Mountain Lake, near San Francisco, a few miles west of said city, curiously distorted pond snails of the genus *Physa* occur, which at one time, some years ago, excited attention. The season of their growth is the summer, and its generative warmth is accompanied with the trade winds, which blow across the lake with considerable violence; the plastic shells of the Physæ are forced against plants, chips and various fragments, odds and ends afloat in or around the lake; and the outer lip thus gets dented and bent, giving a curious twist to many of the individuals. A figure (128) illustrating a distorted specimen from the foregoing locality is given by Mr. Binney in his L. and F. W. Shells of North America. However, I have no reason to believe that this deformity is transmitted, as only a small proportion of the multitude are affected.

The specimens on which Mr. Ingersoll's species is based, were found by him, as stated, in a snow-fed pond of small size, between or among high cliffs. As before implied, the vacillations in plane of coil may be owing to interruption of growth by recurring periods of hibernation, the characters in the environment, mentioned by Mr. Ingersoll, affording a reasonable solution of the phenomena. Such ponds are subject to marked climatic contingencies; and sometimes, or rather in some years, their basins are nearly or quite dry—and again, fluctuations of temperature, according to the volume of water, which is an important factor, are far more critical in small ponds than in lakes or large bodies of water, where the extremes of temperature, as well as other conditions, as quality of water, are less variable or extreme.

These two aspects of variation, bulging and irregularity in coiling are exhibited with more or less frequency in all of the larger American species, and in a greater or less degree, throughout the entire area inhabited by *Planorbis;* occurring oftener, perhaps, among colonies which inhabit elevated stations, than with those living at altitudes nearer the level of the sea. I am of the belief, too, that these aspects of variation are less frequent among colonies inhabiting southerly and semi-tropical regions.

All of the variations referred to are, when present, more conspicuous in the larger forms west of the Rocky Mountains, for the reason that some of them reach a size very much in excess of the largest individuals of the same species, from points east of said range.

The carinated and planulate forms seem to be freer from the bulging or variceal peculiarity than the others.

As to the relations of the various species to each other, or their interrelations, it is quite evident that many of them have an immediate common ancestry. *P. trivolvis* (+ *P. trivolvis* var. *fallax* + *P. lentus*) of the American species appears to be the dominant stock-form, and may be regarded as Americanized *corneus*, if a semi-political term may be used in a physico-geographical sense; its presence in the company of such forms as *Limnæa stagnalis*, *L. palustris* and others, of circumpolar distribution, indicates a geographical identity with the European species.

While the Planorbes attain their maximum of size in that part of North America west of the Rocky Mountains and north of latitude 30° N., the number of supposed species, or of forms which present characters more or less distinct, are more numerous east of said range.

There is apparently no relation between altitude of habitat and size of shell. The quantity of West-coast material accessible at this moment is too small to enable me to give a satisfactory exhibit of measurements. The following will, however, convey a fair idea of the robust proportions of the more conspicuous West-American forms, the first and second being *P. trivolvis* and the third *P. ammon*.

1. Utah Lake, U. T., elevation 4498·5 feet. Greater diameter 1·41; lesser, 1·04 inches. Long. of aperture ·71; longitudinal diameter of whorl at juncture of parietal callus ·45 inch.

2. Washoe Lake, Nevada, elevation 5006 feet. Greater diameter 1·30; lesser, 1·01 inches. Long. of aperture ·60; long. of whorl at junction of parietal callus ·47 inch.

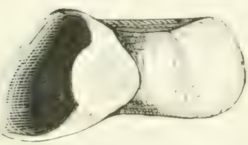
3. Salinas Valley, Cal., elevation 100— feet. Greater diameter 1·24; lesser, ·98 inch. Long. of aperture ·90; long. diameter of whorl at junction of parietal callus ·55 inch.

4. Clear Lake, Cal., elevation 1323 feet. Greater diameter 1·05; lesser, ·74 inch. Long. of aperture ·77; long. diameter at junction of parietal callus ·76 inch.

This last (4) is a typical *Traskii*. A comparison of the measurements of the aperture and of the whorl at the junction of the parietal callus in this and 3 (*P. ammon*), with similar measurements in 1 and 2 (*P. trivolvis*), will give a good idea of the relative obtuseness of their cones or tubes, as well as of the inflation or patulous aspect of the aperture, and of its effect on the physiognomy of the shell. A typical *P. corneus* (British specimens) of 1·10 inches greater diameter measures ·87 inch lesser diameter, while the longitude of aperture is ·42, and longitudinal diameter at junction of parietal callus is ·30 inch.

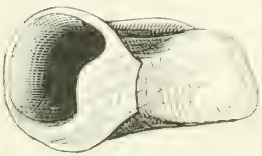
The following original figures from nature, show the Washoe Lake form as above (fig. 23); while fig. 24, from the same locality, also illustrates the distortion resulting by deviation from or eccentricity in plane of coil.

Fig. 23.



P. trivolvis. Original.

Fig. 24.



P. trivolvis. Original (distorted).

The sinistral or dextral inquiry led to the discovery that *P. bicarinatus* is sometimes right and sometimes left; this is an interesting fact, because said species exhibits certain analogies with other peculiar and characteristic forms.

The relations of the dextral *Carinifex*, whose planorboid character led Dr. Lea[1] to describe it as a *Planorbis*, are apparently closer to *P. bicarinatus* than to any other species. The exceeding variability of *Carinifex* is seen by the figures here given, which, however, do not fully represent the range of variation. (Figs. 25, 26, 27).

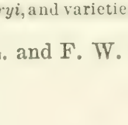
Fig. 25.

From Lea's types. Klamath and Canoe Creek specimens.

Fig. 26.

From Lea's types. Klamath and Canoe Creek specimens.

Fig. 27.



Variety from Pitt River, Cal.

Carinifex Newberryi, and varieties.

In the light of our present knowledge it should perhaps be regarded only as a coincidence that the very territory from which *P. bicarinatus* is with the two exceptions of Hemphill's Antioch, and Portland (Oregon) localities, entirely absent, is the territory inhabited by *Carinifex*, and in which it has been found, either recent or fossil. When the immense area of this territory is considered, the number of localities in which it has been detected, are few; still these few are so related the one to the

[1] Binney's L. and F. W. Shells of N. A., Part II, p. 74.

other as to indicate a wide and general distribution within its boundaries. These localities are as follows, commencing at the easternmost station :

1. Utah Territory; near Utah Lake, in Wahsatch Mountains, collected by Dr. Edward Palmer. Museum Stearns. (Semi-fossil.)

2. Nevada (Tertiaries); as *Vorticifex Tryoni*, Meek, in King's Survey.

3. California; Owen's Valley, collected living by Hemphill; "The most southern locality. The animal undistinguishable externally from that of *Planorbis ammon*." Cooper.

4. California; Klamath Lake and Canoe Creek, living; Dr. J. S. Newberry. S. I. Collection.

5. California; Pitt River, Dr. Cooper; living. S. I. Collection.

6. California; Clear Lake, living; Dr. Veatch. S. I. Collection. Cooper makes a var.? "minor" of specimens from this place.

7. California; Antioch; living. Carlton. "A few very young ones, perhaps a dwarfed southern variety like those from Clear Lake."

8. California; Livermore Valley, Alameda County; "in the hills north of Martin's, near Tassajara," Cooper, fossil; label marked "Planorbis, etc., Tertiary?" in State Geol. Survey Coll., Univ. of Cal.

The Utah specimens, though small, are mature, and include the form rounded above like Meek's Nevada species, as well as the more flattened and grooved features of the Tassajara[1] specimens, which approach in size and general characters more closely to Lea's type, fig. 25. Some of Palmer's Utah specimens are elevated, and vary in the direction of fig. 27, though not terraced or keeled as much; the lot of only a dozen specimens, exhibits a remarkable range of variation.

There are striking analogies between the shells of *Carinifex* in its varieties, and the Australasian brackish water *Amphibolæ*.

A new species has been made on one of the varieties by Mr. Smith, of the British Museum, which he named *C. Ponsonbii*;[2]

[1] Tassajara is the name of a stream which is frequently dry in the latter part of summer.

[2] Proc. Zoöl. Soc., 1875, p. 536. Also Quar. Jour. Conch., Vol. I, p. 150.

the specimens were collected by Lord Walsingham, in *California*. There are several varieties still undescribed, which challenge the attention of those who are ambitious in this direction.

Carinifex exhibits many of the variations in form of tube or cone, in cross-section, which are seen in *Planorbis*, without the bulgings of the varicose forms, and *plus* the elevation of spire which is seen especially in extreme individuals like the figure; the outline of the mouth is very much like that of *P. bicarinatus*, and in some of its varieties suggests a *P. bicarinatus*, with the umbilicus deepened by pushing up the spire from below. With the discovery of new localities, and ample material both recent and fossil, without doubt the sequence of variation will be traced, and its relation to meteorological, geological and chemical changes, within the area of its distribution partially indicated.

In this connection I would direct attention to Prof. Hyatt's interesting letter to Mr. Ingersoll, referring to Steinheim fossils, and to the *Valvatæ* of Lawlor's Lake, Nova Scotia, in Prof. F. V. Hayden's Report, 1874.

MAY 3.

The President, Dr. RUSCHENBERGER, in the chair.

Thirty-four persons present.

Dr. Geo. A. Koenig was elected a member of the Council to fill the vacancy caused by the resignation of Dr. Chapman.

MAY 10.

The President, Dr. RUSCHENBERGER, in the chair.

Twenty-eight persons present.

The deaths of Jos. S. Lovering, a member, and of Dr. James Lewis, of Mohawk, N. Y., a correspondent, were announced.

MAY 17.

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

Twenty-nine persons present.

The following papers were presented for publication:

"Quercus rubra L. var. Texana," by S. B. Buckley.

"Quercus Durandii," by S. B. Buckley.

"Rhus cotinoides," by S. B. Buckley.

MAY 24.

The President, Dr. RUSCHENBERGER, in the chair.

Twenty-nine persons present.

A paper entitled "Revision of the Palæocrinoidea, Part II, Family Sphæroidocrinidæ, including the subfamilies Platycrinidæ, Rhodocrinidæ and Actinocrinidæ," by Charles Wachsmuth and Frank Springer, was presented for publication.

The death of Thos. A. Scott, a member, was announced.

Sexual Characters in Fritillaria atropurpurea, Nuttall.—Mr. THOMAS MEEHAN noticed the occurrence of separate male and hermaphrodite flowers in *Fritillaria atropurpurea*, cases of bisexuality being rare in truly liliaceous plants. His specimens were from western Nevada, and the characters now noted were exhibited in 1880; but as the plant had only been received a short time before, the absence of female organs might be attributed to weakness, but observation this season shows it to be a normal condition.

The plant produced four spikes, flowering on the 15th of May. The spikes were 15, 14, 13, and 11 inches high, respectively, and had from twelve to fourteen narrow glaucous leaves each, and all of apparently equal strength. The tallest spike had but one perfect flower; another had the lowermost perfect, but with four others above, all purely staminate. The other two had three flowers each, all staminate. These staminate flowers had antlers as large and as polleniferous as the hermaphrodite ones, and the perianth seemed in every respect as perfect, the only difference being in the total absence of all traces of a gynœcium. It was evidently the normal condition of the species, which, by the way, seems to run closely into *Fritillaria parviflora.*

Mr. Meehan said the facts were interesting, as drawing still closer the well-known relationship of *Melanthiaceæ* and *Liliaceæ.* A tendency to diclinism had hitherto been supposed to be the special characteristic of the former order, although occasionally, as in *Asparagus*, there were indications of the same characteristics in Liliaceæ also.

May 31.

Ther President, Dr. Ruschenberger, in the chair.

Twenty-five members present.

A paper entitled "Observations on the Hippopotamus," by Henry C. Chapman, M. D., was presented for publication.

Alexander Biddle, M. D., W. Norton Whitney, M. D., and John G. Lea, M. D., were elected members.

Thomas T. Bouvé, of Boston, was elected a correspondent.

The following were ordered to be published:

LIST OF THE FISHES COLLECTED BY MR. W. J. FISHER, UPON THE COASTS OF LOWER CALIFORNIA, 1876–77, WITH DESCRIPTIONS OF NEW SPECIES.

BY W. N. LOCKINGTON.

In April, 1876, the schooner *Harvest Queen*, W. J. Fisher in command, left San Francisco on a collecting expedition to Lower California. The intention was to work down the western coast. and then along the eastern to the head of the Gulf of California; and the object was to collect seals, birds, fishes, mollusks, crustacea, radiates, etc., for sale or exchange.

Financially the expedition proved a signal failure; few skins or shells of value were procured, and most of the former were spoiled before reaching San Francisco; but the scientific results were far from insignificant. Chiefly in consequence of the free use of the dredge in depths under fifteen fathoms, large numbers of small crustacea, many of them new or little known, were procured, also a few rare and three or four new mollusks, and some interesting fishes from the Gulf, the latter mingled with the crustacea and other objects dredged at moderate depths.

Besides these fishes, which will be described in the following pages, several better known species were taken in considerable quantity at Magdalena Bay, upon the Pacific coast of the peninsula.

As these fishes have already formed the subject of two short papers in the Proceedings of the California Academy of Sciences. and one or two were by error described as new, they will be included in the list herein given, with references to my previous papers.

The reptiles obtained were catalogued in the *American Naturalist*, April, 1880, p. 295. Nothing new was found among birds, and the only mammals taken were a fine female Elephant seal (*Morunga proboscidea*), killed at Ascencion Island, on the western coast of the peninsula; several sea-lions (*Eumetopias stelleri*); and the skull of a species of *Orca*.

Diodon maculatus Lac.	Gulf of Cal.
Tetrodon politus Gill.	Magdalena Bay.
Tetrodon punctatissimus? Gunther.	Gulf of Cal.
Antennarius leopardinus Gnthr.	Gulf of Cal.
Hypleurochilus gentilis (Grd.) Gill.	La Paz, Las Animas Bay, Gulf of Cal.
Pholidichthys anguilliformis Locktn.	Gulf of Cal.
Cremnobates altivelis Locktn.	Gulf of Cal.

Clinus phillippi Steind.	Gulf of Cal.
Apodichthys univittatus Locktn.	Gulf of Cal.
Microdesmus dipus Gnthr.	La Paz.
Gobiesox rhessodon Rosa Smith.	Gulf of Cal.
Gillichthys mirabilis Cpr.	Magdalena Bay.
Pimelometopon pulcher (Ayres) Gill.	Magdalena Bay.
Semicossyphus pulcher Locktn. Proc. Cal. Ac. Sci., 1876. p. 87.	
Cynoscion parvipinnis (Ayres) J. & G.	Magdalena Bay.
Menticirrus undulatus (Grd.) Gill.	Magdalena Bay.
Girella nigricans (Ayres) Gill.	Magdalena Bay.
Sparus brachysomus Locktn. Proc. U. S. National Museum, 1880, 283.	Magdalena Bay.
Pristipoma melanopterum Cuv.	Gulf of Cal.
Serranus nebulifer (Grd.) Steind.	Magdalena Bay.
Paralabrax nebulifer Locktn. Proc. Cal. Ac. Sci., 1876, 86.	
Serranus clathratus (Grd.) Steind.	Magdalena Bay.
Serranus maculofasciatus Steind.	Angeles Bay, Gulf of Cal.
Serranus gigas (Ayres) J. & G.	Magdalena Bay.
Centropomus undecimalis Bloch.	Ascencion Island, I. C.
Centropomus viridis Locktn. Proc. Cal. Ac. Sci., 1876, 109.	
Selene vomer (L.) Lütken.	Magdalena Bay.
Argyreiosus pacificus Locktn. Proc. Cal. Ac. Sci., 1876, 84.	
Trachynotus carolinus (L.) Gthr., Cuv. and Val.	Magdalena Bay.
Trachynotus ovatus L. Lac.	Magdalena Bay.
Trachynotus ovatus Locktn. Proc. Cal. Ac. Sci., 1876, 86.	
Trachurus saurus Raf.	Magdalena Bay.
Sphyræna argentea Grd.	Magdalena Bay.
Sphyræna argentea Locktn. Proc. Cal. Ac. Sci., 1876, 88.	
Atherinopsis californiensis (Grd.) Gill.	Magdalena Bay.
Myxus harengus Günther.	Las Animas Bay, Gulf of Cal.
Albula vulpes (L.) Goode.	
Albula conorhynchus Locktn., loc. cit. 83.	
Heterodontus francisi (Grd.) J. & G.	Magdalena Bay.
Cestracion francisi Locktn., loc. cit. 85.	
Mustelus hinnulus (Blainville) J. & G.	Magdalena Bay.
Mustelus californicus Locktn., l c. 87.	
Triacis semifasciatus Grd.	Magdalena Bay.
Triacis semifasciata Locktn., l. c. 87.	
Sphyrna zygæna (L.) Raf.	South of Cape St. Lucas.
Branchiostoma lanceolatum (Pallas) Gray.	Angeles Bay, Gulf of Cal.

Tetrodon punctatissimus ? Günther.

Cat. Fish. Brit. Mus., VIII, p. 302, 1870.

D. 9. A. 8. P. 17, C. 2–7. 2.

Body compressed, short; the dorsal profile from tip of snout to eye slightly concave, thence to origin of dorsal gently convex, thence descending moderately, somewhat concave from posterior margin of dorsal to caudal. Abdominal outline slightly concave in front of eye, thence boldly convex to origin of anal, thence corresponding to dorsal outline.

Head $3\frac{1}{4}$ times, greatest depth $2\frac{7}{12}$ in total length, the greatest depth above the centre of the pectoral base; greatest breadth (at gill-openings) less than the length of the head, and $3\frac{3}{14}$ in total length. Snout $1\frac{1}{2}$, eye 4 times in length of head, width of interorbital area about $1\frac{1}{2}$ times the diameter of the eye. Depth of caudal peduncle nearly $2\frac{2}{5}$ times in greatest depth.

The back behind the head forms a keel.

Snout truncate at the tip, concave above and below, higher than wide; nostrils inconspicuous, a single opening on each side on a minute papilla; mouth small; eyes round, lateral, entirely in the posterior half of the head, the upper orbital margins slightly raised, so that the interorbital area is somewhat concave.

Teeth smooth, sharp-edged, line of junction distinct.

Gill-opening small, almost perpendicular, distant from the eye about an eye-diameter.

Dorsal fin arising at a distance from the gill-opening equal to the length of the head, with nine articulated rays, the first simple, the others once or twice divided. Base of dorsal less than one-third of the length of the snout, height rather more than one-third of length of head.

Anal slightly posterior to dorsal, with eight rays, the first vertical with the posterior margin of the dorsal; height and length of base equal to dorsal.

Caudal very slightly convex on posterior margin when opened out, all the principal rays divided, some of the central ones four times; length of fin about $5\frac{1}{2}$ times in total length.

Pectoral base oblique, its upper axil near the upper end of the gill-slit, thence backwards and downwards at an angle of about 45°. Pectoral fin fan-shaped, rather short (the tips of the rays in the specimen are slightly injured), the uppermost ray short, simple; the next (longest) simple; the others once or twice divided, slightly diminishing in length downwards.

Top and sides of head, breast, and abdomen to anal fin with prickly papillæ, most numerous upon the breast and under side of the snout. Rest of body naked.

Color purple, thickly sown with subcircular or subelliptic lighter spots; these become larger upon the flanks, until the ground color fades out, leaving the abdomen, breast, and under side of snout dirty yellow. Spots of sides and upper portion light purplish. Behind the anal fin the spots can be traced all round the body. No color bands or spots are now evident upon the fins. Specimen in alcohol since 1876.

Angeles Bay; Gulf of California.

From *T. furthii*, Steind. (Sitz. Akad. Wiss. Wien, 1876. Icthyol. Beitrage, V, p. 22) this species may readily be distinguished by the great length of the snout, two-thirds of that of the head, while in the *T. furthii* it is only $\frac{2}{5}$–$\frac{4}{11}$ of the head. Other differences are the absence of a skin-fold on the tail, the inconspicuous nasal papilla, and the smaller development of the spinules upon the back. The coloration is also different. *T. furthii* has indistinct transverse bands, and a dark band on the pectoral base

The short description given by Dr. Günther of *T. punctatissimus* agrees, so far as it goes, with the present species. His specimens were from Panama. Should the present species prove distinct, I propose for it the name of *oxyrhynchus*. Length of specimen, 3·06 inches.

Antennarius leopardinus, Gnthr.?

Trans. Zool. Soc., 1864, 15 *i*.
Fishes Cent. Amer. in Trans. Zool. Soc., Vol. VI, 434, Pl. VII.

This species was originally described from Panama.

Two examples were obtained by Mr. Fisher by dredging at a depth of 22 fathoms, among beds of pearl oyster (*Margaritophora*) off San José Island, Amortiguado Bay, Gulf of California. The spots have in most cases faded into light yellow, leaving the bright vermilion of all the rest of the body and fins unchanged. A black spot persists upon the ninth ray of the dorsal, and there are traces of black upon the sides and head. The under side of the abdomen, in advance of the anal, is light yellowish with dark spots. Total length 1·95 inches; width from tip to tip of pectorals 1·70 in.

Cremnobates altivelis, nov. sp.

D. 4-25, A. 21, P. 13, C. 13, V. 2, L. lat. 37.

Body compressed, greatest depth a little behind pectoral axil, greatest thickness at gill-covers, dorsal and abdominal profiles of similar curvature, decreasing regularly to the caudal fin. Profile of occiput and superorbital regions convex; snout somewhat produced, its upper outline slightly concave.

Head one-fourth of total length, greatest depth a little less than length of head, caudal peduncle about one-fourth of the greatest depth.

Eye round, lateral, with a slight direction upwards, its diameter less than the length of the snout. Interorbital area nearly equal in width to the diameter of the eye, concave transversely, upper orbital borders slightly raised.

A short nasal tentacle slightly anterior to the front margin of the eye. A large fimbriated tentacle on each side of the first dorsal ray.

Cleft of mouth oblique, the lower jaw the longer; the posterior convex extremity of the club-shaped maxillary about vertical with the centre of the pupil.

Teeth of the outer row regular, sharp, incurved, the largest in front, gradually decreasing along the lateral portions of the jaws, and not extending much past the middle of their length. A narrow band of small teeth in the rear of the outer row. Vomerine teeth.

Branchiostegals six. Gill-openings continuous, membranes not attached to the isthmus.

Distance from the first ray of the dorsal to the posterior margin of the eye equal to the length of the snout. First two rays of the dorsal much developed, the first slightly the longer, and nearly equal in height to the distance of its base from the tip of the upper jaw; third ray about half the length of the first; fourth very short; succeeding rays to the twenty-sixth longer than the third, the three last somewhat decreasing.

Anal commencing under the eleventh dorsal ray; coterminous with, and equal in height to the dorsal.

Caudal with thirteen simple jointed rays, the longest in the centre, posterior margin convex.

Pectorals narrow, lanceolate, the fifth and sixth rays longest, and four-fifths the length of the head.

Ventrals inserted in advance of the pectorals.

Lateral line with thirty-seven simple pores, parallel with dorsal outline to opposite the origin of the anal, where it is deflected almost perpendicularly downward to the middle of the side of the body, along which it continues to its termination.

Scales rather large, about ten in a transverse row in the central part of the body, their posterior margin membranous. No scales on fins.

A line of pores around the margin of the orbit, another along the posterior margin of the pre-operculum, connected to each other and to the lateral line by a line from the centre of the hinder border of the eye.

Color (in alcohol) bright pink above, becoming dusky below, under side of head light olivaceous, lower lip blackish. Dorsal pink, dusky on its margin, a black spot on the fourth ray, and another on its hinder part upon the 24–25th rays, the latter spot extending on to the body. Membrane of anal black. Occipital tentacles black.

Total length 1·9 inch. A single specimen from La Paz, dredged at a depth of 22 fathoms.

This species may be distinguished from *C. monophthalmus*, Gnthr., by the much greater development of the first two dorsal rays; by the longer and concave snout, and by the coloration; and from *C. marmoratus*, Steind. (Sitz. Akad. Wiss., Wien, 1876, 174), by its more elongate form, shorter cleft of mouth, and longer first dorsal ray. In *C. marmoratus* the second dorsal ray is longest.

Pholidichthys anguilliformis nov. sp.

Body exceedingly elongate, much compressed, naked, upper profile of head forming a continuous convex curve to the tip of the snout, which is about equal in length to the eye,

Head six and two-fifths, greatest depth sixteen times in total length.

Eye lateral, round; interorbital space about two-thirds of the diameter of the eye, convex transversely.

Posterior extremity of maxillary vertical with the hinder margin of the eye. Tip of snout a little below the level from the centre of the eye; mouth moderately oblique, lower jaw slightly the longer. Teeth of lower jaw in a close-set row, the largest in front, diminishing along the sides. Teeth of upper jaw similar but smaller. Palate smooth.

Vertical fins continuous but distinct, dorsal entirely spinous, anal commencing a little behind the middle of the entire length of the fish. Ventrals two-rayed, very slightly in advance of the pectorals, which are about equal in length to the distance of their base from the eye.

Color (in spirits) dark blackish brown, mingled with white upon top, sides and lower parts of head. Interorbital area and top of snout white.

A single specimen dredged off San José Island, Amortiguado Bay, Gulf of California. Total length 1·60 in. Head 0·25 in.

The example is broken across, the branchiostegals are defective, the caudal fin broken, and some fin-rays missing, so that the fin formula cannot be accurately given. The dorsal fin has above sixty rays. The body is much more slender than that of *P. leucotænia* Bleeker, and there is no trace of the longitudinal bluish white band of that species.

Apodichthys univittatus, nov. sp.

D. circa 95. A. ca. 1–40.

Body elongate, much compressed, band-like, preserving almost the same depth to about the posterior fifth of the body, thence tapering more rapidly to the caudal fin.

Head seven, depth nearly ten times in the total length; depth of caudal peduncle about one-half of that of body.

Snout obtuse, about two-thirds as long as the diameter of the eye, the upper profile of the head a continuous curve from snout to occiput. Interorbital area highly convex transversely, about equal in width to half the diameter of the eye. Eye entirely lateral, round, contained entirely in the anterior half of the head; iris golden.

Mouth small, the posterior extremity of the maxillary reaching to the anterior margin of the eye. Teeth small.

Branchiostegals five.

Dorsal fin continuous with but distinct from the anal, arising vertically above the tip of the operculum, and composed of spines only. Anal preceded by a long, sharp, slender spine of V-shaped transverse section, the hollow side anterior, the length of the spine equal to about half the depth of the fish. Distance from anal spine to tip of operculum a little more than to tip of caudal. Caudal with numerous accessory rays, so that its sides are almost straight, posterior margin broken in specimen, all the rays simple.

General color (in spirits) light reddish, the vertical fins rather bright, and the top of the head reddish brown. Tip of snout brown. A silvery band (possibly bluish in life) from the tip of the snout, across the lower part of the eye, cheeks and opercles, terminating at about the middle of the length of the operculum; this band bordered above by a narrower brown band.

A single specimen. Lower California, probably from the Gulf.

Length 1·88 in. Length of head 0·27 in. Greatest depth 0·19 in. Snout to anal spine 1·10 in.

The peculiar vitta upon each side of the head at once distinguishes this species from the two other described forms.

Microdesmus dipus, Günther.

Trans. Zool. Soc., 1864, p. 26.

A single specimen of this rare species was obtained at La Paz, near low-tide level.

Hemiramphus unifasciatus, Ranzani.

D. 14. A. 16.

With some hesitation I refer two specimens taken in Las Animas Bay, Gulf of California, to this species rather than to *H. rosæ* J. & G. The proportion of the jaw to the length of the body, as well as the number of dorsal rays, agree with *unifasciatus*.

On each side of the median line of the back a row of elongated spots of dark greenish tint, one on each scale, forms a narrow band, and between these bands is a median series of dark spots formed by thickly aggregated black dots. Between the narrow dark-green band and the lateral band similar close aggregations of dark spots form a series of spots, elongated transversely. The silvery lateral band is bordered above by a narrower greenish stripe.

QUERCUS DURANDII, Buckley.

BY S. B. BUCKLEY, PH. D.

I had spent several years in studying the trees of the United States in their native places, when, in the month of September, 1859, as I was walking from Camden to Allenton, in Wilcox County, Alabama, I saw an oak, different from any I had ever seen. It was in a dark, rich, limestone soil, on the right hand side of the road, about three miles from Allenton. The bark of its trunk and limbs was scaly; leaves lanceolate, entire or slightly lobed or repand; acorns small, ovate, obtuse; cup very shallow, about one-eighth as long as the acorn. The tree was 1 foot in diameter and about 25 feet high, and the only one there. I showed specimens of it to the gentleman with whom I staid all night. He told me it was a rare oak in that country, growing near the banks of streams and swamps, that its wood was close grained and very tough, making excellent screws for cotton-gins, firm and durable wagon-hubs, etc., also splints for making baskets for the cotton-field, when the cotton is being gathered; that it was seldom more than 3 feet in diameter and 60 feet high.

This oak was the *Quercus Durandii*, a new species which I described in the Proceedings of the Academy of Natural Sciences in 1861. It is named after the late Elias Durand, who was for many years chairman of the Committee on Botany of the Academy.

In October, 1859, I saw it again at Shreveport, in Louisiana, on the bluffs of the Red River, in the upper part of the town. There its acorns were larger and longer than in Alabama. Here there were several trees of it, one of which was 4 feet 2 inches in diameter at 3 feet from the ground. These were low, spreading trees, growing in an open space.

In Southern Texas, on the Colorado River, in Fort Bend and other counties, it is a large tree, often 2 to 3 feet in diameter and 60 to 70 feet high.

In 1874, in Milam County, Texas, I saw many large, tall trees of this oak in the bottom lands of Little River, a tributary of the Brazos. There it is sometimes called the "bastard white oak" because the bark of its trunk resembles that of the scaly forms of white oak.

Durand's oak grows on the banks of Shoal Creek, one-half to two miles above Austin, also near Mount Bond, about three miles from the city.

In 1872. Mr. Elihu Hall, of Athens, Illinois, was at Austin collecting plants. I showed him Durand's oak, which is referred to as a good species in his "Plantæ Texanæ," published in 1873.

Mr. Charles Mohr, Botanist for the Tenth Census Department of Forestry in the Gulf States, was here, last November, and obtained sections of the wood, and specimens of the leaves and acorns of *Q. Durandii* for the Department of Forestry under the direction of Prof. Chas. S. Sargent, for the United States Government.

Lastly, Prof. Sargent came here three weeks ago, and together we visited the banks of Shoal Creek, where there were several small trees of this oak, the largest being nearly two feet in diameter. He was satisfied it was a good species.

I have been thus particular in giving the history of this oak to the present time, because all who have seen the living trees regard it as a good species, which is not the case with some who have not. In Dr. Engelmann's "Oaks of the United States," published at p. 392, "Transactions of St. Louis Academy," speaking of the forms of *Quercus undulata*, he says: "The var. *Gambelii* runs into variety *Gunnisonii* on one side, and on the other into variety *breviloba* (*Q. obtusiloba* var. *brevifolia*, Torrey, Bot. Bound. and probably *Q. Durandii* and *San sabea*, Buckley)." Dr. E. thus regards it as probably identical with a marked variety of *Quercus undulata*, an opinion which a better acquaintance with living trees would surely lead him to revise. Without extensive field experience it is almost impossible to decide on the limits of species in oaks, as well as in grapes and other difficult genera.

QUERCUS RUBRA, L., var. TEXANA.

BY S. B. BUCKLEY, PH. D.

Quercus rubra is distributed over a larger area than any other oak in North America. According to Dr. Richardson, it is the most northern of oaks; he found it on the Saskatchewan and the rocks of Lake Namakeen, in British America. It is in Nova Scotia, and southward through the United States to El Paso County, in the northwest part of Texas. The writer saw it in the coves of the mountains near Fort Davis, in the summer of 1875, at elevations of from 5000 to 6000 feet above the sea. The differences of soil and climate in which it grows cause it to vary so much in size, wood, leaves and acorns that the two extremes of difference considered apart from intermediate forms, would make two very good species. The Texas form, growing on limestone hills and coves and little valleys in the vicinity of Austin and westward, has been called *Q. palustris* by Torrey and Gray, in the Report of the Botany of the Pacific Railroad, Report of Capt. John Pope, p. 173; also in other reports of theirs on the Botany of Texas. It has also been called *Q. palustris* by Dr. Engelmann, when he named the plants collected by Elihu Hall in Texas in 1872. (See Hall's Plantæ Texanæ, p. 21, Nos. 604 and 605.) Hall obtained specimens of it here in June, and I sent him acorns of it in the fall, and he informed me that Dr. Engelmann regarded it as *Q. palustris*. I have never seen the true *Q. palustris* farther south than the vicinity of Washington. Prof. Sargent and Mr. Mohr both inform me that they do not know of its being in the Southern States, and so says Michaux, in his "North American Sylva." It is not in Chapman's "Flora of the Southern States." These things in part, joined with the characteristics of the oak as growing here, caused me to describe it as a new species. (See *Q. Texana*, in Young's "Flora of Texas," p. 507.) If not a good species, it is a well-marked variety of *Q. rubra*. Let it then be called *Q. rubra* var. *Texana*.

Last December, Mr. Charles Mohr and myself got sections of its wood, etc., which he sent North for the Department of Forestry of the Government Census Bureau. We then thought it to be a good species. A few days after, on the bottom lands of Walnut Creek, about six miles below Austin, we found the acorns and leaves of *Q. rubra* and also those of *Q. Texana* on and beneath the same tree; and also many intermediate forms. It was not only one tree, but many, which showed these differences.

Quercus rubra attains a large size in Eastern Texas; but west of the Trinity River it is seldom more than two feet in diameter. Its wood here is harder, firmer and better than that of the Northern red oak.

About two miles from Raleigh, North Carolina, on the Fayetteville road, in 1858, I measured a *Quercus rubra* which was 20 feet 8 inches in circumference at three feet from the ground. It was a low tree, with a remarkable spread of very large limbs, whose length on the south side was 72 feet and 71 feet. The longest on the north side was 66 feet. Near the base of its limbs at ten feet from the ground it was 27 feet in circumference. The circumference of the largest limb, at two feet from the trunk, was 9 feet 7 inches. Another limb was 7 feet 7 inches in circumference.

In September, 1859, I measured a *Q. rubra* in Wilcox County, Alabama, which was 24 feet 7 inches in circumference at three feet from the ground. It was a tall, well-developed, healthy tree. Another one not far distant was 18 feet 2 inches in circumference at three feet. In the town of Romulus, Seneca County, N. Y., I measured another, in 1865, which was 17 feet 2 inches in in circumfererence at three feet high. Most of the large red oaks of the Northern States have been cut down to make staves for flour barrels, etc.

RHUS COTINOIDES, Nutt.

BY S. B. BUCKLEY, PH. D.

This sumac was discovered by Nuttall, in the autumn of 1819, on the Grand, a large tributary of the Arkansas River, and within the limits of the present Indian Territory. It was on high broken rocky banks at a place then known as the "Eagle's Nest." It grew there only as a shrub, and was not again found by Nuttall. He gives a description of it, with a plate, at p. 71, vol. ii, of his addition to Michaux's "North American Sylva." He there calls it *Cotinus Americana*. Nuttall's specimens were in fruit only.

I found this same *Rhus* on the 6th of April, 1842, in descending from the table lands of North Alabama to the Tennessee River, on the Huntsville road. Here were large shrubs of it growing in clumps from 8 to 10 feet high. They were in fruit and strikingly beautiful. I collected many specimens of them

Soon after, I came to the river and staid all night at a Mr. Chun's. Next morning, I crossed at "Ditto's Landing," and went on the Madison turnpike to Huntsville, nine miles distant. After dinner, I went twelve miles from Huntsville to a Mr. Bailee's, in Madison County, Alabama, on the road to Winchester, Tennessee, via Salem. From Mr. Bailee's house I walked up to the top of a low mountain to get specimens. Near its base and on its sides, in wooded ravines, I saw several trees of *R. cotinoides* in flower, and with larger leaves than those seen before south of the Tennessee River. These trees were about 38 feet high and from 8 to 12 inches in diameter, with trunks and larger limbs coated with light gray and deeply-furrowed bark resembling the bark of the larger trees of the common sassafras (*S. officinale*).

I climbed a tree to obtain specimens. The branches were brittle, and when broken emitted a yellowish sap, the odor of which was highly aromatic; to me very unpleasant.

This sumac, when in fruit, resembles the common Venetian sumac (*Rhus cotinus*), as is indicated by its specific name. It must be very local in its *habitats*, and also very rare. I think it has not been found elsewhere than in the Indian Territory and North Alabama.

In Chapman's "Flora of the Southern States," p. 70, it is stated that I found it in the interior of Alabama. Dr. Chapman was led into this error from our correspondence and exchange of plants when I was living in Wilcox County, Alabama.

JUNE 7.

The President, Dr. RUSCHENBERGER, in the chair.

Eighteen persons present.

The following was ordered to be printed:

OBSERVATIONS UPON THE HIPPOPOTAMUS.

BY HENRY C. CHAPMAN, M. D.

On several different occasions, before and during the reign of Augustus and of his successors, Antoninus, Commodus, Heleogabalus, etc., the Hippopotamus was exhibited at Rome. Naturally one would suppose, therefore, that among the writers of those times a truthful description of this interesting animal would be found. Pliny's [1] account, however, is only a restatement of the imperfect and erroneous descriptions of Herodotus and Aristotle, with some mistakes of his own added, while those of later Latin writers like Tatius, though better than Pliny's, are still obscure and contain errors. Indeed, the Hippopotamus, as described by Herodotus [2] and Aristotle,[3] is so unlike the animal known at the present day, that either these usually most accurate and trustworthy observers could never have seen the Hippopotamus or else they must have described some other animal under that name. About the middle of the sixteenth century it is said that Belon saw the living Hippopotamus at Constantinople, but even so late as the time of Cuvier [4] the living animal had not been seen in Western Europe. The London Zoological Garden, I believe, has the credit of having been the first in modern times (during 1850) to exhibit the living Hippopotamus.

So far as I know, the first dissection of this animal was made in 1764, by Daubenton.[5] The specimen, however, being a female

[1] De animalibus, Lib. viii, cap. xxxix; Lib. ix, cap. xiv.

[2] Historia, Lib. ii, cap. lxxi.

[3] Historia Animalium, Lib. ii, cap. iv.

[4] Ossemens Fossiles, Tome deuxieme, p. 383.

[5] Histoire naturelle, &c., avec la description du Cabinet du Roi. Tome douzieme, 1764, p. 50. Supplement to Buffon.

fœtus, it was questionable how far the description would apply to the adult animal. Nothing further was added to the above account until, in 1844, Vrolik[1] described the stomach of a half-grown individual from drawings sent from the Cape of Good Hope. A few years afterwards Peters,[2] in his Travels, gives a short but valuable account of the appearance that the viscera presented in the adult animal. It will be seen, therefore, that the knowledge of the soft parts of the Hippopotamus was very limited up to quite a recent period. During 1867 there appeared the elaborate monograph of Gratiolet[3] on the anatomy of this animal, and the important observations of Crisp.[4] Gratiolet's description was derived from his dissection of the two young animals, male and female, that were born and had died in the Jardin des Plantes. Science is indebted to Dr. Alix for the publication of this important work, Gratiolet dying before its completion. This distinguished anatomist had, however, before his death, communicated to the Académie des Sciences,[5] an abstract of his researches. A third young Hippopotamus having died in Paris during the preparation of the work just referred to, Dr Alix had a further opportunity of supplementing and confirming Gratiolet's views. Dr. Crisp's specimen was a male and about fourteen months old; it was burnt to death in the fire that destroyed the Crystal Palace in London, and was the first Hippopotamus dissected in England. Dr. Crisp[6] refers to Gratiolet's abstract in Annales des Sciences Naturelles for 1860, but does not mention that in Comptes Rendus for 1860. His observations were, therefore, uninfluenced by those of Gratiolet. In 1872, Mr. J. W. Clark[7] published the "Notes on the Visceral Anatomy of the Hippopotamus" that died in the London Garden. This animal was a female, and only a few days old.

It is well known that in addition to the ordinary Hippopotamus, there is a rarer species from the Western Coast of Africa, first

[1] Amsterdam Verhandelingen, x, 1844, p. 240; Recherches sur la Babyrussa.

[2] Reise nach Mosambique, 1852, i, p. 180.

[3] Recherches sur l'anatomie de l'Hippopotame. Paris, 1867.

[4] On some points connected with the anatomy of the Hippopotamus. Proc. of Lond. Zool. Soc., 1867, p. 601 and 689.

[5] Comptes Rendus, 1860, pp. 524, 595.

[6] Op. cit., p. 601.

[7] Proc. Zool. Soc., London, 1872, p. 185.

made known by Morton,[1] and called by him *Hippopotamus Liberiensis*. Its osteology was afterwards fully described by Prof. Leidy,[2] who showed that this species differed so much from the ordinary one that a distinct name, *Chœropsis*, was given to it, as indicating that the supposed new species was really a new genus. Prof. Leidy's views have since been thoroughly corroborated by other anatomists, particularly by Milne Edwards,[3] in his recent beautiful monograph on this animal. The only living example of the *Chœropsis Liberiensis* ever seen outside of Africa was the female specimen only three or four months old that died a few minutes after arriving at the Zoological Gardens in Dublin in 1874, and that formed the subject of a paper by Mr. Alex. Macalester.[4] Since then, within a year, the late lamented Dr. A. H. Garrod[5] communicated to the Zoological Society of London the results of his dissection of the adult male Hippopotamus that had lived twenty-eight years in their admirably conducted Garden. It will be observed from this resumé of the literature of the subject that, with one or two exceptions, the Hippopotami that have been dissected were young animals; some not more than a few days or weeks, others about a year old, and that with the exception of the *Chœropsis* examined at Dublin, they were of the ordinary kind, or the *Hippopotamus amphibius*.

While the general results of these various observations are confirmatory of each other, nevertheless, on account of the difference in the age and sex of the individuals dissected, it is still important that whenever the opportunity presents itself of examining a full or half-grown Hippopotamus the results of such dissection should be compared with those already made for the sake of confirming, supplementing, or further illustrating them. It is with this object that I bring before the Academy the results of my examinations of the female Hippopotamus which recently died in the menagerie of Mr. Adam Forepaugh, to whom I am indebted for the opportunity of dissecting it; and of the male specimen that died in New

[1] Proc. Acad. Nat. Sciences, vol. ii, p. 14; Journal, vol. i, 1849, p. 231.

[2] Journal Acad. Nat. Sci, vol. ii, 1852.

[3] Recherches sur les mammiferes.

[4] Proc. of Royal Irish Academy, 1874. The anatomy of Chœropsis Liberiensis.

[5] Trans. of Zoo. Soc. of London, 1880. On the Brain and other parts of the Hippopotamus.

York on its way to the Zoological Garden of Philadelphia. I take the occasion also of thanking Mr. Arthur E. Brown, Superintendent of the Zoological Garden where the dissections were made, for materially assisting me in the investigation.

Both the animals were examples of the ordinary species, the *Hippopotamus amphibius*, and measured about 5 feet 6 inches in length. The female was both the taller and heavier of the two. Her height at the shoulder being 28 inches and weight 550 pounds. She was probably older than the male. The condition of the skin in the female suggested the idea that it had not been sufficiently bathed during the past winter. It is well known that the health of the skin, and of the animal generally, depends upon the free use of water, either in the form of a bath, or where that is not practicable, by constant sponging, etc. With the exception of some slight inflammation of the fourth stomach and an apparent hypertrophy of the left ventricle of the heart, the organs were healthy. The male animal died from an inflammation of the stomach and intestines, the epithelium and submucous tissue in parts of the stomach being stripped off, while portions of the intestine were gangrenous. The immediate cause of death was a large well-organized clot in the heart. As the myology of *Hippopotamus* and of *Chœropsis* have been described and figured by Gratiolet[1] and Macalester[2] respectively, I will not dwell upon this part of the subject, but pass to the consideration of the internal organs.

Alimentary System, etc.—The tongue of the Hippopotamus (Pl. XI, fig. 1) is a long, flattened organ expanded and rounded off at the top rather than tapered. It measured 14 inches in length, in breadth 3½ inches at the middle and 5 inches at the top. At the back of the tongue where one finds the circumvallate papillæ in man, in place of these are seen what might be called elongated, thorny papillæ. They do not correspond to either the human filiform or fungiform papillæ. The latter were well developed. I did not notice anything peculiar about the submaxillary gland, the sublingual however was absent;[1] the parotids were present, but not very well developed, as Gratiolet states was the case in the animals examined by him. The small size of the parotids in the Hippopotamus may be due to the habit of passing so much time in the water; the necessity of the secretion not being felt,

[1] Op. cit., Planches IV to VIII. [2] Op. cit., pages 496, 500.

[3] Op. cit., p. 384.

as is the case in fishes. According to Gratiolet,[1] it is doubtful if they were present in the very young animal.

What at once struck me, on exposing the larynx, etc., was the space (Pl. XI, fig. 1) intervening between it and the tongue, and the large size of the back of the tongue as compared with the epiglottis. Through the flexibility of this space the larynx when elevated can be thrust up into the posterior nares; this space, together with the tongue, effectually cutting off the cavity of the mouth. This can be well seen in the living animal. It is possible that this disposition of the parts may be of advantage to the Hippopotamus when sunk in the water. Under such circumstances, the nose only appearing, the air can pass into the external nares and so back directly into the larynx. Further, as the external nares are extremely flexible and close very tightly, it may be that the animal before sinking under the water can take in a considerable quantity of air into the nose and retain it there until needed, when it is then drawn into the larynx. On looking over the literature of the anatomy of the Hippopotamus, I find that Gratiolet[2] and Clark[3] are the only ones who dwell particularly upon this part of its economy. Clark gives figures of the spaces I have referred to, and points out what appears to be the probable function of the parts. The larynx and its muscles have been well described by Gratiolet,[4] Crisp[5] and Clark.[6] It would be superfluous therefore for me to dwell upon them. I will, however, call attention in this connection to the fact of the epiglottis (Plate XI, figs. 1 and 2 *e*) being small as compared with the larynx (Plate XI, fig. 2), the former measuring $2\frac{1}{2}$ inches in length, and 2 inches wide, the latter being $6\frac{1}{2}$ inches long and $6\frac{1}{2}$ in circumference, and that the nares, epiglottis, etc., of the Hippopotamus reminded me rather of those of the Manatee than of those of the Cetacea. The vocal cords were situated obliquely, the anterior ends being lowermost; they measure 2 inches in length and $\frac{1}{2}$ inch in depth. There was nothing peculiar about the lungs; they were not divided into lobes or subdivided into lobules recognizable by the naked eye, as described by Gratiolet.[7]

The stomach in the Hippopotamus is subdivided into four distinct

[1] Op. cit., p. 384.
[2] Op. cit., p. 375.
[3] Op. cit., p. 188.
[4] Op. cit., p. 305.
[5] Op. cit., p. 608.
[6] Compare Gratiolet, op. cit., p. 368.
[7] Op. cit., p. 374.

compartments, *b*, *c*, *d* and *e* (Plate XII); the first, *b*, however, not being so apparent externally as the other three (shown in Plate XI, fig. 3). The œsophagus, *a* (Plate XII), opens freely into the compartment *b*, which is situated posteriorly, and which might be easily overlooked unless opened. I propose calling this compartment the first stomach, as the food can pass from the œsophagus into it without necessarily passing into either of the other two stomachs, *c* and *d*, whereas the food must pass through a small part at least of *b* in order to get into *c* or *d*. This is due to a peculiar disposition at the entrance of the stomachs *c* and *d* (Plate XIII). At this point the lining membrane is raised up into two valvular folds, *g* and *h* (Pl. XIII), of which the former is the best developed. The fold *g* almost divides the second stomach into two parts. These folds are 10 and 4 inches in length respectively, and about the $\frac{1}{8}$ of an inch in breadth, and contain muscular fibres. When these folds are approximated the œsophagus, *a*, and first stomach, *b*, are completely shut off from *c* and *d*. When, however, the valvular folds are separated, then the food can pass from the œsophagus, *a*, or from stomach, *b*, over the edges of the folds, *g* and *h*, into either the stomachs, *c* or *d*. As the compartment *d* passes into *e*, which is continuous with the intestine, *f*, it appears to me that the two compartments may be appropriately called the third and fourth stomachs, in which case *c* would be the second one.

From a simple inspection of the stomachs of the Hippopotamus, one would be disposed to conclude that the animal was a ruminant. As the act of rumination, however, has never been observed in the Hippopotamus, either in captivity or in the wild state, so far as is known, the inference must be that the food passes either directly from the œsophagus into the second or third stomachs, as is probably the case with liquids, or into the first stomach, and then indirectly into the second or third, when more solid articles are introduced.

The four stomachs differ considerably in size, the third, *d*, being by far the largest; it measured from right to left 27 inches, as seen in situ in Pl. XII; it overlaps, when viewed from the anterior surface, the second and fourth stomachs, *c* and *e*, and, to a great extent conceals the first stomach, *b*, especially when the latter is empty. The first stomach, *b*, measured 15 inches from right to left, and is so closely united to the third one, *d*, that externally the two look like one when empty, and their distinctness does not become evident until they are forcibly separated and opened. The first stomach is also connected laterally with the third and fourth ones. These are about the same length, 7 inches, measured from right to left. The third stomach communicated with the fourth by a narrow aperture, which measured 3 inches in diameter. In situ the second stomach was situated in the left hypochondriac region; the fourth stomach on the right; the third stomach lying between the third and fourth and in the same plane, and in front and partially concealing the first stomach.

The difference in the four stomachs of the Hippopotamus viewed internally are even more marked than those observed externally. The smooth mucous membrane of the œsophagus contrasts strongly with that of the first stomach, in which the mucous membrane exhibits parallel folds or ridges. In the second stomach the ridges are seen, but here they consist of rows of villi, averaging the $\frac{1}{8}$ of an inch in height; the villi are not so closely set on the rows but that they can be readily distinguished. The villi in the third stomach, however, are densely packed and smaller than those of the second stomach. In addition the mucous membrane is thrown into eight large (the seventh divided into two) folds that run at right angles to the long axis of the stomach. The mucous membrane of the fourth stomach differed from that of the others in being the only one containing the gastric glands; according to Dr. Hunt, these measure in length $\frac{1}{12}$ of an inch, in breadth $\frac{1}{750}$ of an inch. The food did not seem to be digested to any extent in the first three stomachs, but lay as a sodden mass. In the fourth stomach, however, the food was softened, and its general appearance differed from that of the other stomachs. As the animal died shortly after eating, digestion had not been going on any length of time, so that any great change in the food could not have taken place. In the case of the male, the fourth stomach had been affected by disease and the food appeared almost unchanged. The small intestine in the female measured 70 feet, the large intestine 11 feet. There were no valvulæ conniventes in the small intestine but the mucous membrane was villous and exhibited the Lieberkühnian follicle and the Peyer's patches in the lower two-thirds. There was no very sharp line of demarkation between the small and large intestines, the beginning of the latter being indicated by a slight enlargement. A small transverse fold was the only indication of an ileocæcal valve. As might have been expected on account of the large and complex stomach, there was no well defined cæcum. It is an interesting fact, however, that the peculiar glandular-like structure in the cæcal end of the colon of the Giraffe first described by Cobbold, should be present in the Hippopotamus. There was nothing very peculiar about the pancreas or the spleen. The duct of the former pierced the duodenum separately from the ductus choledochus. The latter was closely bound to the greater curvature of the stomach by a fold of peritoneum. The liver was a quadrilateral mass not subdivided to any extent into lobes. The gall bladder was absent in the female; in the male, however, it was present and measured 6 inches long.

On comparing my observations with those of the anatomists already referred to, I find, that while some of the descriptions accord very well with mine, others differ considerably. Thus Daubenton's description is very good, especially when it is remembered that it is based upon the examination of a fœtus. His[1] figures give a very good idea of the relations of the four stomachs when they are separated from each other by division of their connecting bands. Peters'[2] and Vrolik's[3] accounts are very fair. Unfortunately, however, no figures are given. On the other hand, I cannot say that the figure given by Crisp[4] of the stomachs illustrate the specimens examined by me. His descriptions, however, of the colic gland, spleen, liver and pancreas accord very well with my observations. Clark[5] gives four figures, illustrating the stomach described by him, that by Gratiolet, and of one preserved in the Museum of the Royal College of Surgeons. The figure of the latter gives a much better idea of the stomach examined by me than either that of Clark's or Gratiolet's. Garrod[6] states that "he could find no confirmation of the peculiar position of the different parts described by Mr. J. W. Clark in his specimen." Possibly these differences observed in the stomach may be due to age, sex, to the extent to which the different stomachs had been separated, or to the amount of food that they contained, etc. As all of these conditions will influence greatly the form of the organ, it need not occasion surprise that I find the accounts

[1] Op. cit., figs. 1 and 2, Pl. IV.

[2] Op. cit., p. 180.

[3] Op. cit., p. 240.

[4] Op. cit., fig. 3, p. 604.

[5] Op. cit., figs. 4, 5, 6, 7, p. 190.

[6] Op. cit., p. 16.

somewhat discordant, without, however, intending to throw discredit upon any of them.

A Peccary having died at the Zoological Garden the same day that the Hippopotamus arrived there, a favorable opportunity presented itself of comparing the stomachs of the two animals. While externally the stomach of the Peccary is not subdivided to any great extent, internally through the elevation of the mucous membrane into two ridges, three compartments, cardiac, middle and pyloric, may be distinguished. The cardiac portion further subdivided at its termination into two blind pouches, opens into the middle division of the stomach; the latter receives the œsophagus and communicates with the pyloric part. Conceive the ridges and the cardiac pouches in the stomach of the Peccary greatly enlarged and we would have the stomach of a small Hippopotamus. On the other hand, diminish the first two stomachs of the Hippopotamus to mere blind pouches, at the same time increasing the constriction between the third and fourth ones and we have, without any stretching of the imagination, the stomach of the Manatee. Beginning with the Pig the transition from that form of the stomach through the Babyrussa[1] to that of the Peccary is an easy one. The latter again, leads to the Hippopotamus, which in turn anticipates on the one hand the Manatee and on the other the Ruminant type.

Vascular System.—The circulation of the blood in the Hippopotamus was first studied by Gratiolet. The result of his careful investigation was the subject of a special communication to the Academy of Sciences, which appeared in the *Comptes Rendus*,[2] several years before the publication of his more general work by Dr. Alix. A good account of the heart is also given by Crisp.[3] With the exception of the above accounts, little or no attention seems to have been given to the study of the circulation by those anatomists who have dissected the common variety of Hippopotamus. Daubenton[4] devoting merely a few lines to the heart, while the later writers do not mention the circulation at all. Macalester[5] mentions one or two peculiarities about the blood-vessels in the Chœropsis. Although I have nothing particularly to add to Gratiolet's excellent description, inasmuch as the subject of his

[1] Vrolik, op. cit., p. 240.

[2] Tome li, p. 524, 1860, 1867.

[3] Op. cit., p. 609.

[4] Op. cit., p. 57.

[5] Op. cit., p. 495.

dissection was only a day old, it was important that the heart and blood-vessels in a more fully developed animal should be examined with reference to determining whether the circulation was in any way modified by age.

On opening the thorax of the animal it appeared to me that in both sexes the heart was large in proportion to the size of the animals. This is in a great measure due to the thickness of the walls of the left ventricle. In the female Hippopotamus, which was the first examined, I suspected this might be due to hypertrophy, but finding it to be the case in the male also, perhaps this is normal. The heart, in an empty condition, measured, from base to apex, 9 inches, and in circumference 14 inches. The wall of the left ventricle measured 1 inch in thickness, that of the right $\frac{1}{5}$ of an inch. According to Gratiolet,[1] the heart in the young Hippopotamus terminates in two points, the ventricles being separated by a little groove, reminding one of the form of the heart in the Manatee and the Dugong. There was no indication of this groove in either of the Hippopotami examined by me. With the exception of the absence of the corpora arantii on the semilunar valves of the pulmonary artery and their very slight development in those of the aorta I did not notice anything peculiar about the interior of the heart. The aorta gave off the coronary arteries first, which were very large and then an innominate and the left subclavian. The innominate divided into the right subclavian and a trunk which bifurcated into the two common carotids. The external carotid as well as the ascending cervical and occipital arteries were all rather slender vessels in proportion to the size of the head and neck. The external carotid artery was very much larger than the internal. A peculiarity about the external carotid artery of the Hippopotamus first described by Gratiolet,[2] I noticed in both the male and the female animals, the fact of the vessel in its course towards the head passing between the hyoid bone and the digastric and stylo-hyoid muscles in such a manner that when the hyoid is elevated the vessel is compressed against the bone by these muscles. The effect of this disposition is that the blood is cut off to a great extent from the brain and head when the animal sinks under water, the hyoid being elevated at such times. Gratiolet

[1] Recherches, p. 358, and Planche III.

[2] Op. cit., p. 354.

having shown that the external carotid through the sphenoidal branch of its internal maxillary communicates with the carotid rete mirabile, this sphenoidal branch in the Hippopotamus is as large as the internal carotid and plays the part of an "anterior internal carotid." In this connection I may say that it appeared to me that the elevation of the hyoid bone would compress the internal carotid artery as well as the external, the common carotid bifurcating between the digastric muscle and the hyoid bone in my specimens. The return of the venous blood to the heart from the head, however, was not impeded in any way, the jugular veins lying to the outside of the muscles which compressed the carotid arteries. The superior mesenteric artery came off the aorta in common with the cœliac, the inferior mesenteric separately. The common trunk of the external and internal iliacs was short. I did not notice any rete mirabile in the arteries of the body or extremities. In this respect the venous system, however, differed very considerably from the arterial. I was struck with the large size of the cutaneous and subcutaneous veins and of the many anastomoses between them, especially in the extremities, where numerous rete exist. Another peculiarity about the venous system in the Hippopotamus is the difference between the superior and inferior vena cavæ. The superior being very large and readily transmitting the blood to the heart, whereas the inferior cava, at least that part of it above the diaphragm, is rather small. According to Macalester,[1] in *Chœropsis* a left superior vena cava is partly represented by a small vein. As Gratiolet first showed, there is found in the walls of the vena cava above the diaphragm a circular band of muscular fibres which in contracting will entirely or partially constrict the vessel. The effect of such action is that the blood in the inferior cava is prevented returning to the heart. The circular muscular band in the Hippopotami examined by me was $\frac{1}{2}$ an inch broad. Such a disposition of the vena cava is also seen in the Seal[2] and in some other mammals which habitually remain under water for a certain length of time.[3] Below the diaphragm the vena cava was very much dilated, while the openings into it of the hepatic veins were enormous. It will be seen from the above that while the venous blood readily returns from

[1] Op. cit., p. 495.

[2] Burrow, Muller's Archiv, 1838.

[3] Milne Edwards' Physiologie, Tome iii, p. 594.

the brain and cord and upper extremities to the heart, that from the viscera and lower extremities can be entirely cut off from it, welling back into the dilated cava and cutaneous veins, while congestion of the brain can be prevented when the animal sinks under water by the obliteration of the carotid arteries. In this way paralysis of the respiratory centres of the brain and cord through congestion is prevented, while the demand for fresh air is diminished, so much blood being retained in the viscera and lower extremities and so diverted from the lungs. These peculiarities in the vascular system of the Hippopotamus—taken together with the disposition of the nares, larynx, etc., already referred to, through which the air can be retained—accounts, according to Gratiolet,[1] for the Hippopotamus being able to remain under water for so long a time, from fifteen to even forty minutes.

Bert,[2] while admitting the force of Gratiolet's reasoning, attributes the power that many animals have of resisting for a long time asphyxia, however produced, rather to the relative richness of blood that is contained in their bodies; the blood serving as a storehouse or magazine for oxygen which can be drawn upon when needed. For example, Bert has shown that the blood of the duck is richer than that of the chicken, and explains in this way that the duck will live longer than the chicken, when both are asphyxiated either by submersion in water or by ligation of the trachea. It seems to me, however, that the great quantity of blood present in those mammals that are in the habit of remaining under the water any length of time is an important element in the question. In opening several sea-lions, *Zalophus Gillespii*, that have died at the Zoological Garden, and different Cetacea, I have been always impressed with the enormous quantity of blood that literally ran out of their bodies. In presenting a specimen of a Dolphin, *Delphinus*, to the Academy, I called attention[3] to the vast rete mirabile formed by the intercostal arteries constituting the intercostal gland of the older anatomists, and which is usually regarded as a reservoir of arterialized oxygenated blood, to be drawn upon according to the needs of the animal. If the blood of the seals and cetaceans proves to be relatively richer than that of other mammals,

[1] Recherches, p. 363.

[2] Physiologie comparie de la Respiration, p. 543.

[3] Proceedings of Academy, 1873, p. 279.

it would show that both the quality of the blood, as well as the quantity, is important in enabling the animal to resist asphyxia. Not only was the quantity of blood in the Hippopotamus very great but the color in the arteries was very bright, more so than is usual in mammalian blood. Further I found the blood corpuscles measured only the $\frac{1}{7500}$ of an inch in diameter, or more strictly the $\frac{1}{300}$ of a millimetre—a Nachet eye-piece micrometer being used. The blood of the Hippopotamus should be therefore very rich in oxygen, as a corpuscle subdivided into a number of small ones would expose a larger absorbing surface to the oxygen respired than if undivided. This view is confirmatory of that of Bert, just referred to. It must be admitted, however, that according to the high authority of Gulliver, the blood corpuscle measures the $\frac{1}{3429}$ of an inch in the Hippopotamus. The fact of the Hippopotamus being able to remain under water would seem, therefore, to depend upon the peculiarities of its vascular and respiratory systems, and the great quantity and rich quality of its blood, the structural relations being as important as the chemical.

Genito-Urinary Apparatus.—In the different accounts of the Hippopotamus that I have referred to, with the exception of that of Gratiolet and of Clark, little or nothing is said of the genito-urinary organs. Daubenton[1] devotes a few lines to the description of the uterus and vagina, but his specimen, it will be remembered, was only a fœtus. Peters[2] merely alludes to the mammæ, the penis, etc. In Crisp's[3] specimen, which was a male, the parts were destroyed to such an extent as rendered detailed dissection impossible. The account in Gratiolet's[4] work is really, I presume, due to Dr. Alix, as that anatomist tells us in the preface,[5] the death of a young Hippopotamus born at the Jardin des Plantes a few days previously, gave him the opportunity of adding some details to the dissections left by Gratiolet. Alix's description of the parts, which is an account of both sexes, is excellent, but unfortunately is unaccompanied by any illustrations. Clark's[6] figure of the uterus and vagina is imperfect, but his description is very clear. It is to be regretted that Garrod[7] says nothing of the genito-urinary organs of the male animal examined by him. It

[1] Op. cit , p. 58. [2] Op. cit., p. 181. [3] Op. cit., 608.

[4] Op. cit., p. 396. [5] Op. cit., p. vi. [6] Op. cit., p. 195.

[7] Op. cit.

will be seen from the above that the genito-urinary apparatus in the male Hippopotamus have not been figured, and that of the female only imperfectly so, while the description of Alix is based on very young animals, and that of Clark is limited to the female sex. I trust that the following brief description of the parts as I found them in the male and female, with the accompanying figures will sufficiently illustrate what is wanting in the accounts hitherto given of the animal.

Genito-Urinary Organs in Male.—The kidneys, *k* (Plate XIV), measured five inches in length and were distinctly lobulated. About ten of these lobules could be counted on each face. The ureters were 7 inches in length, and opened into the bladder at the angles of the trigonum vesicæ. The bladder, *b*, from the highest point to the verumontanum in the middle line measured 9 inches. There was no sign of a prostate gland or utriculus. On each side, however, of the middle line below the verumontanum a number of little follicles could be observed. The Cowperian glands, *c*, on the other hand, are very large, being almost an inch in diameter; the main duct was well developed and opened into the urethra an inch below the gland. A considerable amount of a viscous humor could be squeezed out of the gland and duct. The muscular fibres covering the gland no doubt produce this effect in contracting. The distance from the verumontanum to the orifices of the Cowper's ducts measured four inches. The orifices of the ducts were concealed by a little fold of mucous membrane. Under this fold the membrane was thrown into delicate transverse ridges. The mucous membrane of the membranous portion of the urethra was thrown into longitudinal folds. The urethra from the openings of Cowper's ducts to its termination in the glans measured 12 inches. There was nothing exceptional in reference to the corpus spongiosum or the corpora cavernosa. The penis measured in circumference 2 inches. The ischio cavernous and bulbo urethral muscles were well developed. The symmetrically disposed retractor muscles, etc., of the penis arising from the posterior surface of the rectum pass to the bulbous portion of the urethra, where, becoming tendinous, they are continued side by side to the base of the glans into which they are inserted. The glans itself measured in circumference 5½ inches, and when everted presents a very peculiar appearance, it being then thrown into a rosette which consists of folds arranged somewhat like the leaves of a book. The testicles, *t*, were found in the inguinal canal, midway between the internal and external abdominal rings. There was a free communication between the cavity of the peritoneum and that of the tunica vaginalis testis. The cremaster muscle was well developed, and arose, as usual, from the internal oblique and transversalis muscles. The testicle itself measured $2\frac{1}{2}$ inches. The vas deferens, *v*, measured 18 inches from the epididymis to the point where it is joined by the duct of the seminal vesicle. The latter was about an inch in length, but not much developed. The ejaculatory ducts open into the urethra at the verumontanum.

Genito-Urinary Organs in Female.—The ovary, *o* (Plate XV), in the Hippopotamus is elongated and flattened, measuring an inch in length and $\frac{3}{8}$ of an inch in breadth. The Fallopian tube, *f*, 8 inches long and $\frac{1}{8}$ of an inch wide, pursues quite a flexuous course towards the cornua of the uterus, *cu*, into which it opens by a very small aperture. The pavilion, *p*, while not fringed, consists of a series of folds radiating from the central opening. The latter readily admitted a bristle. The cornua of the uterus, *cu*, measured $6\frac{1}{2}$ inches in length and $\frac{7}{8}$ of an inch in breadth. For the last two inches of their course the cornua run alongside of each other, and are apparently fused together, though internally they are seen to be still quite distinct. Finally, each cornu opens by a wide mouth into a common cavity, which probably represents the body of the uterus. While the mucous membrane of the cornua is thrown into longitudinal folds, that of the body of the uterus is smooth. What is usually regarded as uterus is very small, measuring only $\frac{1}{2}$ an inch in length and $1\frac{1}{4}$ inches in width. It appears to me, however, that this space represents only a part of the uterus; the body and that which has been heretofore described as vagina, is really an elongated cervix uteri; this measures 6 inches in length and 1 inch in width. Its mucous membrane was elevated into seventeen folds, *c*, which are situated transversely to the long axis of the vagina, and which resemble valvulæ conniventes. These folds, on an average, were $\frac{3}{8}$ of an inch in breadth and $\frac{3}{8}$ inch in height, and are subdivided by indentations. Every other fold, however, alternates in reference to the part where it was most developed. Thus, the first, third, fifth folds, etc., were thickest in the middle, fading away at the sides into the walls of the vagina, whereas the second, fourth and sixth folds, etc., were thickest at the sides of the vagina, fading away towards the middle.

These folds are disposed in rather a spiral manner, and are so closely set together and developed that the cavity of the tube is almost obliterated. It is difficult, indeed, to conceive how the penis can introduce itself if this is the vagina, the rugosities being capable of offering great resistance. The folds, however, gradually fade away, and in the lower four inches of the genital tube the mucous membrane is smooth or slightly folded longitudinally. It is this part of the tube which appears to me is the vagina. It opens into the genito-urinary vestibule by a distinct aperture, through which a probe was passed without difficulty. According to Gratiolet,[1] the vagina was imperforate. The female urethra, *b*, is about an inch long, and is closely connected with the lower part of the vagina, the openings of the two tubes into the genito-urinary vestibule being situated almost next to each other. Just in front of the opening of the vagina a ridge is seen, and on either side of this ridge there are two small sinuses in which the orifices of the vulvar vaginal glands open. Externally, the vulva appears as a circular fleshy mass, 14 inches in circumference, surrounding and leading into the genito-urinary vestibule. There is no appearance of external or internal labia, and a perinæum can hardly be said to exist, the rectum lying directly against the vulva. Within the vestibule there is quite a large sinus, *s* (next to the rectum). There was nothing particularly noticeable about the clitoris, *cl*, except that the prepuce was very well developed.

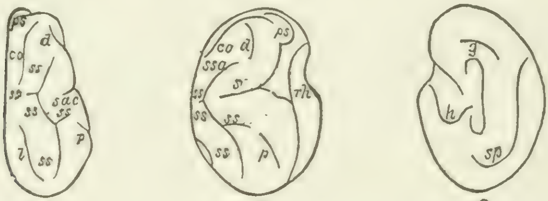
The female generative apparatus of the Hippopotamus is in every respect essentially like that of the Peccary, the only difference being in the relative size of what I have described as the body and neck of the uterus. The body of the uterus in the Peccary being relatively larger than the cervix. The peculiar disposition of the mucous membrane in folds is seen in the cervix of both animals. It is with some diffidence that I have ventured to consider as cervix the part of the genital tube usually described as vagina, for anatomists, even in the Peccary, consider the rugose portion of the tube to be the vagina. Clark[2] seems, however, to have the same opinion as expressed by me, as to the homology of the parts. The two teats were situated in the inguinal region, and although the mammary gland was but little developed externally, on section the milk-ducts could be easily recognized.

[1] Op. cit., p. 401.

[2] Compare op. cit., p. 195.

Brain.—When the study of the structure of an animal is limited to the investigation of its adult condition, without any reference to its mode of development or regard to its natural affinities with closely allied or even remote species, much will be found obscure, or even entirely unintelligible in its organization. The study of the brain is no exception to this general rule. Comparative anatomy and embryology are, indeed, the lamps which throw light upon the darkness of cerebral structure. Taking advantage of the methods cultivated with such success by Owen,[1] Leuret[2] and Gratiolet, Kreug,[3] etc., let us begin our study of the brain of the Hippopotamus by first considering, as suggested by Garrod,[4] so far as is known, the general type of the artiodactyle brain, and then ascertaining the amount of deviation from the type exhibited in the brain of the different genera. Studied in this way, the brain of the Hippopotamus will prove far more interesting and instructive than if merely described topographically.

According to Kreug the simplest kind of ungulate brain is to



1 2 3

be seen in the embryo of the Sheep, *Ovis aries*. Figs. 1, 2, 3, give diagrammatically surface, side and mesial views of the hemisphere of the same. On looking at the surface view (fig. 1), there will be observed to the right of the great longitudinal fissure the coronal fissure, *co*, anteriorly, and the lateral, *l*, posteriorly, and towards the side the supra-sylvian, *ss*, fissure with its anterior, ascending, descending, and posterior branches. In addition to these fissures may be seen upon the side view (fig. 2), the sylvian fissure, *sac*, running transversely into the rhinal fissures, *rh*, the diagonal, *d*, and the postica, *p*. The calloso marginal, *sp*,

[1] Com. Anat. of Vertebrates, vol. iii, p. 115.

[2] Anatomie Comparée du Système Nerveux.

[3] Zeit. für wiss. Zoologie, Leipzig, 1878. Band 31.

[4] Op. cit., p. 12.

genial, *g*, and hippocampal, *h*, are seen on the mesial surface (fig. 3). Let us suppose, now, that that the calloso marginal from the mesial surface and the ascending branch of the supra-sylvian blend with the coronal and that at the same time, while the descending branch of the supra-sylvian lengthens, the posterior limit shortens, we shall transform the typical ungulate brain into that of the Pig, *Sus scrofa.* On the other hand, should the posterior branch of the supra-sylvian lengthen while the descending branch shortens, the result will be the brain of the Cotylophora. The Peccary, *Dicotyles*, differs from the Pig in that the calloso marginal only joins the coronal, and that often at least, the descending branch of the supra-sylvian is wanting. In most of the Cervidæ the ascending limit of the supra-sylvian runs into coronal. From this brief resumé it will be seen that fundamentally the brain is constructed on the same pattern in the Pig, Peccary, Sheep, Camel, Giraffe, Deer, etc.

Let us now try to show that the brain of the Hippopotamus does not essentially differ from the typical ungulate brain to a greater extent than that of the animals just referred to. The most striking feature of the brain of the Hippopotamus, viewed from its upper surface, is the deep fissure, *l co* (Pl. XVI), that runs from the posterior to the anterior part of the brain, and rather in an oblique direction, being situated nearer the great longitudinal fissure anteriorly than posteriorly. This fissure serves to divide the upper surface of the hemisphere into two parts, very much as the interparietal fissure does in man; compared with the type of the ungulate brain, this fissure is evidently due, as suggested by Garrod,[1] to the lateral and coronal fissures running into each other, which I find they almost do in the Camel, Giraffe, Deer and Ox. On the right side of the Hippopotamus' brain examined by me, this fissure runs farther forward than on the left. In the ungulate brain there are usually found between the lateral fissure, that is, the posterior part of the fissure just described, and the great longitudinal fissure, one or two secondary longitudinal fissures. On the left side of the brain in the Hippopotamus a secondary longitudinal fissure may be seen, extending forward to about the usual extent, but on the right side this, *m l* (Pl. XVI), runs forward anteriorly until it passes between the coronal and the great longitudinal fissures. In this respect my specimen

[1] Op. cit., p. 15.

differs from that figured by Garrod.[1] In the brains of the Llama and Giraffe these secondary longitudinal fissures are often found both anteriorly and posteriorly, and are almost continuous with each other; on the other hand, in the brain of the Peccary used by me for comparison, the secondary longitudinal fissure, usually found posteriorly, is absent. The sylvian fissure in my Hippopotamus is quite evident, and within it I noticed a rudimentary island of Reil. This fissure on the right side differs from that described by Garrod, in that it is quite distinct from the Rhinal fissure, there is, however, posteriorly a little connecting branch between the two. I identified, as Garrod,[2] on the left side of the brain the supra-sylvian fissure with its branches, but these were not well matched on the right side. On the mesial surface the calloso marginal sent up a fissure which nearly reached the latiro coronal and terminated in the genial.

As is usually the case in the artiodactyle, there was a secondary fissure between the corpus callosum and the calloso marginal. The minor convolutions of the brain of the Hippopotamus are not very numerous. Indeed, the brain is much less convulated than those of the Giraffe, Llama, or even the Peccary, used by me for comparison; in the general form of its hemispheres the brain of the Hippopotamus resembled that of the Giraffe; the cerebellum, however, differed from that of the Giraffe, Peccary, and other artiodactyles in that its largest diameter was transverse, whereas, in the animals just mentioned, the largest diameter of the cerebellum was antero posterior; the latter, however, seems to be the case in the young Hippopotamus, at least judging from Gratiolet's[3] figure. In the adult the cerebellum resembled more that of the Manatee than that of the Artiodactyle. As the description and figures of the brain of the Hippopotamus given by Gratiolet[4] and Garrod[5] are limited to the surface, it appeared to me very desirable that the interior of the ventricle should be exposed and figured. On making the section, I found a septum lucidum. The lateral ventricle was very large, recalling to my mind that of the Manatee, dissected by me some years since. According to Macalester's figure the ventricle is also large in *Chœropsis*. The general

[1] Op. cit., Plate III, fig. 1.
[2] Op. cit., Plate IV, fig. 3.
[3] Op. cit., fig. 2, Pl. XII.
[4] Op. cit., p. 317, Pl. XII.
[5] Op. cit., p. 14, figs. 1, 2, Pl. 3; figs. 1, 2, 3, Pl. 4.

appearance and size of the corpus striatum, *s*, tænia, thalamus opticus, *o*, and hippocampus major, when compared side by side with the corresponding parts of the Manatee, resembled these more than they did those of the Giraffe, Llama, Peccary, etc. Of the corpora quadrigemina in the Hippopotamus, the testes, *t*, were broader than the nates, *n*, and less rounded in shape.[1]

If the above description of the brain of the Hippopotamus be correct, it follows that the general form of its hemispheres, the arrangement of its fissures, etc., deviate but little from the typical ungulate brain, while the capaciousness of its ventricles, the form of its basal ganglia, and the cerebellum, resemble rather those of the brain of the Manatee.

Sweat Glands.—As is well known, when the Hippopotamus comes out of the water there exudes from the skin a pinkish, reddish secretion, which quickly dries up and does not reappear until the animal comes out of the water again. This secretion has probably given rise to the name blood-sweating Behemoth, by which the Hippopotamus is often known among showmen. This secretion was first examined by Tomes,[2] who stated that it consisted of a transparent fluid containing colorless and red-colored corpuscles, the color of the secretion being due to the solution of the latter. Crisp[3] examined and figured the glands supposed to produce this secretion. It will be remembered that his specimen was burnt to death, and it was to be expected, therefore, that the skin was affected. For this reason I requested that admirable microscopist, Dr. J. Gibbons Hunt, to examine the skin of my Hippopotamus, and I give his result in his own words:

"I put in a camera lucida sketch of the blood-gland (fig. 4) of the Hippopotamus magnified 25 diameters. It has no limiting membrane, but bioplasts or nuclei of the usual apparent form make up the entire gland. In the centre these gland-cells are loosely arranged, thus allowing the contents to escape, perhaps, like common sweat glands do, in which, similarly, there is no external or internal membrane."

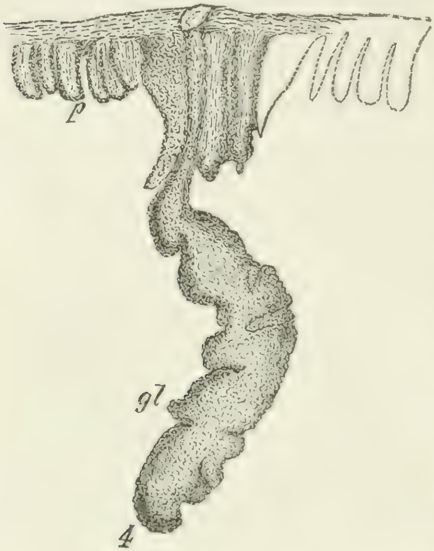
The contents of the gland-cells loosely arranged in the centre are probably the corpuscle, the solution of which, according to

[1] Peters gives in Monatsberichte of Berlin Acad., 1854, a brief description of the brain of the Hippopotamus, but unfortunately not illustrated.

[2] Proc. Zool. Soc. of London, 1850.

[3] Op. cit., p. 602.

Tomes, gives rise to the color. The length of the blood gland measured $\frac{1}{15}$ of an inch, in width the $\frac{1}{45}$ of an inch, the length of the duct $\frac{1}{30}$ of an inch. In many parts of the skin these glands are absent, and when present are situated about the $\frac{1}{10}$ of an inch below the surface.



A most striking feature in the skin of the Hippopotamus is the great development of the fibrous tissue of the corium. This is disposed in great bands, which are so interwoven with each other as to give the appearance of a fabric.

Reflections.—In concluding these observations, it may not appear superfluous to briefly consider what appears to me to be the natural affinities of the Hippopotamus with the Ungulata or other mammalia. In observing the Manatee that lived for several months in the Philadelphia Zoological Garden, the manner in which it rose to the surface of the water to breathe reminded me often of the Hippopotami that I watched in the Zoological Garden of London and the Jardin des Plantes in Paris. The slow way in which the animals rise to the surface, the motionless pose of the almost sunken body, the nostrils often just appearing at the surface, etc., are very much alike in both animals. In speaking of the alimentary canal, I called attention to the stomach of the Manatee representing the stomach of the Hippopotamus in an atrophied condition, while, on the other hand, the stomach of the Hippopotamus is intermediate between the Peccary and the Ruminants. As regards the heart, it will be remembered, that in the young Hippopotamus, at least, it is bifid, resembling in this respect that of the Manatee. The female generative apparatus of the Peccary and Hippopotamus are almost identical. Again, the sexual vesicles are found in both Hippopotamus and Manatee.

While the placenta does not appear to me to have the importance attached to it by some authors as a guide in determining the affinities of animals, it is proper to mention in this connection that according to Milne Edwards[1] and Garrod[2] the placenta of the Hippopotamus is diffuse and appears to be non-deciduous, and such is the case, according to Harting,[3] in the Dugong,[4] and therefore in the Manatee, probably, for as a matter of fact the placentation of the Manatee is unknown.

While the brain of the Hippopotamus appears to be a modification of a type common to the Pig, Peccary, Sheep, Ox, Giraffe, etc., it has also, it seems to me, affinities with that of the Manatee. In a word, then, beginning with the Pig, we pass by an easy transition to the Peccary, which leads to the Hippopotamus, and thence, in diverging lines, to the Ruminantia on the one hand, and the Manatee on the other. Paleontologists have not discovered a form which bridges over the gap between the Hippopotamus and the Manatee, but it will be remembered that certain fossil bones, considered by Cuvier[5] to have belonged to an extinct species of Hippopotamus, *H. medius*, are regarded by Gervais[6] as the remains of the *Halitherium fossile*, an extinct Sirenean, of which order the Manatee is a living representative. According to Prof. Owen,[7] the molar teeth also, both in the *Halitherium*, and the *Felsinotherium*,[8] another Sirenean, are constructed on the same pattern

[1] Physiologie, Tome 9, p. 56.

[2] Proceed. Zool. Soc., 1872, p. 821.

[3] Tijdschrift der Nederlandsche Dierkundige Vereenigung, Deel iv, 1879, p. 1.

[4] Dr. Hartung, in his very valuable paper on the placenta of the Dugong, just referred to, describes and figures bodies attached to the blood-vessels resembling, apparently, very much those of the placenta of the Elephant. His figure (7) shows that the cavity of the vessel communicates with that of the body attached to it. Dr. Harting inquires whether such is the case in the Elephant. I will state in reply, that neither Dr. J. Gibbons Hunt nor myself found any such continuity between the vessel and body in the placenta of the Elephant. These oval bodies in the Elephant are not sacs or cavities, the little branches from the main vessel only ramify through their substance. There seems, then, to be an essential difference between the oval bodies in the placenta of the Elephant and in that of the Dugong.

[5] Ossemens Fossiles, II, p. 492.

[6] Paleontologie Francaise, p. 143.

[7] Geological Magazine, 1875, p. 423.

[8] De Zigno, Sopra un nuovo suienio fossile. Reale Acad. dei Lincei, 1877–78.

as those of the Hippopotamus. It is proper to mention, however, that the same distinguished observer considers the teeth of the Manatee and the *Prorastomus*, another extinct Sirenean, to be rather allied to those of the Tapir and *Lophiodon*, but this qualification does not really invalidate the supposed affinities between the Sirenea and the Hippopotamus. For the Artiodactyla and Perisodactyla are probably offshoots of a common stock, and hence we may expect to find in these two groups certain characters common to both, inherited from their Lophiodon and Coryphiodon-like ancestors. The affinities of the teeth of the Manatee with those of the Tapir—the first an embryonic Artiodactyle, the second a generalized Perisodactyle—would be examples of the above view. I do not mean to imply that the Manatee has necessarily descended directly from the Hippopotamus, though extinct intermediate forms may in the future show this to be so, for possibly they may be the descendants of a common ancestor. To many such speculations may appear mere waste of time, we being unable, from the nature of the case, to experimentally prove or disprove the truth of the hypothesis advanced. It seems to me, however, that the only explanation of the structure of the living forms and of the petrified remains of the animals referred to in these observations is the hypothesis of there being some generic connection between them.

JUNE 14.

The President, Dr. RUSCHENBERGER, in the chair.

Twenty-one persons present.

A paper entited "Notes on the Tertiary Geology of the Southern United States," by Angelo Heilprin, was presented for publication.

The death of Baron Maximilien de Chaudoir, a correspondent, was announced.

Some new Genera of Fresh Water Sponges.—Mr. E. POTTS referred to a recent paper by H. J. Carter. F. R. S., (Ann. Mag. Nat. Hist., Feb. 1881,) entitled, "The History and Classification of the Known Species of *Spongilla*," in which the writer has distributed the species, heretofore grouped under one generic title, among five genera, founded upon the differences in form and arrangement of the spiculæ surrounding the statospheres. He spoke of the arrangement as a timely step well taken in advance, in the history of this branch of the animal kingdom.

He believed that the characteristics of the statospheres and their spiculæ were those which furnished the only reliable distinctions among fresh water sponges; but the recent discovery of novel forms in American waters had already required an increase in the number of genera and seemed to make it desirable to modify the terms of some of those already established.

In illustration he referred to several forms observed in this neighborhood, resembling in many points the English *Spongilla lacustris*, (taken as a type of the genus *Spongilla* in the new arrangement), in which, however, the spiculæ were not acerate, but irregular in shape; were not placed "tangentially" upon the surface; or were altogether wanting. Specific names were suggested for these, but were held under advisement, awaiting a decision as to whether it would be better to create new genera for them or to enlarge the scope of those already defined by Dr. Carter.

The two new genera already decided upon were then described. Under the generic head *Meyenia*, Dr. Carter has grouped those species, in which the statosphere is surrounded by birotulate spiculæ, radiately arranged; one disk resting upon the surface. Throughout the genus as already constituted, the shafts of these spicules are of a nearly uniform length; and the outer disks nearly or quite touching at their edges give the appearance of a second coat to the statosphere. In two species, however, observed by Mr. Potts last summer, this uniform series was broken by another, of about double their length, much fewer in number, somewhat regularly arranged, interspersed among them. He proposed to group these under the genus *Heteromeyenia*, as *H. argyrosperma* and *H. repens;* suggesting that the latter may possibly be the same as Bowerbank's *Spongilla*, now *Meyenia Baileyi*.

Another new genus had been formed and dedicated to Dr. Carter under the name *Carterella*, to include the singular form described by the speaker last year in the Proceedings of the Academy, and then called *Spongilla tentasperma;* changed later to *S. tenosperma*. The distinguishing peculiarity of this genus is that the tube surrounding the foramen of the statosphere is elongated and divides into 2-5 long, curling or twisted tendrils by means of which during the winter the statosphere remains attached to the stems or roots upon which the sponge had grown. This will now be *Carterella tenosperma*.

A second species has been added to this genus, the discovery of Professor Kellicott and Mr. Henry Mills, of Buffalo, under the name of *Carterella tubisperma*. In this, the tube is much longer than in any sponge heretofore described, terminating in several straggling, rather weak tentacles much shorter than in the former species. The birotulate spiculæ in the two forms are quite different, and the species are unquestionably distinct.

JUNE 21.

The President, Dr. RUSCHENBERGER, in the chair.

Nineteen persons present.

JUNE 28.

The President, Dr. RUSCHENBERGER, in the chair.

Fifteen persons present.

Jerome Gray was elected a member.

M. S. Bebb, of Rockport, Ill., and Chas. S. Sargent, of Brookline, Mass., were elected correspondents.

The following was ordered to be printed:

NOTES ON THE TERTIARY GEOLOGY OF THE SOUTHERN UNITED STATES.

BY ANGELO HEILPRIN.

In the following notes the author makes no pretense at unravelling the many knotty points connected with the Tertiary geology of the southern United States; he has merely brought together such facts, old and new, and certain conclusions drawn from these facts, as may possibly serve to facilitate the inquiry into this as yet imperfectly known branch of American geological history. It is with this view of rendering the material treating of the subject more accessible to the working geologist that some of the published sections are here reproduced.

A convenient starting-point in Eocene stratigraphy is afforded by the famous bluff exposed on the Alabama River near Claiborne, Ala., and which has yielded the fossils known to geologists and paleontologists as those characteristic of the "Claiborne Group."

Section of Claiborne Bluff.—Probably the most trustworthy section of this bluff is that afforded by Tuomey ("First Biennial Report of the Geology of Alabama," 1850, p. 152), as follows:

		Feet.
g	Red sand, loam, and pebbles.	30
f	Mottled clay.	8
e	Limestone, with grains of green sand.	54
d	Ferruginous sand; numerous fossils.	
c	Whitish limestone.	62
b	Bed of clay 15 feet thick, with seam of limestone on top.	15

NOTE.—Tuomey does not give the thickness of bed "*d*," but it appears from the concurrent statements of different observers to be about 17 feet. The total height of the bluff above the Alabama River would therefore appear to be in the neighborhood of 190 feet.

The measurements and descriptions of Conrad ("Fossil Shells of the Tertiary Formations," 1833, p 32; Proceedings of the National Institution, 1841. p. 174). Hale ("Geology of South Alabama," American Journal of Science, new ser., VI, p. 354), and Lyell (Journal of the Geological Society, IV, p. 10, *et seq.*) do not differ very essentially from the data given by Tuomey. The arenaceous bed "*d*," about 80 feet above water level, has yielded the vast majority of the fossils for which the locality is famous, and is that which has been identified as the equivalent of the "Calcaire Grossier" (Upper Eocene) of France (*et conseq.*, Bruxellian of Belgium, and Bartonian of England). To what extent the deposits either below or above this bed can be correlated with the remaining deposits of the Paris or London series has not yet been determined; nor has it yet been conclusively shown what exact portion of the American Eocene formation is represented in this Claiborne exposure. Although formerly considered to be near the base of the system, there are now very strong grounds for concluding that these beds are underlaid by older Eocene strata having a thickness of at least 200 feet, and possibly even much more. The age of the limestone bed "*e*," although perhaps the character of its contained fossils does not permit absolute determination, is in all probability Jacksonian—at least in part—and will doubtless be found to correspond with a portion of the bluff exposed at St. Stephen's on the Tombigbee River, about thirty miles almost due west of Claiborne. At any rate, a portion of the white, or so-called "rotten" limestone immediately west of Claiborne has been found to contain several of the characteristic fossils of the Jackson group, and these associated with the remains of *Zeuglodon;* there is, therefore, no doubt as to the age of at least this portion of the white limestone, nor can there be any reasonable doubt as to the continuity existing between these deposits and the similar ones exposed on Claiborne bluff.

Section on Bashia Creek, Clarke Co., Ala.—Probably the section representing the oldest Eocene deposits of the State of Alabama is that exposed on Bashia Creek, Clarke Co., and detailed by Toumey in his report on the geology of the State (First Biennial report, p. 145):

1	Hard Limestone.	4 feet.
2	Marl, highly fossiliferous.	25 feet.
3	Blue sand.	Variable.
4	Lignite and clay.	6 feet.
5	Laminated clay, sand, and mud.	Thickness undetermined.
6	Lignite.	do. do.

NOTE.—Beds 5 and 6 do not properly belong to the section, but "represent beds seen on another part of the stream below the preceding" (Tuomey, *loc. cit,*, p. 146).

Beds corresponding to No. "2" of the above section are likewise exposed on Cave and Knight's branches, tributaries of Bashia Creek, and have been shown by Dr. Eugene A. Smith to underly the *base* of the "Buhrstone" proper by nearly (if not more than) 200 feet (Heilprin, "Proc. Acad Nat. Sciences of Philadelphia," 1881, p. 369). The relations of these various beds will be best understood by a reference to the sections exposed on the Tombigbee River.

Sections on the Tombigbee River.—At Wood's Bluff, near the mouth of Bashia Creek, we have the following exposure: [1]

No.		Feet.
7	Orange sand, or stratified drift.	10–20
6	Grayish or greenish laminated clays, colored brown by iron.	10
5	Ledge of bluish or greenish sand, fossiliferous—capped by a ledge of hard nodules.	2
4	Bluish laminated clay, with few fossils.	5
3	Indurated greenish sand, full of the same shells as marl bed No. 2.	3
2	Greensand marl, quite soft, and full of shells.	3
1	Indurated greensand with shells, and a stratum of oyster shells at water's edge—said to extend 10 feet further down.	10–15

[1] I am indebted to the kindness of Dr. Eugene A. Smith, State Geologist of Alabama, for the use of this heretofore unpublished section.

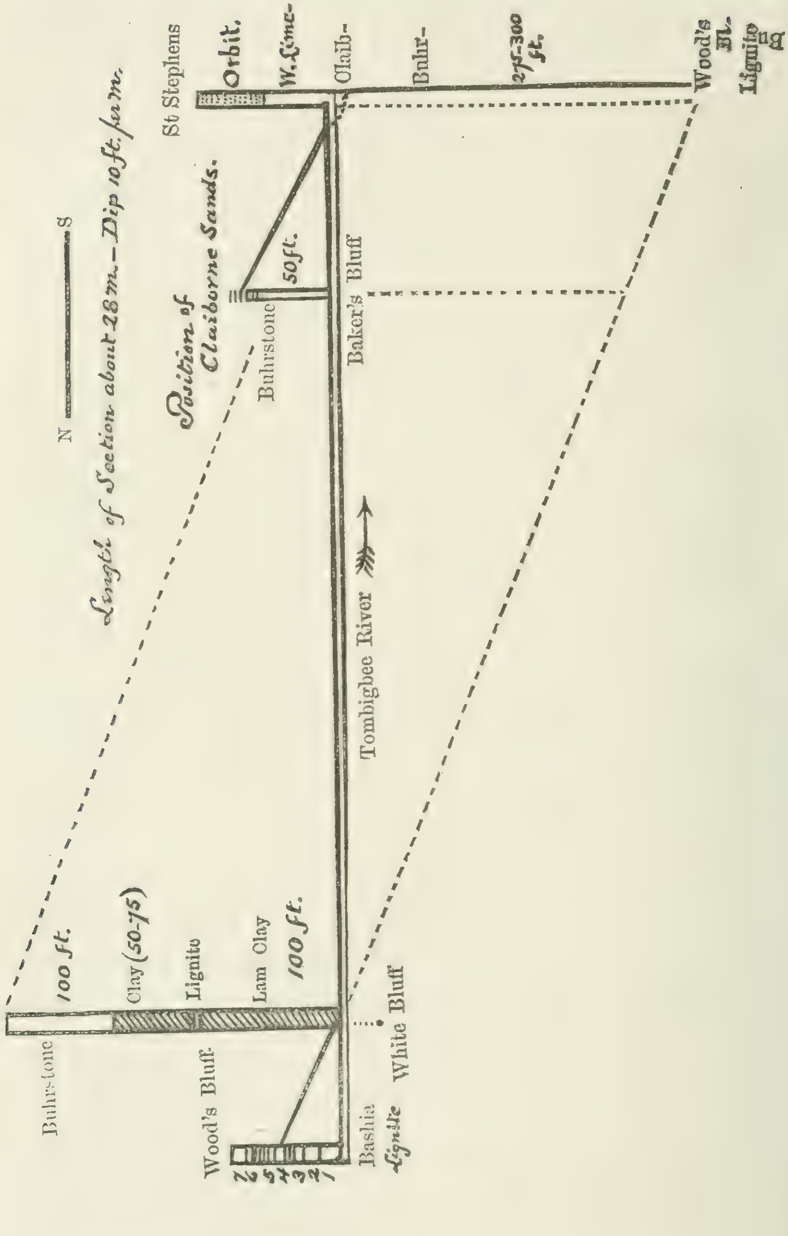
Bed No. 4 of the preceding section is considered by Dr. Smith to be most closely related in the character of its fossil remains to the fossiliferous strata exposed on Cave and Knight's branches, and it is therefore not unlikely that the series 1–5 corresponds in the main with No. 2 of Tuomey's Bashia section. The basal lignite would then probably be found to underly the lowest stratum exhibited at the Bluff (Heilprin, *loc. cit.*, p. 367–8). Bed No. 6 (Wood's Bluff section) can be traced down the river for a distance of two to three miles, when it dips beneath the water's level. Somewhat below this point, and beyond the mouth of Witch Creek, the stratigraphical relation of the different beds is beautifully exhibited in a prominent cliff ("White Bluff"), rising from 250 to 275 feet above the river. The upper portion of this bluff is constituted by the characteristic siliceous clay-stones and silicified shell deposits of the southern "Buhrstone" formation, which make up fully 100 feet of the vertical height. Laminated lignitic clays (bearing numerous leaf impressions), with occasional intercalated beds of pure lignite, enter mainly into the composition of the intermediate portion, *i. e.*, from the water's level to the base of the buhrstone above mentioned. Allowing a uniform southerly dip of 10 feet to the mile, which appears to be consistent with obtained data, it is manifest that at this point the lower fossiliferous strata exposed at Wood's Bluff (and consequently, the equivalent deposits on Bashia Creek and its tributaries, Cave and Knight's branches) must lie from 175 to 200 feet below the base of the siliceous mass constituting the true buhrstone; or, in other words, we have here a series of deposits aggregating about 300 feet in thickness, which can be shown to be of an age anterior to the depositions of the Claiborne fossiliferous sands. At Baker's Bluff, a few miles above St. Stephen's (which is situated about twenty-eight miles south of Wood's Bluff), the buhrstone, according to Tuomey, appears in a vertical escarpment rising only 50 feet above the water, a low height perfectly in accordance with the loss occasioned by the general dip extending over nearly twenty miles. At this point, moreover, and occupying a position above the buhrstone, Tuomey (*loc. cit.*, p. 148) identifies a bed of green sand (8 feet in thickness) as the equivalent of the Claiborne fossiliferous sands "*d*" of his section), and containing numerous fossils identical with those found at Claiborne. Still further south, and occupying a considerably lower level, the same bed is described as having an extent of 12 feet, and immediately above St. Stephen's, was seen to dip beneath the water's edge. At this last locality we have a beautiful exhibit of what has generally been designated by the name of "White Limestone."[1]

There can be not the least doubt, however, that this "White Limestone," which has most frequently been taken to represent strata of Vicksburg age, is in reality, as has been insisted upon by Winchell (Proceedings of the American Association, 1856, Part II, p. 85), a combination of strata belonging to two distinct (at least, as now recognized) groups of deposits. The lower moiety, dipping into the river, and resting upon the subjacent Claiborne sands (Tuomey, *loc. cit.*, p. 157; Lyell, Journal Geol. Soc., London, IV, p. 15; Hale, A. J. Science, new ser., VI, p. 359) is the true "White Limestone," an exponent of the Jacksonian group of deposits, as may be inferred from its position, and the character of its contained fossils.[2] Moreover, were it otherwise the case, it would have been very difficult to explain the total disappearance over a distance of only thirty miles (and with but exceedingly moderate dip) of the equivalent beds exposed on the Alabama River at Claiborne. The upper moiety, on the other hand, is a portion of the well known Orbitoide (Vicksburg or Oligocene) rock, and is that which alone contains specimens of *Orbitoides Mantelli* (Winchell, *loc. cit.*, p. 85).

From the data herewith presented, a section of the Tertiary strata traced along the Tombigbee River from Wood's Bluff to St. Stephen's, may probably, with considerable approach to truth, be constructed as follows:

[1] I have been unable to discover the exact height of this bluff. Neither Lyell nor Tounney mentions it; Conrad, in the appendix to Morton's "Synopsis" (p. 23), states it is about 100 feet.

[2] *Spondylus dumosus* and *Ostrea panda*, originally described as characteristic fossils of the Newer Cretaceous (upper Eocene) deposits of the southern United States, have been found abundantly near the base of the bluff.


Length of Section about 28 m.—Dip 10 ft. per m.
N
S
St Stephens
Orbit.
W. Lime-
Claib-
Buhr-
275-300 ft.
Wood's Bl.
Lignite
Position of Claiborne Sands.
50 ft.
Buhrstone
Baker's Bluff
Tombigbee River
Buhrstone
100 ft.
Clay (50-75)
Lignite
Lam Clay
100 ft.
Wood's Bluff
White Bluff
Bashia
Lignite

An examination of the foregoing section shows almost conclusively that the Eocene deposits of Alabama have a thickness of very nearly 400 feet; and, indeed, I am informed by Dr. Smith that there are good grounds for supposing that Tertiary beds exist in the northern part of the State, whose position would be still 150–180 feet below the Wood's Bluff marl bed. It will further be seen that the Clairbornian (or Claiborne proper, as characterized by the fossiliferous greensands) holds a position decidedly near the top of the series, a position almost precisely similar to that occupied by the "Calcaire Grossier" (Parisian) of France, and more properly Upper than Middle Eocene, which last it has very generally been considered. What relation beds "b" and "c" of the Claiborne Bluff holds to the sub-Claibornian ("Buhrstone" in part) deposits of the Tombigbee River has not yet been absolutely determined; but there can probably be no legitimate doubts that they represent, in a modified form, the upper moiety of those deposits. Although the marked difference in the lithological character of the strata of the two localities as compared with each other (and indeed it must be confessed, this is much greater than could have been reasonably inferred from the general constancy of the deposits in this region) would seem to militate against such a view, there is, nevertheless, sufficient evidence, both stratigraphical and paleontological, to support this conclusion. In the first place, by determining the position of the buhrstone rock near St. Stephen's as immediately underlying the highly fossiliferous greensand layer, Tuomey has proved that the two series of deposits (the Buhrstone on the Tombigbee, and bed "*c*" on the Alabama) hold relatively the same position to the true Claibornian, lying immediately below it. In the second place, the argillaceous strata at the base of Claiborne Bluff (bed "4" of Hale's series) have been identified by Hale, both on lithological and paleontological evidence (A. J. Science, new ser., VI, p. 356), as occurring at Coffeeville Landing on the Tombigbee River, about 14 miles north of St. Stephen's, what might very readily have been expected from an inspection of the general lay of the different formations.[1] No data are given relative to

[1] A line uniting Claiborne and Coffeeville Landing would run almost precisely parallel with the line marking the junction of the Cretaceous and Tertiary deposits lying hence due north. The contour lines traced by Tuomey would indicate a *true* dip west of the southerly line, and that this

the position of the Buhrstone at this last locality, but hypothetically considered (as deduced from its position at White Bluff, and its general dip), its summit must still occupy a position fully 100 feet above the level of the river; and this thickness (100 feet) coincides very closely with the thickness (80 to 90 feet) of the deposits below the true Claibornian (bed "d") as exposed at the bluff on Alabama River. And finally, that at least a very considerable portion of the inferior beds at this last named locality represent strata of a different lithological character in other portions of the state—and consequently, that they are local deposits—is proved by the concurrent statements of Hale (*loc. cit.*, p. 356) and Winchell (*loc. cit.*, p. 86), both of whom assert that the calcareous deposit below the arenaceous bed (not the "White Limestone") is not known to occur at any other locality.[1]

Admitting the conclusions reached in this paper, it will be seen that the Alabama Eocene deposits comprise:—

4. "White Limestone" (Jacksonian), best exhibited at Claiborne (upper portion of bluff) and St. Stephen's (lower moiety of bluff), not very abundant in fossils—*Pecten membranosus*, *P. Poulsoni*, *Ostrea panda*, *Spondylus dumosus*, "*Scutella*" *Lyelli*, etc.—50 — ? feet.

3. The fossiliferous arenaceous deposit (Claibornian), best shown at Claiborne—subaqueous at St. Stephen's—very rich in fossils, and of the age of the "Calcaire Grossier" of France —17 feet.

2. "Buhrstone" (Siliceous Claiborne of Hilgard), comprising siliceous clay-stones (buhrstone proper) densely charged with fossils or their impressions, laminated clays, sands and calcareous deposits—beds "*b*" and "*c*" of the Claiborne section, the cliff at White Bluff, and the so-called "Chalk

is actually the case is proved by the difference (80–90 feet) between the actual heights at which the equivalent beds at St. Stephen's and Claiborne are placed. This also accords with Hilgard's observations in Mississippi, where the dip of the Jackson and Vicksburg strata was found to be about 10 to 12 feet per mile S. by W. (A. J. Science, new ser., XLIII, p. 36).

[1] It is greatly to be hoped that under the present able management of Dr. Smith, the survey will be able to yield much more satisfactory data connected with the geology of the State than have heretofore been rendered.

Hills" of the southern part of the State. At Claiborne the representative beds consist of aluminous and calcareous deposits, poor in fossils, but containing occasional layers of *Ostrea sellæformis*—about 250 feet?

1. The Wood's Bluff and Bashia (with Cave and Knight's Branches) deposits (Eo-lignitic), consisting of alternating dark clays, greenish and buff sands, and numerous seams of lignite, partly very rich in fossils, and as far as is yet *positively* known, the oldest Tertiary deposits of the State.—50 — ? feet.[1]

It is the intention of the writer to discuss in a future paper the relations of these various Alabama deposits to those of other sections of the United States, and to correlate them, as far as possible, with the Eocene deposits of the typical European basins.

[1] It appears to the author that it would be convenient to designate these lower deposits, which hold a rather constant position at the base of the Eocene series in different parts of the eastern and southern United States, by a term which could be readily applied in adjective form, and which would at the same time in some manner express the relation of the beds referred to. He therefore proposes the term "Eo-lignitic," which, while it to some extent indicates the general character of the beds so designated, is not restricted in its definition to the character of the deposits of any one single locality. The "Buff Sand" of Winchell (*loc. cit.*, p. 89), probably falls into this group, but its exact position, or its correspondent, does not appear to be as yet definitely determined. It is seen to underly the "Buhrstone," and is considered by Winchell to represent the absolute base of the Tertiary system of the State. At Black's Bluff, Wilcox Co., it is stated to repose directly on the subjacent Cretaceous limestone, but in a foot-note (p. 90), we are informed that, according to Tuomey, the characteristic fossil of this limestone, an *Ostrea*, is probably Tertiary.

JULY 5.

The President, Dr. RUSCHENBERGER, in the chair.

Seventeen persons present.

A paper entitled, "The Snare of the Ray Spider, Epeira radiosa, a new form of Orb-web," by Rev. H. C. McCook, D. D., was presented for publication.

Sarcodes sanguinea.—Mr. THOMAS MEEHAN referred to discussion among members at former meetings, as to the true character of parasitic plants. They were believed to be in the main of two classes,—one which might be represented by the common mistletoe, with woody stems continuing from year to year,—the other like the *Arceuthobium*, or pine parasite, which died to the surface of the wood, but continued to grow up from the same spot every year—a sort of parasitic herbaceous plant. It was a question how far root parasites partook of these several characters. There were some plants, as *Castilleia* and *Comandra*, which might be said to be in a transition state between an ordinary terrestrial plant and a parasite. Usually they were as other plants, but some of the roots would attach themselves to other roots, and form as perfect a union as genuine parasites, and, by the decline in vigor of the victim root beyond the point of union, evidently showed they were really parasitic, deriving nourishment from the attachment. *Aphyllon uniflorum*, germinated on the annual fibrous roots of Asters and Solidagoes, as had been clearly traced, and perhaps on other plants; and after germination formed a mass of innumerable coral-like spongelets, drawing moisture and perhaps some other elements of nutrition from the surrounding medium. *Epiphegus Virginiana* behaved precisely in the same way. *Monotropa* and others had also this mass of pseudo-roots, or spongelets, and had been supposed to germinate and live wholly on half decayed vegetation, but he believed from analogy they would be found, as in *Epiphegus* and others, to germinate at first on living roots. *Conopholis* was the only root parasite he had found any reason for believing to be a perennial. This had been found attached to quite large roots, evidently coming up from the same spot from year to year as *Arceuthobium* does.

Having correspondents in regions where grows the beautiful Snow-plant of the Sierras—*Sarcodes sanguinea*—about which nothing but its aerial character has been so far known, he had set them to watching for him, their appearance and final end. The places where they grew were carefully marked, and with the following results :—Mr. John M. Hutchings, of Yosemite, found the bottom of the old plants 10 to 14 inches below the surface, with not the slightest signs of attachment anywhere. To him it appeared no more than an "ordinary annual plant of great beauty." Of course an ordinary annual growing from seed, could not push through the ground at so great a depth. The vital power spent in overcoming so heavy an obstruction, would be exhausted long before the growing point pushed through a foot of soil to the surface, as observing seed growers of experience would testify. Only a parasite, or bud, having an unlimited supply of food to draw on could accomplish this feat. But the matter was settled by another observer, Mrs. Ross Lewers, of Washoe Valley, Nevada, who, together with her observations, had sent the dead spongy mass from the last year's plants, which Mr. M. exhibited, and these were found to have a slender pine root through the mass around which the spongy mass had grown, and as it was dead, there was little doubt that it had been the matrix from which the seed had made its original start, and which the plant killed in the end. The dead, spongy mass of pseudo-roots was larger than he had seen in any other species of root parasite. Altogether it might be said that *Sarcodes sanguinea* was an annual, germinating on small pine roots, and subsequently obtaining subsistence from the earth as *Aphyllon*, *Epiphegus*, &c.

Talinum teretifolium.—Mr. THOMAS MEEHAN remarked that the point he made recently in regard to *Draba verna*, that mere light alone evidently failed to account for the special opening-time of flowers, was confirmed by recent observations on *Talinum teretifolium*. When preparing the chapter on this plant for his "Native Flowers and Ferns of the United States," a few years ago, he had watched plants almost daily through the whole season and found that without any exception they opened at 1 P. M. and closed at 2. This season he had watched them again and found that though the time of opening was the same, 1 P. M., they never on any occasion noted, closed at 2, but continued open sometimes to half-past three or half-past four, and on one occasion were found closing at half-past five. Mr. Meehan said he had endeavored to associate these variations with some atmospheric changes, such as heat, light, or moisture, but in no case did these endeavors prove satisfactory. In the "Proceedings of the Kansas Academy of Science," Professor Smyth had contributed materials for a "floral clock" for Kansas, and *Talinum teretifolium* was set down in the list as opening at 11 A. M. in that State.

Mr. Meehan believed that the laws influencing this peculiar class of motion in flowers, were completely hidden from us, and that the subject offered an inviting field to the biologist.

Mr. Redfield suggested that perhaps the age of the plants made some difference in their habits.

Mr. Meehan replied that the patch in his garden was much larger now than at first, from addition through self sown seeds; but all the plants behaved precisely alike. He did not suppose that external circumstances had no influence; but that the condition of the living material on which they acted, decided the final character, and that Mr. Redfield's question was in the right line.

JULY 12.

The President, Dr. RUSCHENBERGER, in the chair.

Ten persons present.

The death of John P. Brock and of Alfred D. Jessup, members, was announced.

The following was ordered to be printed:—

THE SNARE OF THE RAY SPIDER (EPEIRA RADIOSA), A NEW FORM OF ORB-WEB.

BY HENRY C. McCOOK, D. D.

In the vicinity of Philadelphia, June 14, 1881, I found a number of spiders grouped not far from each other on Epeiroid webs, which proved to be of a type hitherto unknown, and which I designate as the Actinic or Ray-formed Orb-web. The spider appears also to be new to science, and is named *Epeira radiosa.*[1]

I. CHARACTER OF THE WEB.

The first example or two of the spiders collected seemed to be upon nests that had been broken by ordinary wear and tear in

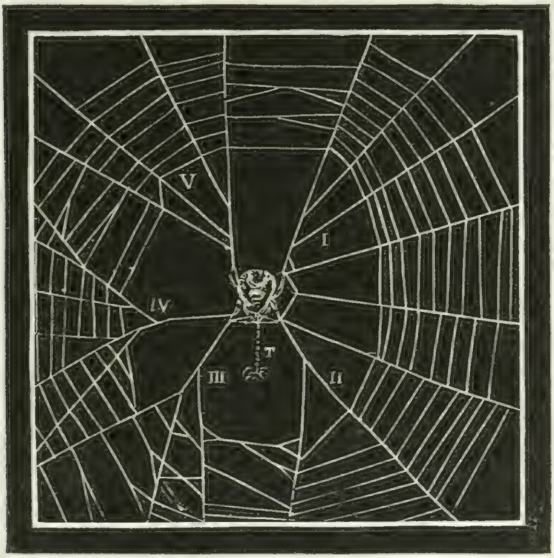


FIG. 1.—The Ray Spider seated in her snare, just before drawing the trap-line.

capturing insects; but the repetition of the form in a third snare, particularly of the peculiar open central, caused more careful examination. The result was the discovery of the remarkable

[1] *Radiosa,* full of rays. A closer study of the spider may compel the change of its generic position.

form of web here described. On account of the continually changing form of the snare, it will be necessary to present it from various points of view, and as seen in different stages of its diurnal changes.

Fig. 1 presents a view of the snare in a partially relaxed condition. The spider is seen seated in the centre of a series of rays, i, ii, iii, iv, v, which are grasped by the third and fourth pairs of legs. There is no hub, properly speaking, but the axes of the rays may be seen at times united upon a central point, as at H, fig. 2. The general tendency is to four or five main divisions or

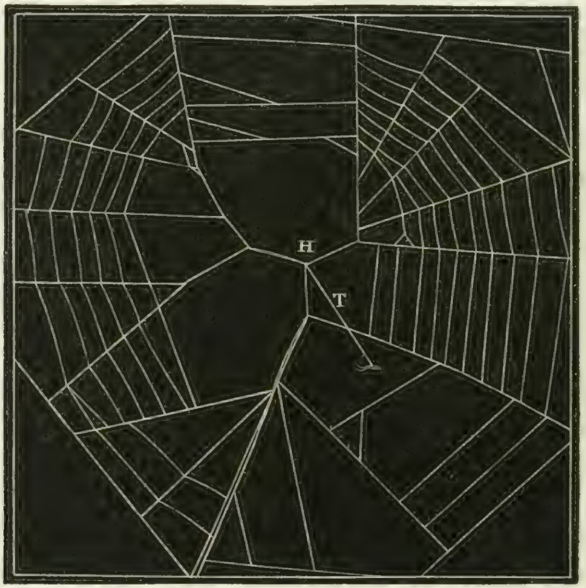


FIG. 2.

rays, as may be seen by studying the figures presented. But there is more or less variation, and in the course of the day's usage in capturing prey two sections will become interblended upon one axis, as appears to be the case in fig. 2, and also in fig. 4.

The central space is a large irregular opening, constituting about one-third of the entire snare, whose diameter is usually from three to five inches (see fig. 3). The central circle, meshes, and notched spirals which so generally characterize the Orb-webs are thus wholly wanting here.

The orb may be said to be composed of a series of independent rays or sectors, each ray composed of several spirally crossed radii, and the whole series united into an orb by cross-lines or spirals like those which unite the radii. In the shifting of the section-lines above referred to, this separation of the orb into independent rays, is always quite evident. The spirals are covered with viscid beads, as in most orb-webs The radii do not all pass to the Hub or Centre, as do those of orb-webs generally, but converge for the most part upon the axes of the rays as represented at figs. 1, 2, 3. These axes themselves converge upon a

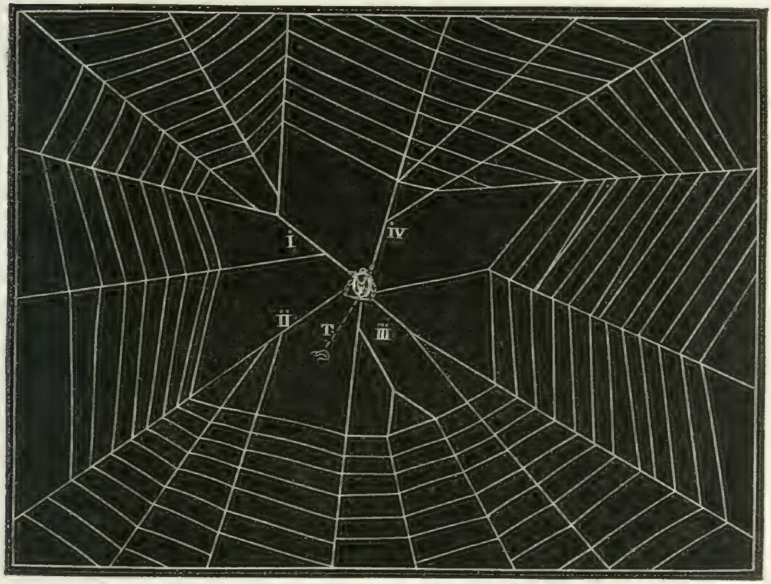


FIG. 5.—View from front. Web taut. Perspective not shown. Central opening exact.

single strong thread, a trap-line, T (figs. 1 and 2, and succeeding cuts), which is attached to some part of the surrounding surface, of rock, earth or plant. When the snare is flat or relaxed, as was the case with the one drawn at fig. 2, and as appears in fig. 1, the trap-line is often about perpendicular to the plane of the orb, as is the handle to the rays of an open Japanese umbrella. This, however, depends somewhat upon the environment; a convenient point for the attachment of the trap-line will cause the animal to divert the thread more or less from the perpendicular.

We may now suppose the spider placed as in figs. 1 and 3, at the point where the rays converge, grasping the axes with the four hind feet. The two front feet seize the trap-line and draw it taut. Then, precisely as a sailor pulls upon a rope, "hand over hand," the little arachnid's feet move along the trap-line, one over another. The axes of the rays, held firmly in the hind feet, follow her; the centre of the snare bears inward, the other parts are stretched taut, and the web at last has taken the form of a cone or funnel (figs. 4, 5). In this position the snares continually suggested to me the figure of an umbrella with ribs reversed by the wind and the covering

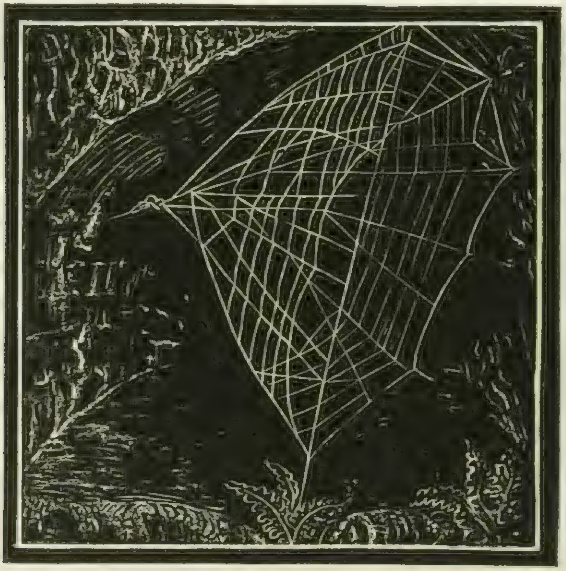


FIG. 4.—Side view of Ray Spider's snare, when drawn taut or bowed. Seen within a cavity.

stripped loose from the top of the handle. Fig. 4 gives a side view of the web when thus bowed or drawn taut; another snare is shown at fig. 5, as seen from behind.

In this example (fig. 5), the spider has moved quite down the trap-line to the surface of the little twig (projecting into the cavity) to which it is attached. It will thus be seen that the snare is more or less a plane surface, or more or less conical, according to the position of the animal upon the trap-line and the degree of tension thereof.

II. Mode of Operating the Snare.

When an insect strikes the snare, the spider has two modes of operating. The first somewhat resembles that of the ordinary orb-weaver in that the insect is simply permitted to entangle itself and is then taken, swathed, returned to the centre and eaten. There is, however, this difference: before going to the insect, the axes of the snare are twisted or knotted, by a rotary action of the body and movement of the legs, so that the untouched parts of the orb remains taut. Fig. 2 represents a snare thus "locked,"

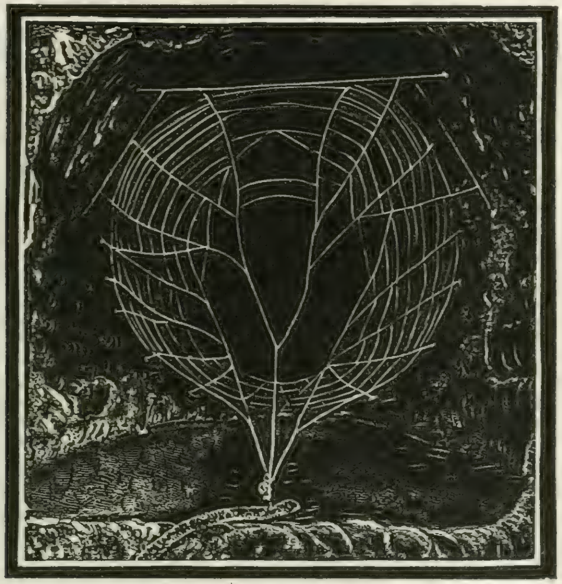


Fig. 5.

or, perhaps I might more properly say, "keyed." The trap-line is now relaxed, although its elasticity is such that the change can scarcely be noticed. The spider then moves upon her victim, quite habitually cutting out the spirals with her mandibles as she goes. When the insect is ensnared well towards the circumference of the web, and indeed, for the most part, in other cases also, it results that the ray or sector upon which the entanglement had occurred, is quite cut away. The spider thereupon proceeds to operate the remaining parts of her snare, which. in time. is thus destroyed by sections, as will be fully illustrated hereafter.

The second mode of operation resembles that of the Triangle spider, *Hyptiotes cavata*, Hentz, which has been so admirably described by Wilder, and which I have very frequently and fully observed in the suburbs of Philadelphia and throughout Pennsylvania. It is at this point that the habit of our Ray spider becomes particularly interesting. The Triangle spider makes a triangular web, which is in fact an orb sector, composed with unvarying regularity of four spirally crossed radii converging upon a single line T (fig. 6, a). Upon this line the spider hangs back downward, grasping it with all her feet, and having a portion of the line, SI (fig. 6, b), rolled up slack, between her two hind, or sometimes,

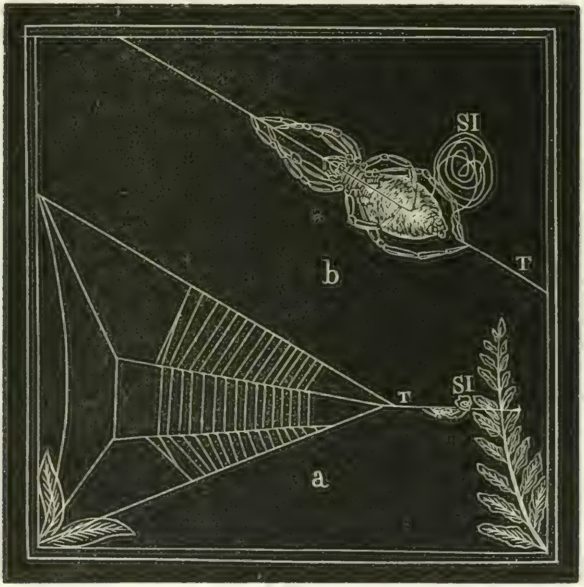


FIG. 6.—Triangle spider hanging upon taut snare. a, Spider in position. SI, Ball of slack-line. b, Enlarged figure of spider, showing the mode of grasping the line.

apparently, her fore and hind feet. Thus the forward and back parts of the trap-line are taut, while the intermediate part is slack. The spiral parts of the snare are also taut. When the web is struck by an insect, the spider suddenly releases her hind feet, the slack line sharply uncoils, the spider shoots forward, the whole web relaxes, as at fig. 7, and the spiral lines are thrown around the insect. This is repeated several times before the prey is seized.

Precisely the same action characterizes the Ray spider. Her ordinary position, or at least the one in which I most frequently observed her, is a sitting posture, back upward, as shown at fig. 1. The axes of the rays are held in the third and fourth pairs of legs, the fourth commanding the upper, the third the lower series, quite habitually, as it appeared to me. A sort of "basket," or system of connecting lines, shown at figs. 1, 9, unites all the feet, seeming to converge toward the fore-feet (perhaps, upon the second pair), where they grasp the trap-line. It is upon this foot-basket that the spider sits when her net is bowed.

This, however, is not the invariable posture; in the reconstruction of the rays and shifting of the axes, as the day's work tells

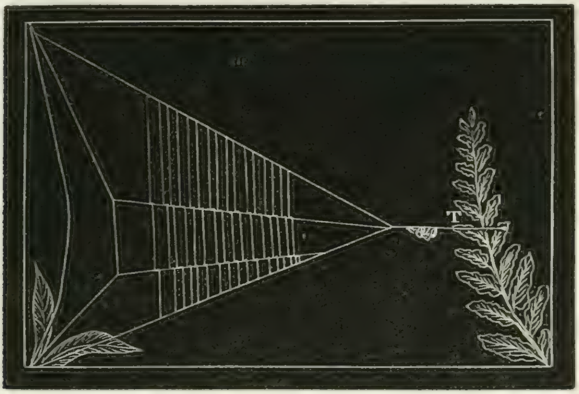


FIG. 7,—Triangle spider, *Hyptiotes cavata*, with slack-line uncoiled and snare relaxed.

upon the snare, the spider will vary her posture to that of fig. 5. The trap-line generally has a direction downward rather than upward, so that the head and fore-feet tend to be depressed below the abdomen, and this depression may gradually result in the complete inversion of the animal, fig. 5, so that she assumes the natural position of orb-weavers. I have even seen individuals with the back turned downward, fig. 8, as is the habit with the Triangle spider and with all those species who make a dome or horizontal orb-web, as the Basilica spider, *E. basilica* McCook, and the Orchard spider, *E. hortorum* Hentz.

If now the feet of the spider be carefully examined with a good glass, *a coil of slack-line* will be seen, precisely as in the case of the Triangle-spider. This is illustrated at fig. 8, where a, b, c, are the axes of several rays, grasped in the third (3) and fourth (4) pairs of legs, and Sl is the coil or slack-line between these and the fore pairs (1 and 2), or simply between the pair of fore-legs, 1 and 2. As the spider does not exceed one-eighth of an inch in body length, and the position of the snare is within cavities and interstices of rocks, where the light does not bring out the delicate tracery of the fine webs, the observation of these and other points of like character, is a matter of some difficulty. But, although the exact relations of the coil to the feet were sometimes in doubt, and indeed seemed to vary somewhat, the existence of the coil and its general relations were determined beyond doubt. It is also certain that the slack-line sharply uncoils and straightens when the spider releases her grasp upon the trap-line, and that the web unbends and shoots quickly forward. It is instantly changed from the bowed or conical form of figs. 4 and 5 to the circular plane of figs. 1 and 2.

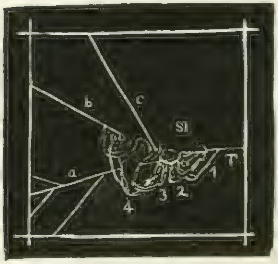


FIG. 8.—Ray spider (greatly enlarged) in position on taut snare. To show the slack-line coil, Sl.

The following points, however, long evaded my observation, before webs were found which presented the conditions for successful study. But at last I was well satisfied, although I hope for further and fuller verification during the present summer. The "springing" of the snare is caused by the sudden releasing of the trap-line from *the fore-feet*, instead of the hind-feet, as with the Triangle spider. The polarity of the two arachnids relative to their webs is reversed, Hyptiotes having her fore-feet, but Radiosa her hind-feet towards the web. The slack-line is therefore coiled between the two fore-feet or between the fore and hind-feet of Radiosa, but between the two hind pairs (as a rule) of Hyptiotes.

A glance at fig. 6, b, will suggest the manner in which Hyptiotes is affected when her two hind feet are released from the trap-line. The coil, Sl, straightens, and the whole body of the spider shoots forward. If now we turn to Radiosa, as represented at fig. 8, or again, as shown somewhat better at fig. 9, we observe that if the *fore-feet*, 1, 2, fig. 9, are released suddenly from the trap-line, T, the whole body shoots *backward*, although still toward the snare, as with Hyptiotes. This was the action which I observed.

The determination was finally accomplished by first carefully sketching the arrangement of the basket stretched between the feet (2, 3, 3, 4, 4, fig. 9). With this chart in one hand, and in the other hand a magnifying glass focused upon the feet, I watched until favored with several successive and unsuccessful springings of the net. As the spider only leaves her seat when she thinks that an insect is well entangled, and again bows her net by pulling on the trap-line if no prey be ensnared, the above conditions enabled me to compare my chart of the basket, with the basket itself as seen under the glass. I found that the outlines on the paper and the lines under the animal's feet exactly corresponded. There had therefore been no change in the relative positions of the hind-feet, mandibles and palps, perhaps also of the second pair (2) of feet. There had been an actual (not seeming) motion of the body with and in the direction of the web, and this had been caused by releasing the first pair of legs (1) from the trap-line.

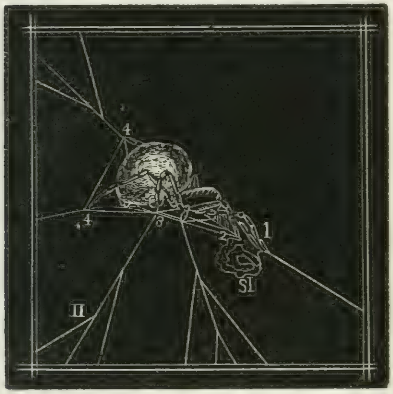
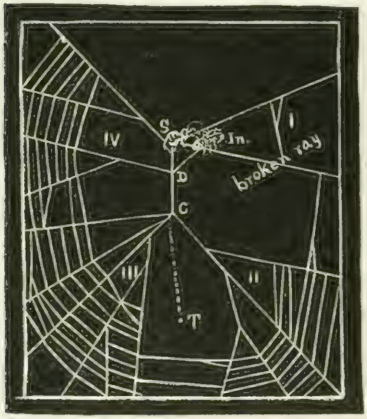


FIG. 9.—Ray spider in position showing slack coil Sl, and foot-basket, 2, 3, 4.

The importance of this determination seems greater from the fact that I had at first concluded that the Radiosa actually *operated her snare by sections*. That is, instead of springing the whole orb at once, as above described, she simply sprung *the ray struck by an insect*, by unclasping the foot holding the axis of that ray. Thus, ray ii, fig. 9, would be sprung by releasing the axis of ii, from No. 3, the third foot. This is probably not done when the snare is in complete form (as at figs. 1, 3, 4), but I now believe that it *is* done when the web has been partially destroyed, and is reduced to two rays or sectors as at fig. 11. This I hope to determine accurately during the current summer. If it should be verified we shall have another resemblance between the habits of Hyptiotes and Radiosa.

III. Gradual Obliteration of the Web.

The fragmentary condition of Radiosa's web after contact with insects has already been referred to. The snare is gradually obliterated, a conclusion to which the spider herself very curiously contributes. When an insect strikes the snare, as at fig. 10, ray I (broken ray), Radiosa first "keys" the snare by twisting together the foot-basket and the parts adjoining (C), including the end of the trap-line This maintains the compact condition of the snare after the spider has left the central point at which she has held all parts together in the manner heretofore described. Then the insect is sought. Creeping along the axis of the ray upon which is the entanglement, she cuts away the cross-lines as she goes, leaving the bare skeleton of radii, as shown, fig. 10, I, *broken ray.* The insect is then brought back to a point (D) near the centre, but (in this case at least,) above it, where it is eaten. While the feast goes on, not unmindful of future supplies, the spider (S) clasps the adjoining axis and (C D) the connecting lines, which appear to be in condition for operating somewhat in the usual way. When the insect is eaten, the former position is resumed, the trap-line clasped, and the net bowed and tightened.



FIG, 10.—Ray spider. Action when an insect is taken. S, Spider; In, insect.

After a morning's trapping, if the game has been plenty, and generally towards the middle of the afternoon, Radiosa's snare will be found reduced to one or two rays or fragments of rays. I have seen it reduced to a bare skeleton. In fig. 11, there are one ray (I), and two fragments of two others united into a new ray, and these are placed in opposite parts of the orb. Again, one-half of the orb may be eliminated (fig. 12), leaving two radii (i, ii) to operate with.

Radiosa was also observed to construct or adopt a new trap-line, thus changing, so to speak, her base of operations. This action is illustrated at fig. 12, where T*a* is the original, and T*b* the new trap-line. This is not a frequent occurrence, as the necessity for changing the original line does not appear to arise frequently.

IV. The Affinities of the Actinic Orb with other Orb Webs.

Not the least interesting and valuable feature of the Ray-spider's industry, is that it discovers a connecting link between two forms of snare which stand at the very opposite poles of the spinning-work of the (Orbitelariæ) orb-weavers. At the one extreme is the familiar circular snare or full orb of the ordinary garden spider, as, for example, that of *Epeira domiciliorum*, Hentz, fig. 13. At the other is the orb-sector of the Triangle spider, figs. 6, 7. A glance at these will show how far they are apart in structure. The same separation appears in the habits of the two araneads.[1] As opposed to the Hyptiotes, the spiders of which *E. domiciliorum* is a type hang head downward in the

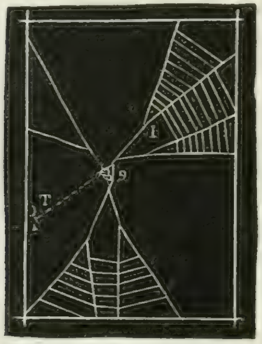


Fig. 11.—Ray spider's snare after usage in taking prey.

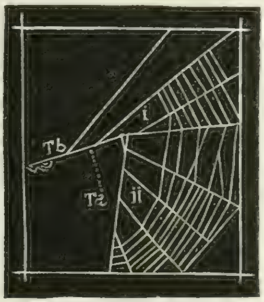


Fig. 12.—Ray spider. Half of orb eliminated and a new trap-line, Tb, formed.

centre of the orb, with their feet grasping small groups of the radii; or sit in a silken den, or crevice, holding to a taut trap-line which is connected with the centre. There is no slack coil, and no springing of the net as with the Triangle spider.

The industry of Radiosa, it is now seen, is united to that of the Full Orb makers (*E. domiciliorum, et al.*), on the one extreme, by the completeness of the circle; but with that of Hyptiotes, on the other extreme, by the independent character of the rays, the nature of the trap-line, and the entire mode of operating the snare. The facts necessary to trace their affinities I have already given.

[1] I hope that I shall be tolerated in the invention of this general word for members of the Order Araneæ; "Arachnid," the class term, is too general; "aranead" is needed for the true spiders.

Some of the striking differences I have also recorded, and they may thus be summarized. The web of Hyptiotes is a single sector; that of Radiosa has four or more, united. Hyptiotes commands one line with her feet, the trap-line and its continuation; Radiosa commands several axes, which are connected with, but not continuous of, the trap-line. Hyptiotes has her head, Radiosa her abdomen towards her snare. Hyptiotes habitually hangs to the trap-line, back downward; Radiosa generally sits upon a foot-basket of lines, back upward. Hyptiotes shoots forward when her net is sprung; Radiosa shoots backward—but both spiders move toward their webs. Hyptiotes holds her slack coil between the two hind-feet (apparently); Radiosa between the fore-feet. In these differences, the points wherein Radiosa varies from

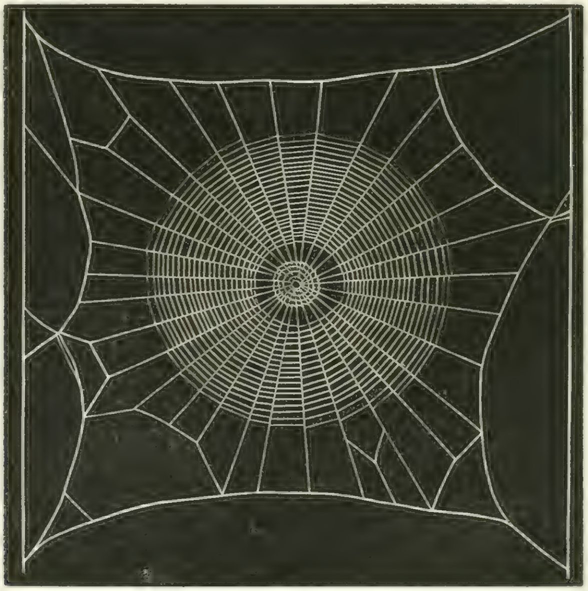


FIG. 13.—Full-Orb snare of *Epeira domiciilorum.*

Hyptiotes show a quite apparent approach to the behavior of *E. domiciliorum* and the Full-Orb makers. Thus the distance which heretofore had separated between the far-away extremes of the spinning-work of the Orbitelariæ, has been completely bridged over by the industry of our little indigenous aranead—the Ray spider. It is to be remarked that while structurally the Triangle spider is as widely removed from the Domicile spider, as economically, the Ray spider is more closely allied structurally to the latter than the former.

V. Natural Habitat and Environment.

The first specimens of Radiosa taken were hung in large openings left between the breastwork stones of a very old mill-dam. The wall had crumbled and quite fallen away in places, leaving large cavities, within whose moist, cool shelter, among ferns and mosses, this, with several species of spiders, had domiciled. The brook poured over the middle part of the wall, making a pretty waterfall; briers, bushes, ferns and various wood plants grew out of the wall and stretched over a deep pool 12 or 15 feet in diameter, into which the fall dropped. On the lower bushes and branches above the stream, and continually agitated by the splashing of the water, was a colony of Stilt spiders, *Tetragnatha grallator*, stretching their long legs along their round webs, and dancing with the motion of the waves; the beautiful nests of *Phillyra riparia*, Hentz, nests of *Tegenaria persica*, *Lyniphia communis*, *L. neophyta*, *Epeira hortorum*, and one or two species of Theridiords, were in close neighborhood. The whole pretty scene was embowered in a grove of young trees. A more charming habitat could not well have been found.

Another colony, not far away, was established within the cavities formed underneath the roots of a large fallen tree, and beneath the ledges of some rocks over which the roots turned. In several similar positions were found the same nests, and also among the rocks in a wild ravine through which ran the stream Lownes' Run.[1]

Further explorations of the surrounding country showed that the spider was largely distributed, and in similar conditions. I found numbers in ravines, on the broad leaves of the skunk cabbage, *Symplocarpus* (or *Ichtodes*) *fœtidus*, the snares stretched over the brooklet, and beneath the shelving banks. They were also found among the rocks of Crum Creek over the beautiful drive to Howard Lewis' mill. The habitat of the Ray spider may therefore be described as moist, cool, shaded cavities and recesses among rocks, roots, beneath banks and foliage, over or near running water.

[1] Since writing the above I have found Radiosa in similar environment at Mineral-spring Glen, New Lisbon, Ohio.

JULY 19.

The President, Dr. RUSCHENBERGER, in the chair.

Twelve persons present.

A paper entitled "A Revision of the Cis-Mississippi Tertiary Pectens of the United States," by Angelo Heilprin, was presented for publication.

JULY 26.

The President, Dr. RUSCHENBERGER, in the chair.

Twelve persons present.

A New Form of Fresh-water Sponge.—A note was read from Mr. EDW. POTTS, reporting the discovery in Chester Creek of another curious form of fresh-water sponge, a third species of *Carterella*, resembling *C. tubisperma* in the character of its birotulates and the length of its foraminal tubes, but much more robust than that species. The tendrils are nearly as long as those of *C. tenosperma*, but broad, flat and ribband-like.

Thus far it is the most conspicuous and peculiar of our American forms. He proposed for it the name *Carterella latitenta*.

John G. Graham was elected a member.

The following was ordered to be printed:

REVISION OF THE PALÆOCRINOIDEA.

BY CHARLES WACHSMUTH AND FRANK SPRINGER.

PART II.

FAMILY SPHÆROIDOCRINIDÆ,

INCLUDING THE SUB-FAMILIES

PLATYCRINIDÆ, RHODOCRINIDÆ, AND ACTINOCRINIDÆ.

The first part of this work was published contemporaneously with the "3d Lieferung" of Professor Zittel's "Handbuch der Palæontologie," which embraces the Crinoidea.

In his classification, this distinguished author follows Johannes Müller, and divides the Crinoidea into three orders: *Eucrinoidea* (*Brachiata*, Müller), *Cystoidea*, and *Blastoidea*; subdividing the first into the Tesselata, Articulata, and Costata. The "Tesselata" agree in general features with our *Palæocrinoidea*, and the Articulata with the mesozoic and recent Crinoids, for which we have proposed the name *Stomatocrinoidea*; but while we treat these groups as of the same rank with the Blastoidea and Cystoidea, they are, according to Müller and Zittel, mere subdivisions of the "*Brachiata*."[1]

Zittel divides the Tesselata into twenty-six families, among

[1] While this was in press, we received from Dr. Etheridge, Jr., and P. Herb. Carpenter, an interesting paper upon the genus *Allagecrinus*, a new form from the Carboniferous of Scotland, which they consider to be "tesselate" in the younger, "articulate" in the adult state. In a discussion upon Müller's terms, *Tesselata* and *Articulata*, they arrive at the conclusion, that at the present state of our knowledge of these Crinoids those names are inappropriate and should be abandoned. They adopt our name *Palæocrinoidea*, but object to *Stomatocrinoidea*, as they think it possible, that also Crinoids of the other group might have possessed an external mouth. They consider the irregular arrangement of the plates in the calyx, against the almost perfect symmetry which is found throughout the other group, and the vault structure, to be better and more persistent characters for distinction than the condition of the mouth. We can only notice here this important paper, but shall take pleasure to refer to it at some future time.

which his Ichthyocrinidæ and Taxocrinidæ substantially agree with our Ichthyocrinidæ, except that he included among the Taxocrinidæ the genera *Lecythocrinus* and *Gissocrinus*, which we refer to the Cyathocrinidæ. Our Cyathocrinidæ include his Poteriocrinidæ, Heterocrinidæ, Cyathocrinidæ and Hybocrinidæ, except that he places among the first of these families, *Agassizocrinus* and *Belemnocrinus*, which we think belong to other families.

Zittel's classification, in its general results and conclusions, does not differ materially from our own; but instead of subdividing the Palæocrinoidea at once into a number of small groups which he calls families, we separate them at first into comparatively few well-marked groups, which we subdivide when necessary. Our families are not based upon mere differences in the arrangement of the plates, but are expressions of important modifications in the structure of the animal, which must have affected the whole organism, and consequently form the basis of well defined natural divisions.

The groups which we recognize as Ichthyocrinidæ, Cyathocrinidæ and Sphæroidocrinidæ existed at the beginning of the geological record, and flourished side by side until they became extinct. They are so well defined by nature, that once understood there is no difficulty in identifying them. The smaller groups into which we have divided the Sphæroidocrinidæ, are likewise of early origin, but they follow more or less the same general plan in the arrangement of their plates, as well as in their mode of development, individually and paleontologically.

There have been several interesting publications on Crinoids during the past year, containing, among others, descriptions of new species of both Ichthyocrinidæ and Cyathocrinidæ. These species will be noticed and systematically arranged in an appendix at the end of this work.

We are under special obligations to Prof. Spencer F. Baird for access to a number of rare and valuable books in the Smithsonian Library; to Dr. C. A. White, of the National Museum, for numerous favors received during the preparation of this work; to Prof. A. H. Worthen, of Springfield, Ill., and to a number of other gentlemen for the liberal loan of books and specimens, and for other valuable information.

III.—SPHÆROIDOCRINIDÆ.

The above name is proposed as a family designation, to include such forms of the Palæocrinoidea, in which both calyx and vault are constructed of a large number of immovable plates and these forming inflexible walls ; with several orders of radials, and one or more of interradials on both the oral and aboral sides. The Sphæroidocrinidæ differ thus conspicuously from the Ichthyocrinidæ with their flexible walls and squamous vault, and from the Cyathocrinidæ with their uniform elements of three rings of plates in the calyx, without interradials, and with simple oral plates in the vault.

The family, as thus defined, will include genera with underbasals, and genera without them. In this we differ from most authors, who make the presence or absence of these plates a marked family distinction, and who place together within the same family Cyathocrinidæ, Ichthyocrinidæ and Rhodocrinidæ.

Pictét, Traité de Paléontologie, vol. iv, included in his "Cyathocriniens" our Cyathocrinidæ, Rhodocrinidæ and partly our Ichthyocrinidæ ; from the former, however, he excluded *Graphiocrinus*, which had been described by De Koninck and Lehon with a single circle of plates beneath the radials, and from the latter *Forbesiocrinus* and *Taxocrinus*, in which underbasals had not been discovered ; while he admitted the allied genera *Ichthyocrinus*, *Lecanocrinus* and *Mespilocrinus* in which they had been observed. Similar opinions were held by d'Orbigny, Hall, Miller, Austin and others, not including, however, Roemer and Schultze, who made the Rhodocrinidæ a distinct family.

In the first part of this work we have discussed somewhat fully the relations of the underbasals, which we took to be the product of growth in geological times, introduced gradually by interpolation between the basals. It is very remarkable that, although the introduction of underbasals dates back to the Lower Silurian, as a rule, the genera in which those plates are found differ at no time materially from those in which they are wanting. Even as late as the Subcarboniferous, we find such species as *Actinocrinus Whitei*, and *Rhodocrinus Wachsmuthi*, both from the Burlington limestone, so strikingly similar in every respect, both in the structure of the body and arms, that the species cannot be separated except by means of the basal portions. There are similar examples in the Silurian and Devonian, which will be noticed later.

If, therefore, it be true that the underbasals had no important bearing or influence upon the general structure of the Crinoids, there is no good reason for making their presence or absence a family character, and basing thereon a division to rank with the Cyathocrinidæ and Ichthyocrinidæ, whose fundamental structural plans offer broad and unmistakable distinctions. Nevertheless, they are not without importance in classification, and certainly characterize a group of more than generic value. We have accordingly brought together the genera of this family in which these plates exist under the name "*Rhodocrinidæ.*"

The great family Sphæroidocrinidæ includes a vast variety of forms, and a mere separation of these into genera does not meet the requirements of a systematic classification. We find that the genera fall naturally into groups which are well defined. These subordinate groups, which are three in number, we consider to be sub-families, and have arranged them in the following manner:

1. Platycrinidæ.—Underbasals wanting; basals and first radials forming the greater part of the calyx; succeeding primary radials very small or rudimentary; all higher orders of radials embraced within free rays; interradial system but little developed.

2. Actinocrinidæ. — Underbasal wanting; calyx composed of basals; two or more orders of radials; well developed interradial, and often interaxillary series.

3. Rhodocrinidæ. — Underbasals present; calyx composed of basals and several orders of radials; interradial system well developed.

Before proceeding to the more detailed consideration of these groups, we will consider the different parts of which the body in the Sphæroidocrinidæ is constructed, and this will throw additional light upon the relations of the subdivisions.

1. Underbasals and Basals.

The genus *Glyptocrinus* Hall, from the Lower Silurian is one of the earliest, most beautiful, and most instructive types of the Palæocrinoidea, and fortunately is often found in excellent preservation. Looking at the great number of plates which compose its body, at its elaborate ornamentation, one is naturally inclined to consider this as one of the most maturely developed forms in the whole family, but in other respects, it possesses in a marked degree the characters of the young crinoid of later geologic times.

Glyptocrinus was originally described with five basals and no underbasals. Hall afterwards discovered in *Gl. decadactylus* small pieces concealed within the basal cavity, so rudimentary, however, that both he and Meek hesitated to call them basals, although both authors apply that term to the proximal plates in all other cases. Meek distinguished them as "subbasals." We have examined the plates in question very carefully in the species named, and find them, although very rudimentary, placed within the basal ring, hence they are, according to our terminology, true underbasals, and not as Hall describes them a "quinquepartite" upper joint of the column.[1]

In some other species of this genus the underbasals seem to be altogether wanting, at least are not developed externally. In *Glyptocrinus Dyeri* no trace of them can be discovered, though we have examined with reference to this point, some most perfect specimens. If the underbasals were elements of family importance, *Gl. decadactylus* and *Gl. Dyeri* would be representatives of distinct families.

Glyptocrinus is exclusively a Lower Silurian genus. The two species from the Upper Silurian, referred to it by Hall, have been transferred by us to other genera. One of these, *Mariacrinus Carleyi*, is another interesting case illustrating our view that the underbasals have no important effect upon the general structure of the body. *M. Carleyi* would be an excellent *Glyptocrinus* were it not that the calyx below the radials is composed of a single

[1] The underbasals cannot be developed from a columnar joint, or their sutures would correspond with the sutures of the column; whenever this is divided, the division occurs alternately with that of the underbasals, and as a rule alternately with the proximal ring of plates.

ring, and this of only four pieces. *Periechocrinus*, like *Mariacrinus* an Upper Silurian genus and like it without underbasals, has instead of four or five basals, only three. In all other respects these genera agree so perfectly with *Glyptocrinus* that they cannot be distinguished, proving again how closely Rhodocrinidæ and Actinocrinidæ are linked together, and that they are in fact variations of one great group.

Where underbasals are unrepresented, families have frequently been created upon the number of the basals, and Angelin based his entire classification upon the number of proximal plates, whether basals or underbasals. Convenient as this scheme of classification may seem, it is altogether artificial, and combines forms which are widely different, while it separates others which are clearly allied.

We have in the introduction to this work, page 17, dwelt at some length upon the basals or first ring of plates below the radials; and believe we have shown that the basal disk, whether composed of one, two, three, four or five pieces, can almost invariably be reduced to five elementary pieces, and that all deviations from this number have been produced by anchylosis of two or more of the original segments. This, of itself, is a strong argument against a classification based upon the number of these plates.

Among the Actinocrinidæ, only a few genera with the original five basal plates are known, and these are confined to the Silurian; indeed we have good reason to believe that only the very earliest representatives of this group possess a base divided into five pieces. Genera with four basals commence in the Silurian and terminate in the Devonian; while genera with three basals are found from the Upper Silurian to the close of the Warsaw limestone where the family becomes extinct. The genera with four basals have been referred by us partly to the Actinocrinidæ, and partly to the Calyptocrinidæ. The latter family has four basals throughout, but even here this number cannot be considered a family character, since *Melocrinus* and *Mariacrinus*, which have four basals, belong undoubtedly to the Actinocrinidæ. Species with three basals are found among both Actinocrinidæ and Platycrinidæ, and the latter are by no means restricted to this number, as *Dichocrinus*, which has been by most systematists placed in the same group with *Platycrinus* and *Hexacrinus*, has but two basals.

It is apparent from these facts that neither the existence of underbasals, nor the modifications which took place in the basal disk, had any such corresponding effect upon the general structure of the crinoids as to entitle them to be considered characters of family importance, though in distinguishing subordinate groups they may possess some value. The radial and interradial plates are elements of far greater value.

2. Radial Plates.

In our nomenclature we have proposed different terms for special parts of the ray, discriminating between radials, brachials and arm plates. We designate as "radials" the whole succession of plates above the basals radially situated and enclosed within the body walls. The "arm plates" form the movable portion of the ray; the "brachials," while radials in position, are arm plates in construction, being free and distinctly articulated. The term "brachials" is therefore purely a conventional one, employed for greater convenience in description. We designate as "primary radials" those below the first bifurcation, while the "secondary radials" compose the first branches of each ray, the so-called "Distichalia" of Müller and other writers; and those of succeeding bifurcations are distinguished by referring them to the order in which they stand in succession. Müller, in applying the term "distichalia," was evidently not aware, that there are many fossil Crinoids in which these plates give off branches which likewise form a part of the test, otherwise he would not have regarded the arms as commencing at the "axillary distichals."

Schultze, in his Monograph Echinod. Eifl. Kalk, p. 5, improved upon Müller's views, and asserted that "the commencement of the arms begins invariably with the first distinct articulation of the ray." Like Müller, he uses the term "distichalia" for the secondary radials, and proposes no name to designate the plates of the higher branches within the body. Schultze differs from Müller in designating the free radials as arm plates, and in this he agrees with us; except that we distinguish those arm plates which are in direct vertical line with the radials as "brachials."

De Koninck and Lehon regarded the arms as beginning from the first bifurcation in the ray, no matter whether they became free at this point, or remained included within the body walls for some distance. They, however, characterized those plates which are immovably united with the calyx—the "distichalia" of Müller—as "pieces brachiales," and the movable joints as "articles brachiaux."

P. Herbert Carpenter, in his late work on the *Actinometra*, p. 22, states that the views of De Koninck upon the relation of these plates were unquestionably correct in the case of the "Articulate Crinoids," but that their application to the "fossil Tesselata" was beset with some difficulties.

We do not exactly coincide with any of these views. It seems to us that either the entire radial series of plates within the calyx, eventually up to the sixth division, or even higher, must be called radials, or this term must be restricted to the first radial plate. The first primary radials are the only plates, besides the basals, which form a part of the calyx *in all Crinoids*, and which can be homologized with the apical plates of other Echinoderms. All succeeding plates in the series are, in our own opinion, originally arm plates, which by growth during the life of the individual—chiefly, no doubt, in the embryo—and by development in geological time, were enclosed within the walls, and became thus modified into radials, the change being produced by growth and the development of additional interradials and interaxillary pieces. That this was the case in the higher orders of radials can be clearly demonstrated, and we feel confident, from analogy, that the same rule extends to the plates throughout the ray, which in turn suggests the idea that the arms fundamentally commence with the second radials, and not with the axillary plate as intimated by Carpenter, nor with the distichalia of Müller. In practice, however, and in this we agree with Carpenter, it is more convenient to regard the arms as commencing with the first free plate beyond the calyx.

The radials, as we designate them, consist throughout the Sphæroidocrinidæ, of five rows of plates, of two to three each, longitudinally arranged. The upper one bifurcates and supports upon its upper sloping sides two rows of one or more smaller plates—the secondary radials—which in turn, either support the arms directly, or divide again, and are followed by radials of the third order. In species of the latter kind, the upper plate in one or both divisions is axillary and supports on each sloping side another row of radials. The formation of higher orders of radials takes place in a similar manner, only one branch generally bifurcating, and one remaining single. In species with but two orders of radials the number of primary arms is limited to two in each ray, which, however, sometimes branch after they become free. Species with tertiary radials may have either three or four arms to the ray, depending upon whether one or both divisions bifurcate. Upon the same principle species with four orders of radials may have five to eight arms, and those with a fifth order may have from eight to twelve and even sixteen. The first number can only occur when all the branches remain simple; the latter when they all divide. Hence the number of primary arms is dependent upon the number of orders of radials represented in the species, and whether part of them bifurcate again or remain simple. It is important to note that simple arms are always given off from opposite sides alternately.

The number of arms is most frequently only of specific importance, but in cases where certain rays throughout a number of species are distinguished by a smaller or greater number, the arm formula may become almost a generic character, as for instance in *Batocrinus*, where the posterior rays are generally more developed. In *Eretmocrinus* the anterior and two posterior rays are less developed than the antero-lateral rays. In some genera the arms appear to be limited to a certain number, in others they vary. In the typical *Actinocrinus* there are species with four, five, six, seven and eight arms to the ray, but the normal number is uniform in the different rays. In all these cases, however, as well as not unfrequently within the limits of species, there are exceptions.

3. Interradials and Anals.

The interradial and anal plates occupy the intermediate spaces between the five radial divisions or rays in the body, and their number and shape depends altogether upon the number, position and proportions of the radial plates. They vary from a single plate to twenty or more, but are represented even in the young crinoid by at least one plate. In species in which the secondary radials of adjacent rays abut laterally, the number of interradials is naturally small, but when higher orders of radials are present, and especially when the rays are widely separated, the number is comparatively much larger. When the second and third radials are short, the number of interradials decreases, and it increases when they are long and narrow. This increase in number takes place by interpolation, contrary to the radials in which the increase is from the distal ends of the rays. The interradials are designed to fill up vacant spaces in the test, and this accounts to some extent for the great diversity which is found in their number within the limits of a genus, and within species at different stages of maturity. The first interradial is always larger than any of the rest, and is situated between the upper sloping margins of the adjoining first radials, except in some species of the Rhodocrinidæ in which it rests directly upon the basals, separating the ring completely. There are generally two plates in the second series, and two or three in each succeeding one, but in forms where the secondary or tertiary radials form an arch over the interradial spaces, as in *Batocrinus*, there is often only a single plate in the second or third series. The plates decrease in size upwards, those of the uppermost row being sometimes barely visible to the eye.

The posterior or anal area is readily recognized in most of the Sphæroidocrinidæ by its greater width, and by having a larger number, and a somewhat different arrangement of plates. In most of the genera the first anal plate is in line with the first radials, resting upon the basals. In our remarks upon the Cyathocrinidæ we noted the fact that in that family the anal plates, with a few exceptions, are directed toward the right side. In the Sphæroidocrinidæ, on the contrary, the symmetry is always bilateral, in some cases almost perfectly pentahedral, and a vertical section through the median line of the anal area, the anal aperture, the central dome plate, and along the anterior ray, divides the body invariably into two equal parts, and this symmetry, which extends to the arrangement of the arms, is one of the most characteristic features of the family.

The term "anal plates," as now used, designates the entire series of plates which compose the posterior interradius. Properly speaking, however, this is not quite correct. Careful examination shows clearly that the majority of these plates are in the true sense of the word "interradials," while only a few of them are actually "anals," by which we understand plates supporting the anus, or that can be accounted for as being in any way, directly or indirectly, connected with that organ. In the earlier genera, *Glyptocrinus*, *Reteocrinus*, *Glyptaster*, *Archæocrinus*, *Eucrinus*, and in all genera up to the Subcarboniferous in which the anal opening is lateral, the posterior area is distinctly divided into two equal parts by a single median row of plates. This row, which often extends to the anal opening, is composed of the true anal plates, but the plates on either side of it are interradials. By considering the latter, without regard to the median row, it will be found, that the two sections taken together correspond exactly in number and general arrangement with the interradials of the other areas, or at least differ not more than the other four differ among themselves. But it must be observed that in genera in which the first anal plate rests directly upon the basals (*Glyptaster*, *Eucrinus*, *Dorycrinus*, etc.), the first true interradial in the posterior area is divided, and is represented by two smaller plates, separated by a special anal plate (Pl. XIX, fig. 2). In these genera the anals proper extend from the basals to the anal aperture. *Glyptocrinus* and its congeners, in which there is no anal piece represented between the first radials and in which the first interradial range, consists of a single plate in all five spaces, the special anal plates begin with the second range in which there are three plates. In later geological times, when the anal opening became more central, the special anal plates decreased to two or three, and in the typical Actinocrinidæ in which we include the genera *Actinocrinus*, *Amphoracrinus*, *Strotocrinus*, *Physetocrinus* and *Steganocrinus*, they are reduced to a single plate.

Some of the Platycrinidæ have no special anal piece, and the posterior side differs merely by having a somewhat larger interradial, others however, as *Dichocrinus* and *Hexacrinus*, have a very large special plate. In some of the Rhodocrinidæ, like the Calyptocrinidæ, the symmetry of the calyx is almost regularly pentahedral, and none of the plates of the posterior side are actually anals.

4. Interaxillary Plates.

The space within the axil of the secondary radials is frequently filled by plates, for which we proposed in the first part of this work the name "axillary plates." This designation is undoutedly appropriate, but finding that it had been previously used by several authors for the bifurcating plates, we have thought best, in order to avoid confusion, to use the term "interaxillary" for these plates.

In the Platycrinidæ, which have rarely more than a single order of radials within the calyx, interaxillary plates are not represented. In the Actinocrinidæ and Rhodocrinidæ they may be present or absent in the same species, and sometimes in different rays of the same specimen, their number, like that of the interradials, increasing with age.

Roemer and Joh. Müller considered the presence of interaxillaries as of generic value, and the latter proposed a division of the genus *Actinocrinus*, placing all species having those plates under *Pyxidocrinus;* but it is evident that such a division is altogether artificial and not warranted by the facts, and if carried out would produce confusion.

5. Vault.

One of the writers, in a paper upon "the internal and external structure of Paleozoic Crinoids" (Am. Jour. Sci., Sept. 1877), discussed the importance of the vault with reference to classification. It was noted that in a large number of genera, among them *Actinocrinus*, *Rhodocrinus* and *Platycrinus*, and their allies, the ventral covering is composed of strong plates closely cemented together, and that these form a free arch which braces the entire oral side of the body without the aid of oral plates. This is the general character of the vault in the family under consideration.

The vault in the Sphæroidocrinidæ is usually well preserved, owing to its solid structure, and is capable of accurate definition. Its plates vary from a few to many hundred; but, notwithstanding this diversity in number, their arrangement is governed by definite rules. Certain of these plates, which we have termed the "apical dome plates," are represented in every species of this group. They consist of a central piece, occupying a position directly above the oral centre, which in this family is quite uniformly the centre of the disk. It is surrounded by six proximal plates, interradial in position, of which four are large, and equal, and two smaller. The four large plates are placed above the four regular interradial spaces respectively; the two smaller plates which are equivalent to and take the place of one large plate, are directed posteriorly, being separated from each other by anal plates or the proboscis. These seven plates are easily recognized in species with comparatively few summit pieces and a lateral anal aperture (Pl. XVIII, figs. 7 and 9), but their identification is often difficult in forms in which a large subcentral anal tube is interposed between the two small plates, pushing them toward the anterior side, while the central piece rests against the side of the anal tube. (Pl. XVIII, fig. 8).

There are other vault pieces occupying a radial position which are either in contact with those just described, or, as is more frequently the case, separated from them by a belt of small pieces. Their number varies considerably among species, and depends upon the number of primary arms, without reference to the number of bifurcations after they become free. They increase in proportion to the number of primary arms, in the same manner and on the same principle as the plates of the calyx, each order of radials has its corresponding plates in the vault. Therefore, in adult specimens, with some practice the number of arms can be ascertained as well from the dome as from the calyx. In species with two arms to the ray, there are two ranges of corresponding radial plates in the dome; the first or upper being a large bifurcating plate, equivalent to the primary radials of the calyx. This is followed by two other plates, which take the place of the secondary radials, one over each arm base, with a third plate—an interbrachial—between them.

When there are three arms to the ray, there are three ranges of radial dome plates, two plates in direct succession from the large bifurcating plate toward the single arm, and a second bifurcation, with one plate in each branch, toward the division with two arms. In species with four arms to the ray, there are two secondary bifurcations, producing radial dome plates of a third order, leading to each arm base, and so on. There are also interradial plates represented in the summit, occupying intermediate spaces between the radials, but their arrangement is very irregular and their number variable. In some genera the number of vault pieces is enormous, notably in *Strotocrinus*, which has a large number of arms. Looking at such a specimen with its vast number of apparently irregular vault pieces, one would scarcely expect to find this multitude of plates arranged upon a definite plan; and this the same that prevails in the calyx.

We have called the principal plates in the vault apical dome plates, because they correspond to the apical plates of the aboral side. The six proximal plates surrounding the central piece represent the basals or genitals, and the radial dome plates, the radials or oculars. The centre piece may perhaps be compared with the underbasals, or the subanal plate of the Echini.

The apical dome plates, as the apical plates of the calyx, are fundamental elements, and are represented in the vault of all Sphæroidocrinidæ both in the young and the adult, from the Lower Silurian to the Subcarboniferous. They are generally larger than the other dome plates, and more prominent, frequently nodose or spiniferous, though in some species they cannot, at least in mature specimens, be readily distinguished from the other dome-plates which have attained equal size. In some genera, for instance, *Culicocrinus*, Müller, they occupy almost the entire ventral disk; in *Glyptocrinus* and *Rhodocrinus*, on the contrary, they fill only the median part. In some species of *Dorycrinus* the central piece is spiniferous and the radials nodose; in others, all these plates are spiniferous. In *Amphoracrinus* only the four larger proximal dome plates are nodose or spiniferous; in *Agaricocrinus* all apical plates are tuberculose; in *Batocrinus* the entire dome is composed of nodose plates. The proximal plates in some species are attached to the centre plate, in others separated from it by a ring of small accessory pieces, and in still others the centre piece is entirely isolated by the wide belt of minute pieces. The latter is frequently the case in large specimens, and in genera with but few primary arms, like *Megistocrinus*. In this genus it is interesting to find in very young specimens and in the smaller species the central and proximal plates in contact, while in the larger and adult specimens all are isolated, even the proximal plates being separated from each other. The radial dome plates are sometimes attached to the other apical plates, frequently so in young specimens, and generally in the Platycrinidæ.

In *Platycrinus* the radial series of the dome is composed of two rows of pieces alternately arranged, which decrease in size toward the arm bases, and of which the first and larger plate fits in the angle of two adjacent proximal plates.

The vault of the Platycrinidæ differs in several particulars from that of the other Sphæroidocrinidæ, and in these same characters it approaches the Cyathocrinidæ. We elsewhere suggest that the Platycrinoid is the simplest form of the Sphæroidocrinidæ, and that it represents the younger stage of the family. This is indicated by the construction of the calyx, but not less by the structure of the vault. In the genus *Coccocrinus* Müller, one of its earliest forms, the vault is composed of five large oral plates, resting upon the upper truncate side of a single interradial, and, as found in the fossil, it has a central oral opening and lateral grooves for the ambulacral furrows. Zittel has already noted the close resemblance of the above structure with the recent genus *Hyocrinus* Wyville Thomson, and the larval state of *Comatula*, calling it very appropriately "ein embryonales Stadium von Comatula in persistenter Form." The similiarity to *Hyocrinus* is probably merely superficial, as the lateral grooves in *Coccocrinus* were evidently closed by additional plates as in other Platycrinidæ, while they are open in *Hyocrinus*. The oral plates of *Coccocrinus* have been, by several authors, confounded with an apparently similar superstructure in *Symbathocrinus*, *Triacrinus* and other forms, but there is really no analogy between the two structures. The parts which enclose the opening at the oral centre in the latter forms are radial in position, and therefore not oral plates, but merely extended articulating facets of the radials. In those genera, the central space, like the opening at the centre of the oral plates, is also closed in perfect specimens by apical dome plates, which rest directly upon the extended processes. This group will be introduced hereafter as a separate family under the name Symbathocrinidæ.

The ventral disk in *Coccocrinus* bears a close resemblance to that of *Cyathocrinus*, but while the former has an additional interradial interposed between its rádial and oral plates, in *Cyathocrinus* the intermediate plate is absent, and the oral plate rests against the incurved upper margins of the radials. In *Platycrinus* and similar genera, the two series of alternate plates which, as mentioned before, cover the radial regions of the dome, are interposed between three and sometimes five interradial plates, which in *Coccocrinus* as oral and interradial plates occupy the same position. This suggests the question whether these plates in the Platycrinidæ, and the interradial dome plates in the Sphæroidocrinidæ generally, are not the homologues of the oral plates, which are here broken up, and represented by several plates instead of one. This interpretation seems to us the more probable because *Coccocrinus* is one of the earliest known forms of the Platycrinidæ, and may be considered an embryonic type of the family. The homology in *Platycrinus*, however, extends only to the second or upper row of interradials, the first interradial, which exceptionally in this group is placed almost within the dome regions, is identical with the outer interradial plate of *Coccocrinus*, and as such forms part of the apical and not of the oral system.

This view differs somewhat from that expressed by us in Part I, p. 13, where we stated that the oral plate of the Cyathocrinidæ had "no representative in the vault of the Actinocrinidæ, at least not *externally;*" we were not at that time acquainted, with the genus *Coccocrinus*, which has given us new light upon the subject. We have thought heretofore that perhaps the triangular porous structures arranged around the inner test of many Actinocrinidæ, might be the homologues of the oral plates.

The vault throughout the Sphæroidocrinidæ is perforated with a single opening, which in all of them is more or less excentric; in some lateral and placed toward the periphery of the disk; in others sub-central leaning toward the posterior side of the body. The construction of the parts at the inner surface of the dome proves that the opening communicated with the posterior side of the visceral cavity, not with the digestive organs. It is separated from the ambulacral and oral systems by a strong partition attached to the inner surface of the vault, and hence the opening represents the anus, and is not the oral aperture, as has been supposed by the earlier writers.

The anus is either in the form of a simple opening through the vault, or is prolonged into a tube, which in *Batocrinus* sometimes attains a length of three times the height of the body including the arms. The tube is in all cases composed of heavy, generally nodose, wedge-form pieces, which are firmly put together, giving but little flexibility to the structure. It has no openings or pores through its plates or at the sutures, but has in the centre a comparatively small passage, with a minute outlet at the extremity. In cases where the anus is not extended into a tube, the aperture is generally situated within the centre of a wart-like inflation composed of very small pieces. It is possible that in such cases the small inner plates formed a little pliable tube, which could be drawn in by the animal like the anus in recents Crinoids,[1] but a

[1] In the genus *Codonites* of the Blastoidea, we find in connection with the anal opening a similar little tube, which we found in one specimen extended outward, while in another, traces of its little plates are left within the opening.

contraction of the long solid tube of *Actinocrinus*, as has been suggested by Austin, is wholly impossible.

There has been considerable difference of opinion as to whether species with a solid anal tube should be separated from those with a simple opening. Considering the slight distinctions upon which many of the genera have been founded, it would seem that the tubular structure ought to be of sufficient importance to justify a generic separation; but when we consider that various generic groups, after being carefully restricted with reference to all other characters, include both forms, its value as a full generic character must be somewhat doubtful. We once supposed that it might be a sexual difference, but the specific relations of the forms thus distinguished do not sustain that supposition. Both forms are not found in all the groups, though they exist in many, and throughout all divisions of this family. In some cases generic separations have been made upon this character, as for instance *Physetocrinus* has been divided from *Actinocrinus*, *Alloprosallocrinus* from *Agaricocrinus*, etc., while in other cases as *Platycrinus*, *Glyptocrinus* and *Strotocrinus* both forms have been retained in the same genus. It must also be observed, in this connection, that in some cases, especially species with a very slender proboscis like *Batocrinus rotundus*, we find occasionally specimens in which the tube seems to have been accidentally broken away during the life of the animal, and in which the fractured edges of its base had become absorbed and rounded, giving it the appearance of a naturally simple opening. That the simple opening could have been produced in a like manner in *Strotocrinus* and other genera, no one would for a moment suppose after examining good specimens.

The fact that the crinoid lived on without the tube, at least proves that this structure had no important influence upon the general organization of these animals.

A tube is more frequently found in genera in which the arms are arranged in a continuous series around the body, while in species with a simple lateral opening the arms are arranged more or less in clusters, leaving wide spaces between the rays. In the former case, the long tube could discharge the excrements free from the arms, and in the latter it was not needed as the refuse matter could be easily discharged between the bases of the arm clusters. In view of these facts, we think a subgeneric division sufficient to mark the two structures, but this should be done uniformly and we shall accordingly propose subgenera where necessary for this purpose.

The vault does not completely cover the calyx, but leaves along the line of junction a row of oval or circular passages which have been called arms or " ambulacral openings." The belt in which they occur is known as the "arm regions," and their distribution in the different rays is expressed by the " arm formula." Through the arm openings which are very conspicuous in the Sphæroidocrinidæ, food entered the body, and they served as passages for the ambulacral vessels. In a mature specimen the number of primary arms can be ascertained by counting the arm openings; but not always in young specimens, or in species in which the radial portions are extended into free rays.

By " free rays " we mean lateral extensions of the body, composed of a succession of radials, unconnected by interradials, and covered with similar plates, as solidly and in the same manner as the radial portions of the dome proper. These free rays, whether composed of only a few plates as in *Platycrinus*, or extended almost to the full length of the arms as in *Eucladocrinus* and *Steganocrinus*, are actually portions of the body, and the arms are given off from them in the same manner as from the body in other cases.

In the Platycrinidæ generally, there are within the calyx primary radials only, all the higher orders of radials being included within the free rays. In the body of a *Platycrinus* in its ordinary preservation, we find but five arm openings, but whenever the bifurcating plate is well preserved at its distal end, ten openings are visible,[1] and these form passages for the free rays which here divide, each branch giving off arms laterally and from opposite sides. The free rays are rarely preserved in the fossil unless the arms are attached, when they really appear like arms and have been described as such. That they are not arms is proved by the fact that their ventral side is not provided with a furrow, but is covered in the same way as the vault proper. In these forms, as might be expected, the number of arms cannot be determined from

[1] This proves that P. Herbert Carpenter is correct in saying that the division of the arms actually begins at the middle of the bifurcating plates, (on Actinometra, p. 22).

the arm openings, unless the full length of the ray is preserved; any fracture of the ray, whether cutting off one arm or a dozen. shows in the specimen only a single opening.

The Platycrinoid with its simple form, is similar in structure to the young Actinocrinoid, in which some portions of the ray are yet in the condition of free appendages. The young Actinocrinoid, at this stage, has the same number of arms as the adult; but in species with numerous arms, the upper divisions of the ray, which in the mature animal are incorporated in the body walls by means of interradial and interaxillary plates, form free appendages in the younger stage, and consequently the number of arms is comparatively less than in full grown individuals. In *Stroto-crinus*, which has the greatest number of arms, we find in very young specimens only four arm openings to the ray; approaching maturity there are eight, afterwards twelve, and in fully matured individuals there are perhaps sixteen or more. Specimens in different stages of growth, have frequently been described as distinct species on account of variation in the number of arm openings; and this has even been extended to genera. As growth progressed, the upper branches gradually lost their free character by being absorbed into the body walls through the interpolation of interradials and interaxillaries, both in the calyx and in the vault. The plates which covered the ventral side of the free appendages were thus drawn into the vault, and became at length a part of the main body; but the Platycrinidæ, which have no interaxillaries nor increase of interradials, retain the free appendages during life.

As a general rule it may be asserted, that in the Sphæroido-crinidæ the plates of the vault increase in number outward in a similar manner to the plates of the calyx. The various plates of which the body is composed might be separated into two classes:

1. Plates which either do not increase in number, or do so only at the distal ends, and not by interpolation, including the basals, radials and arm plates.

2. Plates which increase by interpolation only, including the underbasals, interradials, anals and interaxillaries, to which we might add the joints of the column.

6. Arms and Pinnules.

The arms in the Sphæroidocrinidæ are either simple or branching, and are constructed either of a single or double series of joints. Single arm joints are restricted to the Silurian, all Devonian and Subcarboniferous genera have two rows of alternately arranged joints in the arms. In the Cyathocrinidæ, almost to the close of the Subcarboniferous, the arms are composed of single joints, but in the Kaskaskia Limestone and Coal Measures a few species occur with double-jointed arms, intermingled, however, with species apparently of the same genus, in which the arms are constructed of single wedge-form joints alternately arranged. These two structures run so closely into each other through transition forms, that we have been compelled to arrange them in some cases under the same genus, although we have in other cases considered the arm structure to be of generic importance. For this we have been criticised by Prof. Wetherby, of Cincinnati, who thinks it "a singular statement, that a character in forms of the same geological age may be generic in one case, and only specific in another." He evidently overlooks the fact that all Crinoids in their young stage have single-jointed arms, and that the double-jointed feature is a product of growth which primarily was only an individual variation, but which, by becoming fixed and constant in certain forms, attained generic value, especially when taken in connection with other characters. The best specific and generic and even family characters, originated in individual variation, and at some period in the paleontological history of the organism were without value as a means of classification. Near the close of the existence of the family Cyathocrinidæ, the double-jointed arm structure began to be developed, in some forms irregularly, in others to such a degree as to be constant, and to form a distinguishing characteristic of many species, which thus fell naturally into a generic group. This process is illustrated in *Eupachycrinus*, *Hydreionocrinus* and *Erisocrinus*, and there are similar examples among the Sphæroidocrinidæ. The young *Platycrinus* and *Actinocrinus* have a single series of cuneiform arm joints, which are constructed exactly like those of the adult *Poteriocrinus*, and the pinnules are given off in a like manner. At a more advanced stage the joints begin to enlarge laterally in such a manner that the sharp inner angles interlock. This process commences at the extremities of the arms, and gradually involves the lower portions down to the bases. During this stage we often find the lower arm joints quadrangular, with parallel sutures, followed by wedge-form and cuneiform pieces, and finally the tips constructed of a double series of plates.

The same development, which thus took place during the life of the individual, is observed to go on in geological times, but not contemporaneously in different families. In the Actinocrinidæ and Platycrinidæ it became complete in the Silurian, and is found invariably in all succeeding forms. In the Cyathocrinidæ, that structure appeared only at the close of the Subcarboniferous, shortly before the family became extinct. In this group, the arm pieces attained that marked wedge-form which everywhere preceded the double joints in the Burlington limestone, and here in some species of *Poteriocrinus* and *Cœliocrinus* the plates began to interlock already at the tips of the arms. This became more frequent and more conspicuous in the Kaskaskia group, where in some few cases, it extended to the entire arm.

The different stages of individual growth, as they became gradually introduced paleontologically and fixed, undoubtedly form excellent generic characters, but we must not forget that there was a time in the life of the crinoid at which the arms were neither single- nor double-jointed, but at which the joints began to interlock, and when probably a very few days brought about important changes in the arms of the growing animal. This stage is represented paleontologically among the Cyathocrinidæ by *Eupachycrinus*, *Erisocrinus* and *Hydreionocrinus*, and in this view of the case it is not difficult to understand how this arm structure may be of generic importance as a rule, but scarcely of specific value in exceptional cases.

It has been stated that the double-joint structure was introduced in the Sphæroidocrinidæ in the Silurian, and this occurred under exactly the same conditions as it did later on in the Cyathocrinidæ. By far the greater number of species in the *Lower* Silurian have single arm joints, and these, with a few exceptions, consist of quadrangular pieces with parallel sutures. In the *Upper* Silurian we find a few forms with single joints, and along with them arms with cuneiform joints—either interlocking or not—associated in the same strata with species having double series of arm plates, and we find all intermediate gradations between the two extremes.

In some of these species the two structures are found combined, in others so closely associated that it is next to impossible to separate them; and in still others the extremes are separately represented. Generic divisions based upon these variations, unless accompanied by other distinctive characters, seem to be unnecessary and inexpedient. It would require the creation of a large number of new genera, which would probably have to be subdivided to accommodate other transitional forms, and so on without end.

The double series of joints resulted from the increasing width and outward growth of the arm; hence arm joints which originally were simple and cuneate did not in the mature animal extend through the full width of the arm, but gradually interlocked by their sharp angles, so that joints on each side, which at first were separated by another joint, came by degrees to be partly in contact and to rest upon each other. Therefore, in double-jointed arms every joint at each side bears a pinnule, while in those with single joints the pinnules are found only on alternate sides.

The arms in the Actinocrinidæ and Platycrinidæ divide rarely after they become free, the branching as a rule taking place in the body or in the free rays, *Megistocrinus*, *Amphoracrinus*, and *Periechocrinus* form the only exceptions. In the Rhodocrinidæ, on the contrary, the arms branch as a rule beyond the calyx.

The ventral grooves in the arms of this family are less deep, but comparatively wider than those of the Cyathocrinidæ. They are bordered on each side by a row of long pinnules, which cover them perfectly. Whether the grooves were closed by marginal plates seems to us doubtful, although Prof. Wetherby states that he has observed such plates in *Glyptocrinus*, they probably occur below the bifurcation where the arms should be regarded as free rays, or perhaps they are restricted to oral arms, such as P. Herbert Carpenter describes in *Actinometra*.

The *pinnules* throughout this family are long, closely crowded together laterally, and the two rows with which each arm is provided fit together so neatly, and cover the arm furrow so perfectly, that additional plates were scarcely needed. Each pinnule is composed of a number of joints, which differ in form in different genera. In some they are of equal width and height, outwardly convex; in others higher than wide, with the outer surface flat; in some they are entirely smooth, and in others provided with a peculiar hook; but in all cases they lie so close together side by side, that it appears as if the pinnules were laterally attached. In *Actinocrinus* and *Strotocrinus* each pinnule is furnished near the middle of its outer surface with a tooth-like spine which curves abruptly upwards; these spines are short and obtuse near the arms, but gradually increase in length toward the tips of the pinnules. As a rule the pinnules are deeply grooved on their inner surface, and in perfect specimens the grooves are covered by a double series of very minute pieces, though owing to defective preservation this covering is rarely observed. In young specimens, while the arms are composed of a single series of joints, the pinnules are not in contact, and are only given off from the alternate joints, but when the alternate arm joints meet by lateral growth, and the pinnules attain their full size they become gradually connected. D'Orbigny's genus *Edwardsocrinus* was founded upon a young *Platycrinus*, whose arms and pinnules were in their transition state.

7. Internal Cavity.

The construction of the interior of the body of all Paleozoic Crinoids is best known in the Sphæroidocrinidæ, among which, specimens preserving some parts of the delicate organs have occasionally been found.

The inner surface of the vault is often deeply grooved toward the brachial zone, producing corresponding elevations outwardly on the test. There are generally five large grooves, each branching into two smaller ones, the former corresponding to the five rays, the latter to their main divisions. This kind of vault is found most frequently among the Rhodocrinidæ. Among the Actinocrinidæ external ridges are rarely observed, but in their place the vault within is strengthened with bars or braces radiating from near, but not joining at the centre. The braces widen toward the arm bases, where they fold over to form regular tubes, corresponding with the natural grooves in the vault just described, and they branch as those do. In genera in which the rays are extended into free appendages, and in which but five ambulacral canals pass out from the vault proper (*Platycrinus*, *Steganocrinus*, etc.), the grooves are deep and in some cases were evidently closed and formed into tunnels, leaving, however, in either case beneath the median portion of the dome and in front of the anus, a space which is occupied by narrow grooves, meeting in the centre, and following the median line of the radial depressions and galleries below the vault to the arm openings.

In some specimens of Actinocrinidæ, almost the entire test is lined with a delicate calcareous plexus or network. This lining is not in contact with the test directly, but connected with it by small partitions, producing innumerable little chambers, which communicate with each other and with the visceral cavity. There is, at least, one such partition or support from each plate of the test, generally arising from the median portion of the plate. (Pl. XIX, fig. 16). The plexus is very delicate in some specimens, in others—mostly in large specimens--rather dense and rigid, but in all of them perforated with conspicuous pores or passages, whose arrangement corresponds with the direction of the sutures between the plates of the test. There is one pore at least to each angle of the plate, but sometimes additional ones in large individuals. The structure extends but little below the regions of the second radials, leaves passages at the arm openings, and toward the vault reaches to a place near the median portion of the ray, leaving at the centre an open space in the test which is occupied by the central vault piece. From this space five wide avenues, corresponding with the grooves on the inner surface of the vault, pass out toward the arm bases. The avenues produce five subtriangular interradial or interpalmar fields, which are raised conspicuously above the floor of the vault. They are of rather dense texture at the borders, the inner side somewhat thickened, while the surface of the median portions is rough and uneven, perforated with large and small passages which communicate with the avenues.

Four of the interpalmar fields are equal, the posterior one frequently larger and penetrated by the anal aperture. In species with a lateral opening all five fields have about the same form, and the central space between them is of pentangular outline. The case is different in species with a subcentral anus, when frequently the posterior field is larger and encroaches deeply upon the middle space, giving to it a lunate instead of a subcircular or pentangular outline. In species of this kind, the anus is placed near the edge of the interpalmar field, but separated from the central space by a partition which forms the border of the field. In species with secondary radials, the avenues divide, sending a branch to each arm, and forming thereby, between the interpalmar fields, a smaller intrapalmar[1] one similarly constructed.

A calcareous lining, such as described, has been observed by us with slight variations in *Batocrinus*, *Dorycrinus*, *Teleiocrinus*, (Meek and Worthen's Strotocrinus B), *Agaricocrinus* and *Eretmocrinus*, and probably existed in many other genera. In the *Actinocrinites*, or typical Actinocrinidæ, the inner framework was either less developed, or was of a more perishable nature. In the genus *Actinocrinus* it is indicated on the inner floor of the test by little roughened places, which we take to be traces of the pillars which supported it. In *Physetocrinus* even these have not been observed, but it is a characteristic feature of that genus, that the plates of the calyx have along the sutures at each angle very distinct indentations resembling pores, which give to the outer surface of the test almost the appearance of the inner plexus in species of *Batocrinus* or *Dorycrinus*. Whether there was any communication with the visceral cavity through these indentations cannot be ascertained from the fossil. The test at these points is exceedingly thin and transparent, but we have never detected an actual passage. It must also be noted that the vault in that genus has similar indentations, but these, contrary to the others, open out from the inner floor of the test, being arranged along the radial grooves, not interradially as those along the calyx (Pl. XIX, figs. 5 and 16). In *Strotocrinus*, an internal framework has been observed in connection with the calyx, but none with the vault, and its typical form had apparently, like *Physetocrinus*, slight indentations along the inner floor of the vault.

The general internal structure indicates a concentration of organs toward a point beneath the centre of the vault, in front of the anus, but not to the anus itself. The latter is situated distinctly outside the radiation, *i. e.*, interradially. The grooves which we have noticed in the vault were figured by De Koninck and Lehon in their Recherches Crin. Carb. Belg., but they seem to have regarded them as muscular impressions. Billings, in the third and fourth Decades of the Canada Geological Report, was the first to treat

[1] The term "*inter*palmar Felder" was used by Joh. Müller for the "interradialen Felder zwischen den Tentakelrinnen im Perisom des Pentacrinus, '*Intra*palmar Felder' for the interdistichal Felder" Monatsber. Berl. Acad. 1841, p. 218).

of them in connection with the ambulacral system. He showed how impossible it was that the ambulacral canals in some Paleozoic Crinoids could be continued along the outer surface of the vault, and he reached the conclusion that they passed into the body at the arm bases. It is remarkable that Billings, after making this important discovery, in connection with which analogy suggested that the food entered the body in the same manner, clung as late as 1870 to the old theory that the subcentral passage in these crinoids—interradiately situated as we have shown—served both as mouth and vent. This view was advocated by him in a series of interesting articles, published 1869–70 in the Am. Jour. Science and Arts, Nos. 142, 145, 149, as "Notes on the Structure of Crinoidea, Cystidea and Blastoidea." Since that time, it has been most generally conceded that the interradial opening was the anus only, and that the oral centre or mouth in the earlier crinoids was hidden from view by external structures.[1] Billings' views with regard to the ambulacral passages were confirmed by Wachsmuth's discovery of radiating tubes beneath the vault,[2] which, as he ascertained, connect with the ambulacral furrows in the arms. We have since examined these tubes in several other specimens, both of *Actinocrinus* and *Strotocrinus*, and are enabled to give additional information regarding them.

The *radiating tubes* are attached to the vault, running parallel to its inner surface. They consist of five main trunks, which follow the direction of the five main avenues which separate the interpalmar fields. They bifurcate in the same way and until a branch connects with every arm. They are composed of four rows of plates, two below and two above. The two latter touch with their edges the inner surface of the vault, are alternately arranged, and grooved along their median line, leaving a tunneled passage between the walls of the tube and the vault. The trunks of the two lateral sets of tubes on the same side not un-

[1] The following writers have expressed this opinion: Schultze, 1866, Monog. Echin. Eifl. Kalk, p. 7; Meek and Worthen, 1869, Proc. Acad. Nat. Sci., Phila., p. 323; Lovén, on *Hypomene Sarsi*, reprinted Ann. and Mag. Nat. Hist., Sept., 1869; Wachsmuth, "On the Internal and External Structure of Paleozoic Crinoids," Am. Jour. Sci. and Arts, Aug. 1877, p. 115; Zittel, 1879, Handb. d. Palæontologie.

[2] Described by Meek and Worthen, Geol. Rep. Ill., vol. v, p. 329, and Wachsmuth, Am. Jour. Sci., Aug., 1877, p. 119.

frequently meet before reaching the peristome, but the anterior ray is always distinctly separated.

Whenever tubular canals have been observed, they are preserved only to the border of the central space, but none of them have been found to join in the centre. In a specimen of *Actinocr. glans*, however, the tubes before terminating bend downward toward the visceral cavity, give forth lateral processes, as if disposed to branch, and expose two openings at the extremities directed to opposite sides. The openings indicate that the tubes may have been connected with each other by lateral passages, and formed a ring around the centre. This is evidently the structure of *Actinocr. Verneuilianus*, in which a circular vessel is observed beneath the centre at a short distance from the vault; no ambulacral tubes are attached to it, but there are small radial openings with which they might have been connected. The lower portion of the ring is composed of minute interlocking pieces, with five additional openings interradially situated. This ring is comparatively large, enclosing within its circumference the contracted upper part of the convoluted digestive organ, which is well preserved in the specimen from which these facts were obtained.

A tubular skeleton, as above described, has thus far been observed only in the Actinocrinidæ, but a tubular passage beneath the vault, in connection with the arm grooves and oral centre, has been traced in most groups of the Palæocrinoids, and no doubt existed also in the Blastoids. In *Cyathocrinus*, and probably in the Cyathocrinidæ generally, the tube is constructed of two series of pieces overlying the oral plates, and these again are covered by two similar series of plates, which form a part of the vault. In *Granatocrinus* the tubes follow the pseudambulacra, being covered by three series of small plates which must be considered extensions of the vault(Pl. XIX, fig. 3).

It is now generally conceded that the tubular canals beneath the vault contain the same organs which in modern crinoids are exposed on the ventral disk, and like them embrace the food passages, and certain other vessels in connection with the ambulacral system. In this view of the case, it is reasonable to further consider that the annular vessel, above described, served as a water-vascular ring.

The relations between the vault and the ventral covering of recent Crinoids are not so close as has been sometimes supposed, they are indeed different things, although there are certain analogies between some of their parts. Among these are the oral plates, which are represented in some of the later Crinoids, but absent again in the fully grown *Pentacrinus* and in the *Comatulidæ*. They are also absent in the Sphæroidocrinidæ, unless we consider the interradial vault pieces to be their representatives. We have already suggested that all interradial plates in the dome—exclusive of the proximal pieces—may perhaps have been modified oral plates which, either by division or interpolation, gradually increased in number. The dome of *Coccocrinus* has a single oral plate to each interradial field, while the corresponding spaces in most species of *Platycrinus* are occupied by three and occasionally five pieces each. It is as easy to consider the single plate of the former to be represented by three in *Platycrinus*, as that the three are sometimes replaced by five within the limits of the same genus, the plates occupy the same position in both cases, but in some groups the true orals meet laterally which is not the case with the interradial dome pieces of *Platycrinus* or *Actinocrinus*, nor with the undivided plates of *Coccocrinus*. In *Cyathocrinus* where the orals are very conspicuous, they join beneath the radial groove, and form the floor upon which the ambulacral tube rests. The bottom of the tube is composed of two series of pieces, which are covered directly by vault pieces in two alternate rows, whose lateral margins rest upon the upper edges of the two orals; while in *Platycrinus* the corresponding vault pieces abut laterally against the sides of the interradial—oral—plates in an unbroken succession. In *Platycrinus* the interradial plates thus take exactly the same position as the exposed part of the oral plates in *Cyathocrinus*, while the covered parts are unrepresented. In *Coccocrinus*, a covering of the ambulacral groove has not yet been observed, but judging from the fissure between the oral plates, it probably rested just upon their edges, and formed an intermediate link between the vault structure of the Cyathocrinidæ and Platycrinidæ.

In the Actinocrinidæ and Rhodocrinidæ, the alternate dome plates are not so readily distinguished, as in the Platycrinidæ and forms with free rays, in which they are well marked in the extended parts. In the recent Crinoids the alternate plates are represented by the "Saumplättchen," which, however, instead of forming a part of a solid vault, are movable, and line the lateral margins of the tentacle furrows.

The proximal and central dome plates are altogether unrepresented in recent Crinoids. This is best perceived by comparing *Coccocrinus* as usually preserved, with *Hyocrinus* or other recent genera in which the oral plates are developed. In both cases, there is at the oral centre an opening at which the grooves converge, surrounded by the oral plates; but, while in *Hyocrinus* and all recent genera this opening is unobstructed by solid parts, in *Coccocrinus*, *Cyathocrinus*, and the Palæocrinoids generally, it is covered by the apical dome plates. The central piece generally occupies the median portion of the vault, and always indicates the centre of the oral system.

We have already noted narrow grooves upon the inner surface of the vault, which meet on the central piece, and follow the median line of the radial depressions and galleries to the arm openings. Only three main grooves meet at the centre, those of the two lateral rays are uniting before reaching that point (Pl. XVIII, fig. 1). The grooves are best observed in natural casts of the interior, in which they appear on the surface in the form of narrow bands or ridges (Pl. XIX, figs. 5 and 9). The position of the grooves indicates that they may have contained axial cords in connection with a nervous system located beneath the central plate. The location of the nervous system within the regions of the ambulacral centre is in analogy to the structure of other Echinoderms, except the Comatulidæ, in which, according to P. Herbert Carpenter, the principal nervous systems are located at the apical side, and in connection with the quinquelocular organ which occupies the cavity of the centrodorsal plate.[1]

The interpalmar fields are composed of a soft skin, but although this is more or less incrusted with limestone particles, which sometimes almost look like vault pieces, they have no affinities with the plates of the vault. The plates of all recent Crinoids are perforated with numerous pores for the introduction of water into the body, a function which could not well be performed by the interradial pieces, but much less by the solid undivided oral plates of *Cyathocrinus* and *Coccocrinus*. In the Cyathocrinidæ, these functions may have been performed by the ventral sac

[1] On some points in the anatomy of *Pentacrinus* and *Rhizocrinus*. Jour. Anat. and Phys., vol. xii p. 35.

which is profusely punctured, but evidently not by the simpler ventral tube of the Sphæroidocrinidæ which is destitute of such openings. Nor can we imagine that there was any such communication through the dome proper, its plates are perfectly connected at their sutures, and the interradial series especially are strengthened by strong braces within.

There are evidently closer relations between *Cyathocrinus* and *Hyocrinus* or genera with oral plates, than between the Pentacrinidæ and Sphæroidocrinidæ, in which those plates are either unrepresented or greatly modified. The latter two types form the extremes, and are probably more distant in their relations with each other, than most Blastoids and Cystideans from the Palæocrinoids.

The affinities of the Palæocrinoids with the Blastoids, become more apparent by our recent discovery of hydrospires in a specimen of *Teleiocrinus*. Their exact construction has not yet been fully ascertained, but that such organs existed in some of the Actinocrinidæ is now demonstrated beyond a doubt. The specimen is fragmentary, it was obtained from a narrow cherty band of the Upper Burlington Limestone, and is itself silicious. The interior is solid, with the exception of a natural concavity beneath the vault, at which point it was broken in quarrying, exposing a part of the upper face of the tubular skeleton. Portions of two tubes only are visible, and these are broken transversely after their second branching, the fracture giving a cross-section of the tubes and surrounding parts. In *Teleiocrinus* as in *Strotocrinus* proper, the lateral rim contains radiating tunnels formed by partitions between the divisions of the rays. The tunnels, as observed by us in several specimens, are divided transversely into two compartments, of which the upper one is occupied by the ambulacral tubes (Pl. XIX, figs. 7*b* and 8). In the specimen under consideration the lower or dorsal compartment has a semicircular outline, and within this, below one of the branches of the ambulacral tubes, there are visible two distinct folds, closely resembling the folds in the hydrospires of *Granatocrinus* (Pl. XIX, fig. 3). Beneath the adjoining branch, the folds cannot be so well distinguished, but the outlines of the hydrospires are also there faintly indicated. Considering that the arms in the Blastoids are inverted and recumbent, and that their calcareous portions represent not only he solid parts of the arms, but also a part of the test, it will be seen that the hydrospires above noted, and those of the Blastoids, have not only a similar form, but also a very similar position.[1]

The hydrospires of the Crinoids, like those of the Blastoids, are placed in close proximity to the arms with which they were probably in communication, close to the test and within the general cavity of the body.

The above is, to our knowledge, the only case in which hydrospires have been observed among the Sphæroidocrinidæ, but they were probably present in other genera, and perhaps in the Palæocrinoids generally; while these organs are unknown in all later and recent Crinoids, and in other groups of Echinoderms.

It is a fact worthy of note that all Cystideans and Blastoids, and so far as known, all Palæocrinoids which possess hydro-

[1] The vault in the Blastoids, as we understand it, consists not merely of the plates which cover the oral opening, but extends all along the median portions of the pseudambulacra (Pl. XIX, fig. 3), forming underneath a good-sized tunnel, which we take to be the homologue of the ambulacral tube of the Crinoids. If this interpretation is correct the structure bears the closest similarity to that found in those Crinoids in which the vault is extended into free rays, and in which these extensions combine to some degree the characters of the arms and body. The recumbent arms of the Blastoids are, according to this, lateral extensions of the body which take the place of true arms; but while in the Crinoids the radial extensions give off regular arms, in which the ambulacral tubes are converted into grooves, the corresponding parts in Blastoids remain attached to the body, and the pinnules form the only free appendages. It is possible, however, that in the Blastoids the lateral furrows which traverse the ambulacral fields were not covered by plates, and that these correspond to the open arm grooves—respectively arms—in Crinoids.

Dr. Hambach (Contributions on the Anatomy of the genus *Pentremites*, p. 7) is probably correct in supposing that the pinnules of the Blastoids were not connected with the pores, as hitherto believed. We think it probable that they rested in the funnel-shaped pits which alternate with the pores, and which communicate with the lateral grooves of the pseudambulacra, while the pores probably communicated with the hydrospires. This view coincides with what we have heretofore suggested, that the upper face of the pseudambulacra corresponds to the grooves within the arms of the Crinoids, and indicates that there are close affinities between the ambulacral field itself and the solid portion of the arms. The passage directly beneath the field is probably the dorsal or axial canal, which by the inverted position of the arms became the inner instead of the outer passage. The hydrospires in the Blastoids are placed beneath the canal, and extend along the perivisceral cavity of the body, like in the case of *Teleiocrinus*.

spires had a subtegminal mouth, and a solid test built up of plates so closely fitted together that expansion or contraction was impossible. Expansion in some parts, however, was necessary to produce circulatory currents for the introduction of food. In most Echinoderms, including all recent Crinoids, this is accomplished by means of the pliant test and soft appendages which surrounded it. The Echini alone, like the Paleozoic Crinoids, have a rigid test, but they possess an external mouth, and in addition to their numerous soft appendages a movable actinal membrane, capable of considerable expansion, even in some cases beyond the line of the actinostome. It seems to us not unlikely that the hydrospires served the purpose of gills, producing by their contractions and dilatations the requisite circulation to introduce food and expel the refuse matter. This would account for their absence in the recent Crinoids and other Echinoderms, and would suggest that they were probably connected with numerous soft appendages along the arms, arranged perhaps in like manner as the pores along the ambulacra of the Blastoids, but not as in the Cystideans, in which the pores which connect with the hydrospires are distributed over different parts of the body. A better knowledge of these organs, as they exist among the three great divisions of the Paleozoic Crinoids, would doubtless afford far more satisfactory characters for separation than we now possess.

In the abdominal cavity of the Palæocrinoidea, the only structure which has been observed consists of a peculiar skeleton located beneath the tubular canals, which from its position, in analogy to other Echinoderms, has been referred to the digestive apparatus.[1]

In its usual preservation, it is a large convoluted body resembling the shell of a *Bulla*, open at both ends. The upper end is placed beneath the centre of the vault, and the lower directed toward the base. It is dilated above; contracted below; its surface about parallel with the walls of the visceral cavity. In some species it is subcylindrical, with the vertical axis the longer; in others globular or even depressed globose; but it is always truncate below, and never extends to the inner floor of the basal plates. The walls are coiled without touching at any point, and

[1] Meek and Worthen, Geol. Rep. Ill., v., p. 328, call it a convoluted support of the digestive sac. Wachsmuth, Am. Jour. Sci. Aug., 1878, p. 125, terms it the "alimentary canal."

the convolutions are directed outward from left to right, varying in number from two to four in different species.

In the usual state of preservation the walls are perfectly solid, almost like a "convoluted plate" as which it was described by Hall. In transverse sections, they are seen to be strong, and appear to be constructed of two partitions closely fitted together and united at the edges. The unusual thickness and apparent double nature of the walls in these specimens misled Wachsmuth in 1877, who considered the walls to be the body of the alimentary canal. This is evidently a mistake. We now know, from a number of other specimens, that the wall was simple in all cases, very delicate, and constructed of an extremely fine filigree work, which generally in the fossil became thickly incrusted with silicious matter on both sides, thus producing the apparent duplication of the wall. In good specimens, a magnifier shows the wall to be composed of an extremely fine network of minute pieces or bars, with intervening meshes. These bars, according to Meek and Worthen, "do not intersect each other at any uniform angle, but anastomose so as to impart a kind of irregular regularity to the form and size of the meshes."

That this network was in some way connected with the digestive organs, is no doubt true, but whether it formed a mere support for the digestive sac, as Meek and Worthen suggested, or was an extensive plexus of blood vessels surrounding the ambulacral canal, is a question we are as yet unable to solve. It should, however, receive a more appropriate name than any yet given, and we propose to call it the "œsophageal network," which may be changed when its special functions and affinities are discovered.

One of the writers found a specimen of *Actinocrinus*, in which the convolutions were nearly intact, and by removing the outer fold, the inner or upper end, as distinguished from the outer or terminal part, could be examined (Pl. XIX, fig. 12). The organ has the usual dense structure, and where it comes into view, is an elongate tube, which passing downward widens at first gradually to near the middle of the visceral cavity, then rapidly until it attains a width equal to two-thirds the entire length of the cavity. The upper part descending spirally turns from right to left, but on becoming wider the whorls are abruptly reversed, and thereafter the convolutions are from left to right. The outer end also tapers rapidly, assuming the form of a flattened tube, and ascends spirally on the outside, while the other end is directed toward the oral centre, but a connection with the food grooves has not yet been observed.

In all cases where the œsophageal network has been examined, among the Actinocrinidæ and Platycrinidæ, it varies only in outline and in the number of whorls; while in *Ollacrinus* the entire skeleton resembles a large spiral. In the only specimen observed, it apparently consisted of a large round canal, which turned spirally on its axis, and which near the basal plates turned upward, but the organ is in a fragmentary condition, and it is quite possible that this part was surrounded by other convolutions. Until recently this organ had been observed only in crinoids from the Burlington group. Angelin, however, in the Iconographia Crinoideorum Sueciæ, figures several examples from the Upper Silurian of Sweden (Pl. 26, figs. 12, 12 *a*, *b*,). It is well preserved in these specimens, and resembles that of later Actinocrinidæ. It differs, however, in being closed at the outer side, while the inner parts, as in Burlington specimens, are distinctly coiled. The outer wall is pentangular in outline, open toward the basal disk, and consists of a very delicate porous texture, appearing like an envelope for the inner or coiled parts, and as such possibly represents the perivisceral plexus, which in some cases almost equals the œsophageal network in delicacy of structure.

8. Column.

The column in the Sphæroidocrinidæ is generally circular transversely, though sometimes elliptical or pentagonal and even quadrangular. It is elliptical only in *Platycrinus*, and the pentagonal form occurs only in *Reteocrinus* and some few species of the *Glyptocrinites*. The central canal varies from large to extremely small, and is round or pentagonal. In *Platycrinus* it is so minute that in columns of an inch or more in thickness on their long diameters, the opening will scarcely admit the point of a needle. In the Rhodocrinidæ it is irregularly pentagonal, and as a rule small. Among the Actinocrinidæ also, the passage is generally not above medium size, but in *Megistocrinus* it is remarkably large throughout the column and all its branches.

By the earlier writers, new species were often based upon fragmentary columns, a practice which has fortunately been abandoned, since it became known that the different parts of the column in the same specimens are often widely dissimilar.

In the growing animal, new columnar joints were continually introduced by interpolation between the older segments, and these younger joints, which are found throughout the column in all stages of development, produce striking changes in the general aspect. The column matured from the root upward, and the upper part remained throughout the life of the crinoid in a kind of immature state, wherein the intercalated joints did not attain the width of the others. The uppermost joints, however, although they were probably among some of the earliest developed parts of the column, are not separated by smaller joints. Gradually, sometimes between the third and fourth joints, new plates make their appearance; the first one so thin as to be scarcely visible, the next which lies between the succeeding joints much larger, the third probably reaching full size. Secondary intercalations follow between the new pieces, the intervening spaces between the larger joints increasing gradually to a maximum, from which point down the column seems to be mature, for all succeeding spaces have a like number of intercalated joints. As a general rule, the column decreases somewhat in thickness from the calyx for a certain distance down, after which it increases again towards the root. In some species the primary joints are only longer, but not of greater diameter than the others. This is the case in *Platycrinus* where the new joints seem to have been formed directly beneath the calyx, their number increasing in length gradually along the stem, and not in sections as in the Actinocrinidæ and the Rhodocrinidæ.

Lateral cirrhi along the column have been rarely observed, and in this family probably existed only toward the root. The form of the root is exceedingly variable, and depended evidently upon the conditions of its place of attachment. When living in a soft or sandy soil, it seems to have been provided with a great number of small rootlets which are given off both vertically and horizontally; but when it was attached to a rock or other hard substance, the lower surface grew entirely flat and was often deeply grooved. The grooves pass out from the root, and apparently took the place of the vertical rootlets. The central passage extends to the smallest rootlets and is often of considerable size. We have already noted this fact in Part I, and suggested that probably the rootlets may have had respiratory functions by introducing water into the body.

In adult specimens of Actinocrinidæ and Rhodocrinidæ the column was long. We have never seen its full length, but have in several instances traced it three to four feet without seeing either root or body, and we suppose that it was in some genera very much longer.

Of *Platycrinus*, however, we have examined five complete specimens measuring from the tips of the arms to the extreme ends of the fine rootlets from 7 to 27 inches—the latter in a large species. In all these specimens, the column gives off for some distance large lateral branches, which decrease in size toward the end of the root, each one with irregular branches which divide again and terminate in hair-like tubes. We never saw a *Platycrinus* in which the root was flattened, as in some of the Actinocrinidæ, and it seems possible that the crinoids of this genus only grew on a soft bottom, or possibly floated about with their column like an anchor. The same was evidently the case in the genus *Glyptocrinus*, in which the column was short, tapering to almost a needle's point, without lateral branches.

9. Mode of Growth and Palæontological Development.

In the Pentacrinoid larva of *Antedon*, the calyx is composed chiefly of very distinct, rather large basals, alternating with which are five dots, which represent minute radials. The crinoid at this stage consists only of five columnar joints, the large basals, the rudimentary radials, and of five large oral plates which cover the entire peristome. The succeeding radials, at first unrepresented, develop afterwards, and the arms make their appearance at a much later period.

Of the Palæocrinoids, the first stages are, of course, unknown, all the specimens we have discovered—even the very youngest—being already provided with arms, and hence were considerably advanced in the scale of growth. It can be ascertained, however, by a comparison of larger and smaller specimens, that their mode of growth must have been similar to that of *Antedon*. In the smaller, and as we consider them, younger specimens, the basals, compared with the other plates, are much larger, being almost the same size as in mature individuals. Next in size are the first radials, which are larger than the second and third. In the interradial series the first plate is much the largest, and the number of interradial and anal plates is considerably less in young specimens than in the adult, thus indicating that the calyx in these crinoids was developed from the basals up, as in their living representatives.

With the development of the first interradial, apparently simultaneous with the second and third radials, the Platycrinoid form, the simplest of the Sphæroidocrinidæ was complete. The earliest types of the Platycrinidæ known to us, but evidently not the earliest representatives of that group, are from the Upper Silurian. In *Coccocrinus* the body is composed of three basals, two by five radials—the first very much the larger—a single interradial, and five large oral plates, exactly as we must expect from analogy to find the Actinocrinoid in its earlier phases. The rays in the Platycrinoid are free from the primary radials up, but the first joints of the two main divisions are simple and constructed similar to the radials in the body of the Actinocrinidæ. To transform the Platycrinoid into an Actinocrinoid, it only requires the interpolation of one or more interradial pieces between the proximal plates of the first division of the ray. By this simple process, the plates which were before free in the Platycrinoid, were incorporated into the body, and raised to the dignity of secondary radials.

Many of the earlier Rhodocrinidæ and Actinocrinidæ are characterized by highly elevated ridges, which extend all along the radial series of the body. They run vertically along the middle of the primary radials, divide upon the third plate, and branch to the secondary and tertiary radials, whence they pass very gradually into the arms. The ridges are very prominent, rounded exteriorly, and as they approach the arm bases, assume nearly the shape and size of the arms. The plates upon which they are extended, in their upper series, scarcely differ in length from the first free arm plates, and all gradually diminish upward. The longitudinal ridges are evidently not accidental, nor a mere ornamentation, but represent the arm joints as they were when first developed in the young animal. In this early stage they were round joints, the lateral wing-like extensions being developed afterward, when by reason of the upward growth of interradial and interaxillary pieces, the plates became parts of the body. We find on the surface of many internal casts of forms belonging to this group similar but narrow ridges, which follow the same direction as those upon the test. The ridges in these cases are evidently the impressions of rudimentary grooves, indicating that the plates at that stage were provided with ambulacral furrows like regular arm plates. They also had pinnules attached, which like the arm plates were by the growth of the animal absorbed into the calyx. The fixed pinnules, which Wetherby describes in *Glyptocrinus Richardsoni*, Cincinnati Soc. Nat. Hist., 1880, and which we found also in *Gl. decadactylus* and *Reteocrinus O'Nealli*, confirms our views as to the mode of growth of the Palaeocrinoid, and throws light upon the palæontological development of Crinoids generally.

The number of secondary radials varies considerably with age. In *Reteocrinus O'Nealli* we have observed as many as seven, but the number may be even more in some cases; and on the other hand we found in some younger specimens only three or four. The first and second of these plates, and the third and fourth seem to have been united by syzygies, at least the first and third bear no pinnules, while beyond the fourth pinnules are given off regularly from alternate sides as in the free arms. The proximal pinnule is given off toward the outer side of the ray, or, which is the same thing, toward the interradial area, the next one toward the interaxillary space. The plate which gives rise to the first pinnule has almost the form of a bifurcating plate, but instead of supporting radials of a higher order, it bears on its inner sloping side a third secondary radial, and on the outer a stout pinnule. The first fixed pinnule is highly elevated above all other plates of the interradial space, is rounded like the radials, and almost as conspicuous. In one of our specimens it consists of five plates, three of which are soldered into the body, and the fourth apparently free. The fixed plates are nearly as strong as the radials and may be easily taken for them, having like them winged extensions by which they are laterally connected with the interradial plates. The upper joint is much smaller and constructed like the joints of the free pinnules. The second pinnule has only two joints in the body, the third but one, which in either case are larger than any of the free joints, but which already attain somewhat more the aspect of regular pinnules, and are given off in a similar manner. In a specimen of *Glyptocrinus Richardsoni*, kindly loaned to us by Prof. Wetherby, the first fixed pinnule is given off from the second plate above the first bifurcation, and consists of seven plates within the body, the third and fourth plates were joined by syzygies. The second pinnule, with but four joints within the body, springs from the opposite side of the fourth plate. The fifth plate, instead of a pinnule, supports a regular arm, and the sixth again a pinnule, but from the same side as the preceding pinnule. This is important as it suggests the idea that the pinnule may have here developed into an arm. That a transformation of this kind took place in some groups, is more than probable, as will be shown presently. In *Glyptocrinus decadactylus* only the second and third secondary radials are joined by syzygies, all succeeding pinnules being given off regularly.

The number of arms has been considered of specific importance among the Palæocrinidæ, and even genera have been based upon this character. The greatest variation in the arm formula is found among species of the typical Actinocrinidæ, in which we include, besides the genus *Actinocrinus*, also *Strotocrinus*, *Teleiocrinus*, *Physetocrinus* and *Steganocrinus*. These genera agree in the style of their ornamentation, and in the construction of the anal area, which differs somewhat from that of all other Actinocrinidæ. It is to be noted that in this group the specimens have, as a rule, the same number of arms in the different rays, the few exceptions being due to deficient or abnormal development of these parts.

The genus *Actinocrinus* has been very appropriately separated by Meek and Worthen into two sections. The one, with *Actinocrinus proboscidialis* Hall, as a type, has the arm-bases arranged in a continuous series all round; the other, with *Actinocr. multiradiatus* as type, has the rays formed into more or less protuberant lobes.

A. proboscidialis of the first section, which represents the simplest form of this interesting group, has only four arms to the ray. The first departure is *A. reticulatus* with four arms in all but the two posterior rays, which have five; the fifth arm where it exists, being placed below the line of the others and appearing somewhat crowded. Next in order are *A. limabrachiatus* and *A. clarus* with five arms, in which one of the divisions in each ray divides again. *A. sexarmatus* and *A. opusculus* have six arms or three to each division of the ray. *A. multibrachiatus* and *A. penicillus* have probably six, seven or eight arms, without regularity as to arrangement or distribution. *A. cœlatus* and *A. spinotentaculus* have a greater number than any other species of this section, having normally eight arms to each ray.

On examining a large collection of the different species, it will be found that a separation according to the number of arms is not so satisfactory as might be expected, for only a few specimens will be found—except the four-armed ones—which agree with the given arm formula of the species. The majority will be found to have in one or more rays very irregularly, either a surplus or a deficiency of arms, and the greater the number of arms a species possesses, the oftener such irregularities occur. The difficulty of identifying these species is further increased by the similarity—we might almost call it identity—of general form and ornamentation, which prevails throughout the group.

The gradual increase of arms would naturally lead us to inquire whether it might be connected with the growth of these crinoids—an idea which seemed at first plausible, inasmuch as the above species are found exclusively in the Lower Burlington beds; but an examination of specimens, with the arms in place, shows that such is not the case. Specimens with four arm openings in the body to each ray, have also four simple arms, while they should have, if representing a younger stage of the six- or eight-armed species, the same number of arms as the adult, with the bifurcations taking place beyond the body as in *Platycrinus*. The fact is, however, that the arms of *A. proboscidialis* are not only simple, but from the base up, are composed of a double series of pieces, while the plates which should form the higher orders of radials in the adult are entirely absent.

In *Strotocrinus*, which is closely related to *Actinocrinus*, the variations in the number of arms are still greater, being among the different species from eight to twenty-four to the ray. *Strotocrinus* has also been divided by Meek and Worthen into two sections; the first including species with a simple anal opening directly through the vault, which they call the typical form, and the second, those with a large sub-central anal tube, for which we have proposed the sub-genus *Teleiocrinus*. The ornamentation among the different species of the two sections is remarkably similar, only that in some species the striations are more prominent, in others the nodes. The most important feature of the genus is the peculiar rim, which extends out horizontally from the body, formed of the higher orders of radials, which are connected by interradial, interaxillary, and some other apparently accessory pieces. In the allied *Actinocrinus spinotentaculus* with eight arms to the ray, the *Strotocrinus* rim is already indicated, and in specimens in which the arms are preserved, their lower portions stand out horizontally as in that genus; but the plates of these parts are not connected laterally, which feature, aside from the difference in the number of arms, constitutes the principal distinction between *Actinocrinus* and *Teleiocrinus*.

Throughout this group, all bifurcations of the ray—after the first—take place on the first plate in each order, only one of the branches dividing again, and this alternately from opposite sides, the other branch remaining simple. The arrangement is such that the bifurcating plates of each primary division of the ray follow each other in direct succession, forming two main trunks, while the plates which remain simple, and are succeeded by others to the edge of the rim, are given off alternately like pinnules. These lateral branches are separated from the main rays by small pieces, and each branch supports a free arm at the edge of the rim. Within the rim, the radial series are conspicuously marked by sharp carinæ or ridges, which pass from plate to plate, and follow both main and lateral divisions, while the small accessory pieces, which connect them, are formed into deep depressions. Comparing the ridges with the elevations we have described in *Glyptocrinus*, and which are found in other Silurian genera, the resemblance is indeed very striking. The ridges in the latter extend over the primary, secondary, and sometimes over the tertiary radials, and pass gradually into arms; but while we find in *Glyptocrinus* very strong arm-like pinnules, there are in *Strotocrinus* and *Teleiocrinus* pinnule-like arms, both included within the body walls, and both springing off laterally like ordinary pinnules. The lateral branches in the rim of *Strotocrinus* were evidently pinnules in the young animal, and free as in the younger stage of *Glyptocrinus*, but with growth gradually developed into regular arms; while those of the latter remained as pinnules during lifetime. This explanation accords with the construction of pinnules, which is so similar to that of arms, that it is in many cases exceedingly difficult to draw a line between them. In *Melocrinus* the alternate pinnule-bearing appendages were called by some authors arms, by others pinnules. The branches in *Cyathocrinus* were called pinnules by Wyville Thomson, and arms by most other authors.

Following out the observations, it seems probable that all arms above the first bifurcation are metamorphosed pinnules, given off from the primary radials. Applying this rule to the case of *Actinocrinus* and *Teleiocrinus*, the idea is suggested that *A. proboscidialis*, which is the most common species of the group, and has only four arms to the ray, is in all probability the progenitor of all similar Burlington species, evidently of both genera. In *A. recticulatus* only the proximal pinnule toward the posterior side was transformed; in *A. clarus* one pinnule in each ray; in species with six arms the first pinnule on the opposite side was added; in species with seven arms the first and second pinnules of one side, and the first of the other, and so on alternately on opposite sides. Although the increase of arms is frequently attended with some irregularity, the number of arms should here be considered of specific importance, and deviations from the normal number as intermediate steps between the species.

During the Lower Burlington Limestone epoch, the number of arms never exceeded eight to the ray, but in species even of that number the arms are so crowded together, that they could not have been arranged side by side, were not their lower portions bent outward, in the same direction as we find the rim in *Strotocrinus*. In species of *Actinocrinus* with only a few arms, the arms are movable from the base up; movement is less free in species with six arms to the ray, and the facility of motion is lessened with every increase of arms. This lack of mobility, of course, only extended to the lower arm joints, which for some distance were so closely crowded together that they could not have moved in any direction, and it was probably in consequence of this inactivity that the proximal arm pieces, which in the simpler forms were free, became gradually connected by growth. This was evidently the first step in the direction of *Teleiocrinus*. Afterwards, by still further increase of arms, additional plates became laterally attached, and in this way the rim was gradually developed. In *Actinocrinus* the rim was merely indicated by the adhesions of a few plates to the calyx, the primary rays, and their main divisions being still distinctly separate. In *Actinocrinus* (*Strotocrinus*) *serratus*[1] Meek and Worthen, which forms a kind of connecting link between *Actinocrinus* and *Teleiocrinus*, only the two main

[1] This is the only species from the Lower Burlington beds which might be referred to *Teleiocrinus*.

divisions of the rays were laterally connected, but the rim is not continuous above the five primary divisions of the ray.

We have already noticed the presence of small plates interpolated between the radial portions of the rim, forming sunken areas, and having altogether the appearance of accessory pieces (Pl. XVIII, fig. 1, *fp*.). A closer examination, however, shows a marked regularity in their arrangement, and there can be little doubt that they represent pinnules, given off alternately from opposite sides, and soldered into the body walls together with arm joints. This interpretation is confirmed by the allied genus *Steganocrinus*, in which the corresponding parts, under more favorable conditions, instead of forming a rim, remained free (Pl. XVIII, fig. 3).

Steganocrinus Meek and Worthen is connected with the other section of *Actinocrinus*—type of *A. multiradiatus*—in the same manner as the *A proboscidialis* group with *Teleiocrinus*. In *A. multiradiatus* and allied species, the third primary radial is bent abruptly outward, its upper articulating faces which support the higher radials being directed almost horizontally, thereby forming the rays into protuberant lobes, separated by wide and deep interradial depressions; contrary to *A. proboscidialis*, in which the arms are more or less continuous, and the sides of the calyx nearly straight up to the tertiary radials. We should have separated the two sections upon these characters, at least subgenerically, if Miller, in establishing the genus *Actinocrinus*, had not unfortunately chosen for the type a species which is intermediate between the two, thus rendering it difficult to determine the typical form. It is very evident that the structure of the rays of *A. multiradiatus* did not admit the development of a rim like that of *Strotocrinus* and *Teleiocrinus*, as even the most profuse growth could not well have filled the break between the rays, and the spaces between the arms within the ray were amply sufficient to afford them free motion. This we think furnishes a reason why, under similar conditions, the arms and pinnules of this genus, contrary to those of *Teleiocrinus*, remained free during life. *Steganocrinus* and *Teleiocrinus* have very close affinities in their structure. In both of them there are five main rays—a succession of radials longitudinally arranged—which give off arms alternately and from opposite sides; but, while in *Steganocrinus* the plates of the different order of radials are extended into free appendages, with free arms and free pinnules, the radials in *Teleiocrinus* and their branches and pinnules, to a certain height, are laterally connected and included within the body walls.

Strotocrinus bears the same relation to *Physetocrinus* as *Actinocrinus* to *Teleiocrinus*, *Physetocrinus* differs from the *A. proboscidialis* form, mainly in having a simple anal opening through the vault, instead of a tube, and the same character separates *Strotocrinus* from *Teleiocrinus*.

In *Eucladocrinus* of the Platycrinidæ, the case is the same as in *Steganocrinus*. In that genus an indefinite number of radials, apparently intersected by syzygies, are formed into long radial appendages, which give off pinnule-bearing arms from opposite sides. It agrees exactly with *Platycrinus* in the construction of the body, and both have free lateral appendages, in which the arms originate alternately on opposite sides. The arms of *Platycrinus*, however, are only given off close to the body, while those of *Eucladocrinus*, as in *Steganocrinus*, are given off continuously and the free rays extend almost to the height of the arms (Pl. XVIII, fig. 7).

Not less interesting is the case of *Melocrinus*, which we take to be a successor of *Mariacrinus* (as amended by us). Both genera make their appearance in the Upper Silurian, but, while the former does not survive later than the Silurian, the latter flourishes in greatest profusion in the Devonian. *Mariacrinus*, in its simplest form, has but four arms to the ray, two of which are given off like pinnules from the body toward the interradial spaces, while the two inner ones stand erect, are parallel and lie close together. In other species of the genus, the inner arms give off from one to three additional arms, always directed to the outer side of the ray. The arms are composed of single joints, which bear pinnules in the usual way. The two median arms of the ray, which in *Mariacrinus* are placed side by side, are connected in *Melocrinus* by a suture, and appear as a single arm composed of two series of plates, but the suture between them is straight, and the opposite plates are scarcely ever alternately arranged. That a coalescence of two arms actually took place here, is best demonstrated by the fact, that in the calyx the two parts are not only separate, but often have interaxillary pieces between them, and that each one has a distinct passage. The compound arms of *Melocrinus* give off at regular intervals, instead of pinnules, lateral arms, which are composed of a double instead of single series of joints, and bear pinnules. The difference from *Mariacrinus* thus actually consists only in the much greater number of lateral arms, and their being composed of a double series of plates. The increase of arms evidently took place under the same conditions as in *Steganocrinus* and *Eucladocrinus*, the modifications in the arm structure, due originally to individual growth, becoming fixed as generic characters, and following a general rule, by which it seems that the arms in all genera of the Sphæroidocrinidæ, on passing into the Devonian, change from single to double joints.

Let us now consider some cases of *Batocrinus* in which an increase of arms took place in the species under somewhat different conditions. It has been shown by us (Proc. Acad. Nat. Sci. Phila., 1878, p. 230) that *Batocrinus Chrysti*, as a rule, has two arms from each arm opening, differing thus from other species of that genus. In the *Actinocrinites*, and many other of the Sphæroidocrinidæ, the arm openings are mere breaks in the body, and the proximal arm joints consist of single plates, while in *Batocrinus* they appear more like passages penetrating the test, and the arms from their very base up are constructed of two series of pieces. We have in our collections several specimens, which in every other respect resemble *B. Chrysti* except that they have single arms. They were obtained exclusively from the lower strata of the Upper Burlington Limestone, the typical form of the species occurring in greatest abundance in the upper layers. The specimens with double arms are generally larger than the others, but we find them also very small, thereby indicating that the modified arm structure had passed beyond the stage of mere individual variation due to growth, and became a permanent character of specific value perhaps. *B. Chrysti* and its variety with single arms—for which we propose the name *B. Lovei*—have twenty arm openings, but at the same time only twenty so called respiratory pores, which are located, as usually in species with twenty arms, above the interradial and interaxillary areas. In both species the pores are placed at like distances from the arm openings, which seems to prove that the additional arm was given off from the opposite side alternately from the pores. The arm starts from the first free arm piece, which is changed into a bifurcating plate, but without materially increasing its size. Toward the close of the Burlington Limestone *B. Chrysti* underwent some changes, and the variety thus produced has been described by Meek and Worthen as *B. trochiscus*. It has a more spreading disk, a more concave dome, a comparatively lower body, is of larger size, and consequently has more interradials, but otherwise is not different from *B. Chrysti*. *B. planodiscus* Hall, which occurs still higher in the Burlington and Keokuk transition beds, and in the lower part of the Keokuk Limestone, is evidently a more mature form of *B. Chrysti* and *B. trochiscus*, which by enormous development in the radial regions, and a great increase of interradial and interaxillary plates, attained a still greater expansion of the disk. In *B. Chrysti* and *B. Lovei*, interaxillary plates are wanting; they are occasionally represented by one or two plates in *B. trochiscus*, while *B. planodiscus* has from nine to eleven, with a similar increase of interradials. In the latter species, the small bifurcating arm pieces, from which in *B. Chrysti* the second arms are given off, and also the two succeeding rows of pieces, in both arms, are enclosed within the body walls, the inner row as radials, the other as interradial or interaxillary pieces, which all attain the form and size of the associated plates in the lower orders. *B. planodiscus* has forty arms like *B. Chrysti* and *B. trochiscus*, but they are simple, branching in the body; while the other two species have twenty arms which branch in their free state. The increase of arms no doubt takes place in this group in a similar manner as in *Actinocrinus* and *Strotocrinus*, but while in the two latter, the alternate pinnules of only the two *main divisions* of the ray became arms, in *B. planodiscus* the proximal pinnule of each arm was thus transformed.

In *B. Chrysti* and its allied forms, we find an illustration of the difficulty we often encounter in discriminating between species and varieties. There are apparently four forms represented in that type, of which the two extremes, viewed separately, are well defined specifically as well as geologically, but placed in connection with the two others, they form a series which might well be taken for variations of one species.

A similar case is presented by a series of specimens obtained from the Keokuk Limestone of Indiana. The collection comprises nearly two hundred specimens of *Batocrinus*, but contains comparatively few species. By far the greater number came from Bono, Lawrence County, others from Edwardsville, Floyd County, a few from Canton, and the rest from Crawfordsville. The Bono and Edwardsville crinoids, in their general habitus, resemble Burlington fossils, but we have so far not been able to identify a single Burlington species among them, while we found several identical with species from Crawfordsville, though generally smaller. The crinoidal fauna of Canton includes both Bono and Crawfordsville forms, but embraces also some of the huge forms so characteristic of the Upper Keokuk beds of Keokuk, Iowa, and Nashville, Tenn., and which are entirely wanting at Crawfordsville and Bono. We have not been able to ascertain the exact relative age of each stratum, but are inclined to believe that the Crawfordsville bed occupies an intermediate position between those of Bono and Canton on one side, and Keokuk on the other.

The crinoids to which we allude are easily separated into two groups. Those of the first have flat, somewhat spatulate arms, a subconical or subturbinate calyx, and a variable arm formula, and are appropriately referred to the genus *Eretmocrinus*, while those of the second, which we refer to *Batocrinus*, have a globose body, round arms, with arm formula: $\begin{array}{c}4\ 4\\ \underline{4\ 4}\\ 2\end{array}$, rarely $\begin{array}{c}4\ 4\\ \underline{4\ 4}\\ 4\end{array}$.

Among thirty-two specimens of the first group, all from Bono· there are twelve which have sixteen simple arms: $\begin{array}{c}3\ 3\\ \underline{4\ 4}\\ 2\end{array}$, two others have at one side of the right posterior ray *a pair* of arms instead of a single arm—the formula may be graphically represented thus: $\begin{array}{c}1\,1\,1\cdot1\,1\,2\\ 1\,1\,1\,1\ \ 1\,1\,1\,1\text{—}\\ 1\,1\end{array}$, and in one specimen we find one of the anterior arms represented by a pair, while all the others are simple. The last three specimens no doubt are abnormal cases, but they are interesting as showing a tendency of the species to an increase of arms in the postero-lateral and anterior rays. All the above specimens can be safely referred to a new species which we call *Eretmocrinus originarius*.

There are thirteen other specimens, for which we propose the name *Eretmocrinus intermedius*, which agree with the former in all essential points, having the same peculiar ornamentation, the same form and size, and being derived from the same layers; but they differ in having, as a rule, in the anterior ray two, and in both postero-lateral rays three additional arms, while the antero-lateral rays are unchanged. The additional arms are given off alternately from the two main divisions of the rays as in Actinocrinus. They are simple and in most cases included within the body walls, except in the two posterior rays, in which the arms arising from the last bifurcation are arranged in pairs.

In this lot of crinoids there are two more specimens, one having twenty-one arms distributed thus: $\underset{2\,2}{\overset{1\,1\,2\;1\,1\,1}{1\,1\,1\,1\;1\,1\,\underline{2\,2}}}$, and the other twenty-seven, thus: $\underset{2\,2}{\overset{2\,2\,1,2\,2\,2}{2\,2\,1\,2\;1\,1\,1\,2}}$. Both agree with the two preceding species except in the arm formula, but even this is fundamentally identical with *E. originarius*, the simple arms of the latter being in part replaced by pairs. None of our Bono specimens have the double arm structure throughout all the rays, but we obtained from Edwardsville and Canton several specimens in which that feature prevails, and for which we propose the name *Eretmocrinus adultus*. The two irregular Bono specimens may not be the intermediate forms between that species and *E. originarius*, but this is probable, and they show how the double arm structure became introduced.

Scarcely less interesting are some specimens of *Batocrinus*. Among sixteen examples of a form which we call *B. Whitei*—eleven from Bono, two from Canton, and three from Edwardsville—there are fourteen with the arm formula: $\frac{4\,4}{\underset{2}{\underline{4\,4}}}$, while two of them have four arms to the posterior ray. No double arm structure has been observed in this species at Bono, but its apparent representative at Crawfordsville has always two arms from each opening. *B. Indianensis* has the same form and ornamentation as *B. Whitei*, and the same arm formula—with substitution of double for single arms—and it evidently bears the same relation to that species as *B. Chrysti* to *B. Lovei*, and *E. adultus* to *E. originarius*.

It would be interesting to pursue this line of examination further, and trace the relations subsisting among other groups similarly connected. But we have perhaps gone far enough to serve our present purpose. It is to be observed, however, that the importance of this kind of investigation, in its bearing upon systematic classification, can scarcely be overestimated. It has to do with the principles which lie at the very bottom, and it is only by the study of these relations, of the exact anatomical changes which produced individual variation, and in time permanent modification of forms, that we can hope to arrive at a correct understanding of the groups in nature, or be able to make scientific discrimination of families, genera, species and varieties.

Many species have been made, upon mere differences of growth; some upon unimportant variations in the arm formula; some upon abnormal development in certain parts of the body; others upon slight modifications in ornamentation; while still others were founded upon material so imperfect that neither figure nor description sufficiently defines the form. Our literature is so overburdened with synonyms that we fear a very large percentage of so-called species ought to be eliminated. We have undertaken to point out such cases among the Burlington and Keokuk Crinoids, and although we have been obliged to throw out a considerable number of species, we have only done so where necessity seemed to require it, and we suspect we should not have gone amiss by reducing the list still more. Schultze undertook the same task for the Crinoids of the Eifel, and, although we cannot agree with him in retiring certain genera, we concur in his determination of synonymic species. There are no doubt, also many synonyms among the Subcarboniferous Crinoids of Belgium and England. One of us had an opportunity, several years ago, of studying the original collection of De Koninck in the Museum of Cambridge, and became convinced that the eleven Belgian species of *Actinocrinus*, described in the Recherches Crin. Carb. Belg., might be safely reduced to four or five.

10. The so-called "Respiratory Pores."

In the first part of this work, on page 11, we called attention to certain pores, located in the body at the arm regions, on either side of the ambulacral openings, and we endeavored to show that they correspond in position with the so-called ovarian openings of the Blastoids. At that time we asserted that the pores were in some genera fixed at a definite number, independent of the number of arms in the species; that *Batocrinus*, for instance, had always twenty pores, whether the species had twenty arms or more, and that one-half the pores were located radially and the rest interradially. In this we were evidently in error; the pores probably always agree in number with the arms, and are really neither radial nor interradial, but are placed at the base of the arms. A specimen of *Batocrinus subæqualis*, now before us, with twenty-two arm openings, has twenty-two pores, and a specimen with twenty-four arms has twenty-four pores. In the former the vault became accidentally detached from the calyx, in such a manner, that we were enabled to follow up in both parts the direction of the pores as they pass into the body (Pl. XIX, fig. 4). Neither the pores nor the arm openings penetrate the plates, but both are placed between the sutures and appear as grooves situated within the upper series of radials. The grooves in the calyx are opposed by similar grooves in the corresponding parts of the dome. and pores as well as arm openings enter the body horizontally. The grooves which constitute the arm openings follow the median course, while the smaller grooves, forming the pores, enter obliquely from the sides, and join the others at—or just before—the point where they enter the general cavity of the body. The pores which are given off toward the outer arms of the ray are deeper than the rest, and connect with the arm openings at the moment these enter the general cavity. Those of the inner arms meet midway in the test, and in case there is another arm between the two divisions of the ray, its pores join the arm passages close to the outer surface of the test. This explains the fact that the partition between the two last-mentioned openings is so rarely preserved, and that these openings are generally found united in the fossil. The arrangement of the pores is similar in other genera of the Actinocrinidæ, the pores between the main divisions of the ray being universally more conspicuous than the inner ones. In the Platycrinidæ and other genera in which the upper radials are extended into free rays, the pores are located at the base of the arms, not at the base of the free ray, and hence are rarely observed. *Ollacrinus*, so far, is the only genus in which, in connection with the pores, appendages have been observed. They there form heavy, arm-like extensions, often surpassing the arms in length, with a channel through their centre. The channels unite with the arm passages within the test in a similar manner as the pores in *Batocrinus*.

The affinities which are apparent between the pores of the Actinocrinidæ and the ovarian openings of the Blastoids with regard to their position, suggests a probable analogy in their functions, and if the latter served as a madreporic apparatus it would seem reasonable to suppose that the pores in the Actinocrinidæ did the same. But there are objections to this, and another interpretation is at least possible. From what is now known of the ontogeny of the Palæozoic crinoids, we are inclined to think that the pores may have been originally pinnules, which with progressing growth were soldered into the body. This would explain the fact that all pores located beside the inner arms are located closer to the arm openings than those of the outer arms.

for they are pinnules of higher branches in the body, and hence were less deeply enclosed in the test.

It would be interesting to trace the pores in genera like *Glyptocrinus*, in which the fixed pinnules retain their forms after they became fixed; but in those genera the arms are unfortunately located at the edge of the ventral disk, and an examination is difficult. In all carboniferous Crinoids in which the pores are clearly seen, no fixed pinnules can be traced externally in the test, and apparently no free pinnules were attached to the pores, or they should have been found preserved in some of our specimens.

The proximal pinnules in the recent Crinoids contain the genital glands, and it is at least not impossible that the pores as rudimentary pinnules, served as genital organs. This supposition is strengthened by a comparison with the ovarian openings of the Ophiuridæ and Astrophytidæ, which apparently occupy a very similar position to the pores of the Actinocrinidæ. Those, we believe, are said to be in part respiratory and so it is possible that the pores of these Crinoids had both functions.

As a convenient summing up of our discussion of the Sphæroidocrinidæ, we give the following

Condensed Family Diagnosis.

Body comparatively large, globular, conical or biturbinate; plates solidly cemented together, immovable, separated only by sutures; symmetry bilateral, sometimes almost perfectly pentahedral.

Calyx composed of basals, radials, interradials and sometimes interaxillary plates. Underbasals present or absent. Radials in at least two orders, the upper one frequently extended into free rays. Posterior or anal area wider than the four interradial areas, and the arrangement of its plates generally distinct. Ventral disk more or less elevated, constructed of numerous plates forming a free arch, unsupported by oral plates. The plates of the vault are arranged substantially upon the same plan as those of the calyx, and consist of the same elements. Apical dome plates well defined. Anus in form of a simple opening directly through the vault, or prolonged into a solid tube, perforated at the distal end, but without respiratory pores.

Arms composed of one or two series of pieces. Pinnules long, slender, generally in contact laterally. Food grooves and ambu-

lacral vessels entering the body through openings in the test, whence they are continued beneath the vault by means of tubes.

Digestive apparatus composed of a convoluted sac, surrounded by a delicate calcareous network.

Column long; its cross-section circular, elliptical, sometimes pentagonal or quadrangular; central perforation small to medium, rarely large.

A. Sub-family **PLATYCRINIDÆ** Roemer.

(Amend. Wachs. & Spr.)

The name Platycrinidæ has been used by most writers in a full family sense, and in this they seemed to be justified, as most of the genera are by their general aspect readily distinguished from those of the Actinocrinidæ and Rhodocrinidæ. The differences, however, which produce that particular habitus, are evidently not the result of marked anatomical modifications.

The body of the Platycrinidæ, according to the views of other writers, is composed only of basals, primary radials, and vault pieces, all succeeding plates in a radial direction are considered by them to be arm plates. The rays in this group generally become free from the first axillary, but the extended parts are true extensions of the body, covered like this by regular vault pieces, and these arranged in the same manner, they are not arms in our sense, as they possessed no true articulation. If the respective parts in the Actinocrinidæ are to be regarded as radials, then also are those of the Platycrinidæ, they compose in the former the sides of the body walls only in adult specimens, in the younger state they form free appendages as in the mature Platycrinidæ. The plates of the extended parts are joined by suture, there is no hinge line, and the articulation was by ligament only, probably similar to that of the anal tube, which certainly was flexible to some extent.

The distinctions between Platycrinidæ and Actinocrinidæ are more readily perceived than described, and seem to be fairly expressed by saying that the former represent a younger stage of the latter, and remained as a persistent type of that stage of growth. The interradial regions are represented by a single plate, leaving the upper radials unconnected laterally as in the young Actinocrinoid.

A close comparison of the three sub-divisions of the Palæocrinoidea shows that the modifications which each undergoes, sometimes in the same geological epoch, are more or less repeated in all of them. This is particularly the case as to the construction of the arms. The same development from single to double arm joints occurs in all of them, and simultaneously in the Upper Silurian. A similar analogy is found in the arrangement of the arms. In each group there are simple and branching arms, arms which are given off directly from the body, or laterally from free rays, and even the pinnules are arranged in a like manner. The plates of the body are composed essentially of the same elements, but in the Platycrinidæ comparatively few plates are enclosed within the calyx, many of them, which in the Actinocrinidæ form a conspicuous part of the body, being here found in the lateral appendages. In the Platycrinidæ, the calyx proper is constructed almost exclusively of basals and first radials, all higher orders of radials either forming a part of the brachial appendages, or, when partially incorporated with the calyx, being insignificant compared with the other parts. In this respect they exhibit a marked difference from the Actinocrinidæ and Rhodocrinidæ, in which the higher radials are prominent elements in the calyx. In the Platycrinidæ, the interradial plate is pushed into a line between calyx and dome, and appears like a dome plate, though being in fact a part of the aboral side, and analogous with the first interradial in the Actinocrinidæ, like this it rests upon the upper edges of the two adjoining first radials, which are generally notched for its reception, a position very different from that of the interradial dome plates. In *Dichocrinus* the radials are not notched, and the plate in question is actually pushed into the dome, but here also, as in all similar cases, a more profuse development of second and third radials within the calyx, would place this plate in position with the interradials in the Actinocrinidæ.

We have stated in our family diagnosis that the Sphæroidocrinidæ have at least one interradial plate; *Pterotocrinus* seems to be an exception to this rule, but in that genus the family relations are otherwise so clearly expressed, that it seems to us unnecessary to separate it on account of the absence of that plate. *Pterotocrinus* is the last survivor, and probably the most mature and extravagant form of the family In its typical species there are not only secondary, but also tertiary radials enclosed in the calyx, and the plates of the different rays meet laterally in the body. The case is similar to that of *Strotocrinus;* the arms, as in that genus, are crowded together, naturally producing at first a lack of mobility in the proximal parts of the rays, until eventually the sides became attached. In *P. crassus* and *P. Chesterensis* Meek and Worthen, in which the lower arm portions are comparatively narrower, the connection between the rays is not perfect, especially at the posterior side; while in *P. depressus* Lyon, and in all of Wetherby's species, the connection between the upper radial is uninterrupted, and the arms are given off directly from the body, and not from brachial appendages or free rays. In Meek and Worthen's species, in which the first radial plate extends to the top of the calyx, it is apparent that the first plate above, though pushed into the dome, is the analogue of the regular interradial plate of the group, but in *P. depressus*, in which that plate rests above the tertiary radials, it is probable that the interradial plate proper was pushed inwards, and either became obsolete, or is perhaps visible only at the inner side of the test.

The construction of the dome has been already so fully discussed that a few general remarks here will suffice. The vault resembles fundamentally that of the Actinocrinidæ and Rhodocrinidæ. The plates are comparatively large, and the apical dome plates very conspicuous. The radial regions are each composed of two rows of plates alternately arranged, which commence either close to the centre plate, or near the edge of the disk, and branch toward the free rays, following their direction, and paving their ventral surface. The interradial regions of the dome are comparatively large, composed of one, two or more plates. Anus in form of a small tube, or simple vault opening. Column round or elliptic, never pentagonal; perforation very small.

For greater convenience we have divided the Platycrinidæ into two sections:

A. Platycrinites, including genera with a marked pentahedral symmetry, and without special anal plates in the calyx.

B. Hexacrinites, with a decided bilateral symmetry, and a large anal plate enclosed within the calyx.

The presence of a special anal plate, upon which this division has been based, is somewhat remarkable, on account of the great size of the plate, and the comparatively large space which it occupies in the body; but too much importance should not be attached to it, as we find in the Actinocrinidæ and Rhodocrinidæ the same variation, and apparently without any disturbance of the relations between the genera. The presence of this plate in the Platycrinidæ is entirely in harmony with our idea that this group represents a younger stage of the Actinocrinidæ, for this anal plate was early developed in the animal, and is found in the youngest individuals in both groups of equal size with the first radial.

In 1843, the two Austins proposed (Monogr. Rec. and Foss. Crinoids) the name Platycrinidæ as a family designation, embracing the genera *Platycrinus*, *Cyathocrinus* and *Caryocrinus*, without special diagnosis, merely mentioning that those genera "had but few plates below the ray, and thus might conveniently be arranged into a natural group." They placed *Marsupiocrinus* along with *Crotalocrinus* under the "Marsupiocrinoidea."

Not any better is the arrangement of D'Orbigny, who placed *Platycrinus* under "Melocrinidæ," and *Edwardsocrinus* and *Dichocrinus* under the Cyathocrinidæ.

F. Roemer's "Platycrinidæ" (1855. Leth. Geognostica, Ausg. III, p. 228), agree substantially with ours. He brought into the family: *Platycrinus*, *Dichocrinus*, *Hexacrinus*, *Culicocrinus* and *Marsupiocrinus*, but unfortunately added *Atocrinus*[1] and *Symbathocrinus*, the first of which we place under the Cyathocrinidæ, and the latter we consider the type of a new family. Pictét (Traité de Paléont., 1857) made his *Platycriniens* a sub-division of the *Cyathocrinidæ* and enumerates under it the genera *Platycrinus*, *Edwardsocrinus*,[2] *Amblacrinus*,[3] *Marsupiocrinus*, *Atocrinus*, *Symbathocrinus* and *Adelocrinus*,[4] but placed *Coccocrinus* and *Haplocrinus* under the *Haplocrinidæ*, following Roemer.

The arrangement of Zittel (Handb. der Palæontologie) agrees

[1] *Atocrinus* McCoy, is evidently a *Cyathocrinus* in which the sutures between the plates are invisible, owing to the condition of the fossil, and not a *Platycrinus* as supposed by some authors. The plates of the body and the arms agree exactly with *Cyathocrinus*, while no *Platycrinus* of the Subcarboniferous has single arm joints.

[2] Syn. of *Platycrinus*.

[3] D'Orbigny, insufficiently defined, probably syn. of *Coccocrinus*.

[4] Phill., insufficiently defined.

with that of Roemer, except that he separates *Symbathocrinus* and adds *Cordylocrinus* and *Pterotocrinus* which had been established later. He also placed here *Storthingocrinus* which we propose to transfer to the Symbathocrinidæ.

The Platycrinidæ are first met with in the Upper Silurian, whence they range to the close of the Subcarboniferous.

We arrange the two sections as follows:—

a. PLATYCRINITES.

1. *Coccocrinus.*
2. *Cordylocrinus.*
3. *Culicocrinus.*
4. *Marsupiocrinus.*
5. *Platycrinus.*
   Subgenus *Eucladocrinus.*
6. *Cotyledonocrinus.*

b. HEXACRINITES.

7. *Hexacrinus.*
8. *Dichocrinus.*
9. *Talarocrinus.*
10. *Pterotocrinus.*

a. PLATYCRINITES.

1. COCCOCRINUS Joh. Müller.

1855. Müller. Verh. Naturh. Verein Rheinl., xii, p. 20.
1860. F. Roemer. Foss. Fauna. Westlich. Tenn., p. 51.
1879. Zittel. Handb. d. Palæont., i, p. 347.
Syn. *Platycrinus* Roemer, 1844 (not Miller), Rhein. Uebergangsgeb., p. 63.

Müller proposed the genus *Coccocrinus* for a species which had previously been referred by Roemer to *Platycrinus.* The two genera are identical in the construction of the calyx, and the summit really forms the only distinction between them. In well-preserved specimens of *Coccocrinus*, the vault is constructed of five large oral plates, which rest upon five interradial pieces. The oral plates are not in contact laterally, but leave five slits, which in the fossil have no floor nor covering, and leave an open space in the centre. It is evident that the central space and open furrows were covered in the animal as in similar genera, and this suggests a closer analogy with *Platycrinus* than had been suspected by Müller, Schultze, Zittel or Carpenter, who suggested an unobstructed mouth. The interradial plate which rests upon the edge of the first radials is characteristic of both genera, and the two or more succeeding interradial dome pieces of *Platycrinus* are possibly analogous with the single so-called oral plates of *Coccocrinus.* This, if correct, would reduce the generic difference to that of a compound oral plate in *Platycrinus*, as against a simple one in *Coccocrinus.*

Zittel has arranged this genus with *Haplocrinus* under a separate family.

Generic Diagnosis.—Body small, globose; calyx constructed like that of *Platycrinus;* vault composed of five oral plates, resting upon five smaller interradial pieces.

Basals three; two of them equal, the third smaller by half, the suture between the two equal plates directed toward the right posterior ray; the two sutures in connection with the smaller one directed to the anterior and left lateral rays, thereby disturbing the general symmetry of the calyx, which otherwise would be perfect.

Radials 2×5; the first large, quadrangular, its upper corners slightly truncate for the reception of the interradial, and its upper side slightly convex. Second radials narrower by half than the first, and very short; they are almost quadrangular—although bifurcating plates—on account of the very obtuse angle upon which they support the arms.

Arms unknown, only a single joint having been discovered, which is small and round.

Interradials, one to each area resting upon the corners of the first, and between the second radials; its upper part truncate, deflected towards the summit, and supporting another somewhat larger plate. giving five in the vault, which form a low pyramid. The latter, which are oral plates, do not join laterally, nor in the centre, but leave a median space and lateral slits, which. in perfect specimens, were doubtless closed, the one by the apical dome plates and the slits by small marginal pieces. Posterior side only distinguished by the anal opening, which is placed within the suture of the interradial and oral plate.

Column small, cylindrical; central canal round and narrow.

Coccocrinus differs from *Haplocrinus* in having the first radials simple instead of compound, and in the oral plates, which in the latter are formed into compartments for the reception of the arms. It differs from *Platycrinus* and *Cordylocrinus* in the summit structure, and from the former also in having the column round instead of elliptical and twisted.

Geological Position, etc.—Of the two species referred to this genus, one is from the Lower Silurian of Tennessee, the other from the Devonian of the Eifel, Germany.

1844. **Coccocr. rosaceus** F. Roemer. (**Platycr. rosaceus**) Rhein. Uebergangsgeb., p. 63, Pl. 3, fig. 3; Müller, 1855. **Coccocr. rosaceus**, type of the genus. Verh. Naturh. Verein Rheinl., xii, p. 21, Pl. 7, figs. 5 a, b, c Bronn, 1860. Klassen des Thierreichs, ii, Pl. 28, figs. 8 a, b, c; Schultze, 1867. Echinod. Eifl. Kalk., p. 89, Pl. 12, fig. 13. Devonian, Eifel., Germany.

1860. **Coccocrinus bacca** F. Roemer. Silur. Faun. West. Tenn., p. 51, Pl. 4, figs. 5 a, b, c. Niagara Gr., Tennessee.

2. CORDYLOCRINUS Angelin.

1878. Angelin. Icon. Crin. Suec., p. 3.

1879. Zittel. Handb. der Palæontologie, i, p. 365.

Syn. *Platycrinus* Hall (not Miller), Pal. N. Y., iii, p. 113.

Hall (Pal. New York, iii) describes three species under *Platycrinus* which evidently belong to *Cordylocrinus*. They have the same number of radials, and the arms are similarly composed of a single row of joints. The genus should, however, be amended so as to admit species with branching arms. We propose the following:

Generic Diagnosis.—Body small, closely resembling a young *Platycrinus*.

Basals three; unequal, closely anchylosed. Radials 3×5: the first very large; the second quadrangular, much wider than high, resting within the concave upper margin of the first; the third, which has the proportions of the second, but bifurcating, supports the two primary arms of which each ray is composed.

Arms simple or branching, composed of single joints. Pinnules long.

Interradials, one between the upper edges of the first radials, and followed by three or more similar plates in the dome, the number of the latter being greater on the posterior side.

Form of dome and anus, and condition of the apical dome plates unknown.

Column cylindrical, joints alternating in size, the larger giving off sometimes at intervals long lateral cirrhi.

Geological Position, etc.—Restricted to the Upper Silurian, both in Europe and America.

We place here the following species:—

1878. **Cordylocrinus comtus**, Angelin. Type of the genus. Iconog. Crin. Suec., p. 3, Pl. 23, fig. 3. Upper Silurian. Gothland, Sweden.

*1861. **Cordylocrinus parvus**, Hall. (**Platycr. parvus**). Pal. New York, iii, p. 114, Pl. 4, figs. 6, 7, 8, 9. Lower Helderberg. Herkimer Co., New York.

1861. Cordylocr. plumosus, Hall. (Platycr. plumosus.) Pal. New York, iii, p. 113, Pl. 4, figs 1–5. Lower Helderberg. Herkimer Co., New York.

1861. Cordylocr. ramulosus, Hall. (Platycr. ramulosus. Pal. New York, iii, p. 115, Pl. 4, figs. 10–13. Lower Helderberg. Herkimer Co., New York.

3. CULICOCRINUS Joh. Müller.

1855. Joh. Müller. Verh. Naturh. Verein Rheinl. xii, p. 23.
1855. F. Roemer. Lethæa Geogn. Ausgabe iii, p. 243.
1879. Zittel. Handb. der Palæont., i, p. 367.
Syn. *Platycrinus* Wirtgen and Zeiler, 1855. Verh. Naturh. Verein, p. 15.

Müller proposed *Culicocrinus* merely as a subgenus of *Platycrinus*, a distinction which seems to us scarcely in proportion to the differences apparent between the two forms, and we therefore propose it as a genus. Zittel even places it with *Briarocrinus* under a separate family. *Protoergale confluentina*, Roemer (Verh. Naturh. Vereins, xii, p. 29, Pl. 9, figs. 2, 3), is according to Müller probably identical with *Culicocr. nodosus.*

Generic Diagnosis.—Body elongate; calyx higher than wide; basals and first radials heavy and nodose; symmetry almost perfectly pentahedral.

Basals three, large; two of them equal, pentagonal, the third smaller by half and quadrangular; sutures very distinct. They form a pentagon, the central part excavated for the reception of the column; separated from the radials by a deep groove. Primary radials 3×5; the first large, tuberculous, quadrangular in outline but in fact hexagonal, owing to the slight truncation of the upper corners adjoining the interradials; the second about quadrangular, narrower than the first, very short, and three or four times wider than high; the third varying in form and size, but generally triangular. The latter plates mostly occupy only the median portion of the margin of the second radials, in which case the outer ends of those plates aid in supporting the secondary radials; sometimes, however, they fill the entire width of the second primaries, and the secondary plates rest wholly upon the sloping sides of the triangular pieces. Secondary radials 1×10, generally wider than high, supporting two arms to the ray.

Arms stout, attached laterally up to the second or third joints, above which at some distance they branch. They are from the base up composed of two rows of joints, alternately arranged, and meeting by zigzag sutures.

Interradials: one, placed between the upper corners of the first radials, higher than wide, narrowing toward the summit, extending to the top of the secondary radials, and abutting against the proximal dome plates. The plate at the posterior area is somewhat wider, and supports the anal aperture which is almost lateral.

The dome, according to Müller, is composed of only five plates, but we suggest that probably his largest plate includes four plates, the spiniferous central vault piece, the two proximal vault pieces, and a small anal plate between them. The four large proximal vault pieces, each crowned with a spine, are no doubt, correctly represented. Those few plates occupy the greater part of the summit, leaving but little space for the radial dome plates, which as yet are unknown.

Column round.

Culicocrinus, in its form and general habitus, has the closest resemblance to our genus *Talarocrinus*, which bears the same relation to *Dichocrinus* as *Culicocrinus* to *Platycrinus*. In *Platycrinus* and *Dichocrinus*, all radials above the first plate form a part of the free rays, while in the two other genera all the primary and even the secondary radials are included in the calyx. This genus further differs from *Platycrinus* in having three primary radials, a character which distinguishes it also from *Marsupiocrinus*, the construction of the vault being likewise very distinct. It differs from *Cordylocrinus* in the arm structure.

Geological Position, etc.—The only known species is from the Lower Devonian of Germany.

1855. **Culicocrinus nodosus** Wirtgen and Zeiler. (**Platycr. nodosus.**) Verh. Naturh. Verein, xii, p. 15, Pl. 6, figs. 2, 3. Müller, 1855. **Culicocr. nodosus.** Ibid., p. 24, Pl.. 8, figs. 1–4. Grauwacke. Near Coblentz, Germany.

This species is known only by impressions left in the rock, and casts taken therefrom.

4. MARSUPIOCRINUS Phillips.

(Not **Marsupicrinites** Blainville = **Marsupites** Mant., nor **Marsupiocrinites** Hall. = **Lyriocrinus**).

1839. Phillips apud Murchison, Silur. System., p. 672.
1842. Austin. Ann. Mag. Nat. Hist., x, p. 109.
1843. Austin. Ibid., xi, p. 198.
1857. Pictet. Traité de Paléont., iv, p. 332.
1878. Angelin. Icon. Crin. Suec., p. 2.

1879. Zittel. Handb. der Palæont., p. 365.

Syn. *Platycrinus* F. Roemer, 1860. Silur. Faun. W. Tenn., p. 35.

" *Cupellæcrinus* Troost, 1850. List. Crin. Tenn., p. 61; also Shumard, 1866. Catal. Pal. Foss. North Amer., p. 361.

Marsupiocrinus has undoubtedly close affinities with *Platycrinus*, with which it has been identified by Joh. Müller and Hall, but it differs in the higher orders of radials, which, instead of being extended into free rays, form a part of the calyx; and also in having the column round instead of elliptic, and the canal larger.

Troost's genus *Cupellæcrinus*, which was defined as late as 1866 by Shumard, must be considered a synonym of this genus, unless it should hereafter be found that the anus in the former consists of a simple opening through the vault, and not a tube as in the latter, in which case a subgeneric division might be justified. Troost, in his List. Crin. Tenn., mentions several species under *Cupellæcrinus*, one of which is probably identical with Roemer's *Pl. Tennesseensis*, but none of them have ever been described or figured.

Angelin's *Marsupiocrinus dubius* is quite a different thing, probably an Actinocrinoid, as is indicated by the basal disk, which, instead of being pentagonal, is hexagonal and divided into three equal pieces.

Joh. Müller considered *M. cœlatus* a *Platycrinus* (Monatsb. Berl. Acad., 1841, p. 207), differing from the Austins, who made it the type of a separate family in which they included the genus *Crotalocrinus*. Pictet, Angelin, and Zittel view the matter as we do, and place it as a distinct genus under the Platycrinidæ.

Generic Diagnosis.—Body globular; calyx low, basin-shaped, the lower portions flat or slightly convex; sides more or less straight, surface corrugated or ornamented by fine striations; symmetry perfectly pentahedral; secondary and tertiary radials forming part of the calyx; connected laterally by a single interradial plate.

Basals three, large, unequal, arranged as in *Platycrinus*. Radials 2×5; those of the first row large, meeting laterally, bent abruptly from their connection with the basals, and forming with them a shallow cup, the middle of their upper margins excavated for the reception of a small triangular second radial, which is at least as high as wide, but often higher, and which has convex sides. This plate occupies not more than one-fourth to one-third the width of the first radials, and supports on its upper sloping margins the secondary radials. Secondary radials 2 × 5, enveloping the little bifurcating plate entirely except below. They are comparatively large, pentagonal to heptagonal, meeting by their short inner sides above the apex of the small bifurcating plate, and resting with their lower sides upon the upper margin of the first radial, filling the greater part of it. In some cases they touch with their outer edges the interradials, and support upon their long upper sides several small plates which pass gradually into the arms. In other cases there is on either side of these plates, and between them and the interradial, another plate of about the same size, which sometimes rests also partly on the first radial, and forms the first of a series of three tertiary radials, which support the outer arm on each side of the ray. One, and sometimes two similar tertiary radials support each of the inner arms of the ray. In forms like the last, the secondary radials seem to be bifurcating plates, supporting on each upper sloping face a series of tertiary radials leading to an arm.

Arms twenty, sometimes perhaps only ten; composed of a double series of interlocking joints, either throughout their entire length, or all except near the base, where there are sometimes single cuneiform joints passing gradually into a double series. Arm furrow deep and wide; pinnules long, composed of round joints, somewhat contracted in the middle and widening toward the articulations.

Interradial plate large, higher than wide, supported upon the upper sloping corner of the first radials, and connecting the secondary and frequently the tertiary radials with the body. Posterior side of calyx in no way distinct from the other sides.

Vault low, hemispherical, composed of a larger number of plates than usually found in this family; plates small, particularly the radial dome plates. These are generally formed into narrow ridges, which bifurcate twice within the body. Interradial dome plates larger than the radial; apical plates not prominent and identified with difficulty; interpalmar spaces paved with small pieces. Anus subcentral, tubular, or perhaps in form of a simple opening (?).

Column round, composed of rather large joints alternating with small ones; central perforation obtusely pentagonal, considerably larger than in *Platycrinus*.

Geological Position, etc.—*Marsupiocrinus* is strictly an Upper Silurian genus, and is found both in Europe and America.

We recognize the following species:—

1839. **Marsupiocrinus cœlatus** Phillips. Type of the genus. Murchison's Silur. Syst., p. 672, Pl. 18, fig. 1; Austin, 1842. Ann. and Mag. Nat. Hist., x, p. 109. Upper Silurian. Dudley, Eng.

1878. **Marsupiocr. depressus** Angelin. Icon. Crin. Suec., p. 3, Pl. 10, figs. 15–17. Upper Silurian. Gothland, Sweden.

1878. **Marsupiocr. pulcher** Angelin. Icon. Crin. Suec., p. 3, Pl. 22, figs. 27, 28; and Pl. 27, figs. 4, 4 a. Upper Silurian. Gothland, Sweden.

1878. **M. radiatus** Ang. Icon. Crin. Suec., p. 2, Pl. 10, figs. 18–21. Upper Silurian. Gothland, Sweden. This species was erroneously referred by Hisinger to **Eucalyptocrinus rosaceus** Goldf.

1878. **M. rugulosus** Ang. Icon. Crin. Suec., p. 2, Pl. 22, fig. 1. Upper Silurian. Gothland, Sweden.

*1860. **M. Tennesseensis** F. Roemer. (**Platycr. Tennesseensis**) Sil. Fauna. West Tenn., p. 35, Pl. 3, figs. 4, a-e; Shumard, 1866. **Cupellæcrinus Tennesseensis**, Cat. Pal. Foss., pt. i, p. 362. Niagara Gr., Upper Silurian. Decatur Co., Tenn.

*1861. **M. tentaculatus** Hall. (**Platycr. tentaculatus**) Pal. New York, iii, p 116, Pl. 5, figs. 1–4. Lower Helderberg Gr., Upper Sil. Schoharie, New York.

5. PLATYCRINUS Miller.

1821. Miller. Hist. of the Crinoidea, p. 73.
1833. Goldfuss, in part. Petrefact. Germ., i.
1835. Agassiz, in part. Mem. Soc. Neuchat., i, p. 197.
1836. Phillips. Geol. of Yorkshire, ii, p. 204.
1839. Goldfuss, in part. Nov. Acta. Ac. Leop., xix, p. 343.
1841. Joh. Müller. Monatsb. Berl. Akad., i, p. 207.
1842. T. Austin. Ann. and Mag. Nat. Hist., x, p. 109.
1843. T. Austin. Ibid., xi, p. 199.
1843. T. Austin. Mon. Rec. Foss. Crin., p. 6.
1849. McCoy. Ann. and Mag. Nat. Hist. (ser. 2), iii, p. 146.
1850. D'Orbigny. Prodr. de Paléont., i, p. 156.
1852. D'Orbigny. Cours. Elém. de Paléont., ii, p. 242.
1852. Quenstedt, in part. Handb. d. Petrefakt., p. 619.
1853. De Koninck and Lehon. Recherch. Crin. Belg., p. 155.
1855. F. Roemer. Lethæa Geogn. (Ausg. iii), p. 242.
1857. Pictét. Traité de Paléont., iv, p. 330.
1858. Hall. Geol. Rep. Iowa, i, Pt. ii, p. 525.
1866. Meek and Worthen. Geol. Rep. Ill., ii, p. 170.
1878. Wachsm. and Spr. Proc. Acad. Nat. Sci. Phila., p. 243.

1879. Zittel. Handb. d. Palæontologie, p. 364.

Not Phill., 1841. Pal. Foss. Cornwall, p. 28. = *Hexacrinus.*

Not F. Roemer, 1844. Rhein. Ueberg. Geb., p. 63. = *Coccocrinus.*

Not D'Orbigny, 1850. Prodr. d. Pal., i, p. 103. = *Hexacrinus.*

Not F. Roemer, 1851. Foss. West Tenn., p. 35. = *Marsupiocrinus.*

Not Hall, 1861. Pal. N. York, iii, p. 113. = *Cordylocrinus* and *Marsupiocrinus.*

Not Schultze, 1866. Echin. Eifl., p. 68. = *Storthingocrinus.*

Not Lyon, 1869. Am. Phil. Soc., xiii, p. 459. = *Hexacrinus.*

Syn. *Astropodia* Ure., 1797. Hist. of Rutherglen.

Syn. *Nave Encrinite* Parkinson, 1811. Org. Rem., vol. ii.

Syn. *Encrinites* Schlottheim, 1823. Nachtr. Petrefaktenk.

Syn. *Centrocrinus* Austin, 1843. Rec. and Foss. Crin., p. 6

Syn. *Pleurocrinus* Austin, 1843. Rec. and Foss. Crin., p. 6.

Syn. *Edwardsocrinus* D'Orbigny, 1850. Prodr. d. Paléont, i, p. 156.

Syn. *Edwardsocrinus* D'Orbigny, 1852. Cours. Elém., ii, p. 145.

Syn. *Edwardsocrinus* Pictét, 1857. Traité de Pal., iv, p. 331.

Platycrinus was correctly defined by Miller, and his original species with the single exception of *Pl. pentangularis*, have been retained in the genus ever since. This species, described from an imperfect specimen, was made by D'Orbigny the type of his genus *Dimorphocrinus* (Prodr., i, p. 155), but is evidently a *Pentremites.*

Austin supposed the basal disk to be undivided in *Platycrinus*, and admitted into it species which have a large anal plate in line with the first radials, but such only in which he thought the base to be composed of a single piece; he refers all species, in which he had "observed a tripartite base," to his genus *Hexacrinus*, whether they have an anal plate or not.

The several species which Goldfuss placed under *Platycrinus* embrace very different forms, only comparatively few of which can be retained, and some of them must be arranged under distinct families.

Phillips' two species, from the Devonian of Cornwall, have been placed with Devonian species from other localities under *Hexacrinus.*

Roemer's *Platycrinus rosaceus* is a *Coccocrinus*, his *P. Tennesseensis*, and Hall's *P. tentaculatus*, both from the Upper Silurian, have been referred by us to *Marsupiocrinus:* Hall's *P. parvus*, *P. plumosus* and *P. ramulosus* to *Cordylocrinus.*

Schultze, in 1866, described under *Platycrinus* several species from the Eifel, which he found to differ from that genus in having no interradials, and, as he supposed, no solid ventral covering. He proposed, in case a separation should be found advisable, to call this form *Storthingocrinus.* We have no specimens for comparison, but if the figures are correct, we cannot doubt that these species are not only generically distinct, but belong to a different family. In the entire absence of interradial plates they resemble *Symbathocrinus*, and they seem to have been, like other genera of that group, covered exclusively by apical dome plates resting directly upon the external articulating facets of the first radials. We accordingly recognize the genus, but remove it to the Symbathocrinidæ.

Edwardsocrinus D'Orbigny, as previously stated, is nothing but a young *Platycrinus. Eucladocrinus* Meek, is a more mature form in a phylogenetic sense, and is therefore properly separated as a subgenus.

Platycrinus, as now restricted, includes species with an anal tube, and those in which the opening is directly through the vault. The tube has been represented by the two Austins and by De Koninck and Lehon as extending almost to the height of the arms, heavy and rounded at the distal end. We fear that some of their figures are more ideal than real; at least we never saw an American species with so long a tube. Where we have observed it, the tube is heavy, but short, and we doubt whether in any species it extended to more than two-thirds the height of the arms, if indeed as high. Nor is the upper end closed, as the Austins supposed, nor valvate; it has a small opening, and this, without being lateral, is somewhat excentric. The opening through the vault, where there is no tube, is located more or less laterally, never centrally, and usually at the top of a wart-like process, which may perhaps be considered a rudimentary tube.

The two Austins attempted a division of the genus, based upon the form of the anus. They proposed to place under *Platycrinus* only species with a "central *oral* tube;" those with a "valvate, unobtrusive *mouth*, or *mouth* capable of being withdrawn into the visceral cup," they called *Centrocrinus;* and those with a "*mouth* placed laterally, or not central," *Pleurocrinus.* Some of these characters are not in accordance with the facts. The so-called mouth, by which they meant the anus, is always excentric, and a withdrawal of the tube into the body, as suggested, is an entire impossibility. The species of this genus are so numerous that a sub-division would be very desirable, but even a subgeneric separation, based upon the presence or absence of an anal tube, upon which other genera of this family have been successfully divided, cannot be practically carried out at present, for the reason that these parts are known only in comparatively few species, and we have been unable to discover any additional characters by which to separate the two forms. We have, however, added *Pleurocrinus* in brackets, wherever the species is known to possess a simple opening, and it may be said that, as a pretty general rule, species of their kind have a more discoid form, while those with a tube have a more elongate body; but there are exceptions in both cases, and often the facts are exactly the reverse.

Generic Diagnosis.—Body spheroidal; low discoid to elongate. Calyx composed of basals and first radials, without anal plates intervening; all succeeding radials embraced in the free rays; surface of plates variously ornamented; symmetry almost equilateral.

Basals three, unequal; one quadrangular, the other two pentangular and twice as large. They are cemented together by their sides and form a flat disk, or a more or less shallow cup, the smaller basal being located below the suture between the anterior and left lateral radials. Primary radials 2×5; the first very large, about quadrangular in outline, the second small, triangular or pentagonal, resembling an arm plate in form. Second radial inserted upon the excavated upper margin of the first, or upon this and a projecting callosity or thickening of the margin. The plate is sometimes so small that even both radials of the second order rest within the excavation of the first plate. The orders of radials vary in number, corresponding to the number of arms in the species: each order consisting of two plates, both wider than high, the second bifurcating. All the radials from the second primary up, are placed into free rays, from which the arms are given off alternately from opposite sides, with two arms to the last bifurcation.

Arms long, rather heavy, composed of a double series of plates, which have the same style of ornamentation as the plates of the calyx. In the younger stage, the arms are composed of single wedge-form joints, giving off pinnules in a zigzag form. Pinnules long, slender, composed of rounded joints, closely packed together; their ventral furrows covered by two rows of alternate pieces.

Interradials, one to each space, placed between the free rays; supported by the first radials, but not touching the second primary or any other radial plate.

Dome elevated, composed of comparatively few and large plates; apical dome plates prominent; the central and the four large proximal pieces nodose or even spiniferous. Radial regions somewhat elevated, constructed of a double row of larger or smaller pieces, alternately arranged, which, decreasing in size, extend to the extremities of the free rays. Interradial spaces occupied by three—rarely five—plates, smaller than the central dome plates and less nodose, but yet comparatively large, and resting upon the interradial of the calyx. On the postero-lateral sides, there are several additional plates, supporting the arms. In rare cases, the interradial dome plates of different zones are laterally connected, and the radial pieces are thereby pushed to near the edge of the disk.

Anus in form of a short, heavy tube, composed of smooth plates; abruptly rounded at its upper end; with opening nearly central (*Platycrinus*), or in form of a simple lateral opening through the vault (*Pleurocrinus*).

Column large and twisted; composed of rather large joints, which increase in length as they recede from the body: central perforation minute. The column is comparatively short, and toward the base provided with numerous lateral branches, which like the main stem, terminate in thin, almost hair-like tubes. The joints are transversely elliptic, each one being twisted so that the long diameters of opposite faces make an angle with each other; and, the articulation being in the long diameters, a rapid twist is imparted to the whole stem, permitting motion in all directions. The stem seems to be regularly articulated, which is not the case in crinoids with a round or pentagonal stem; the articulating lines run lengthwise of the faces of the joints and consist of a long ridge along the middle, with deep depressions on either side, which latter were evidently filled by ligament. The column forms one of the most characteristic features of the genus.

Geological Position, etc.—*Platycrinus*, as here defined, is almost exclusively a Subcarboniferous genus, only two small species (one of them doubtful) being known from the upper part of the Devonian. It is found most abundantly in rocks of the Burlington epoch, which embraces the lower portions of the Subcarboniferous, it ceases to exist at the close of the St. Louis limestone. No other genus of the Palæocrinoidea has so great a number of species, is so abundantly represented, and has so wide a geographical distribution.

We recognize the following species :—

1861. **Platycrinus æqualis** Hall. Desc. New Sp. Crin., p. 117; also Geol. Rep. Ill., v, p. 456, Pl. 3, fig. 8. Upper Burlington limestone. Burlington, Iowa.

1850. **Pl. americanus** Owen and Shumard. Journ. Nat. Sci. Phila. (ser. ii), ii; also 1852, U. S. Geol. Rep. Iowa, Wis. and Minn., p. 594, Pl. 5 b, figs. 1 a, b. Lower Burlington limestone. Burlington, Iowa.

Syn. **Pl. truncatus** Hall. 1858, Geol. Rep., Iowa, i, pt. ii, p. 537. Hall in this case described a young specimen of **Pl. americanus**. The lower part of the arms are composed of single, wedge-form joints, giving off the pinnules in a zigzag arrangement.

1861. **Pl. asper** Meek and Worthen. (**Pleurocrinus**) Proc. Acad. Nat. Sci. Phila., p. 129; also 1868, Geol. Rep. Ill., iii, p. 468, Pl. 18, fig. 9. Upper Burlington limestone. Burlington, Iowa.

1853. **Pl. arenosus** De Koninck and Lehon. Recherch. Crin. Carb. Belg., p. 182, Pl. 5, fig. 7. Upper part of Mountain limestone. Tournay, Belgium.

(?) 1838. **Pl. armatus** Münster. Beitr. zur Petref., vol. i. Mountain limestone (?). Tournay, Belgium (?).

1853. **Pl. Austinianus** De Koninck and Lehon.†[1] Recherch. Crin. Carb. Belg., p. 169, Pl. 5, figs. 3 a, b. Mountain limestone. Tournay, Belgium.

Syn. **Pl. trigintidactylus** Aust. (in part). Mon. Rec. and Foss. Crin., Pl. 3, fig. 1 a (not fig. 1 b-g).

1875. **Pl. bedfordensis** Hall. Geol. Surv. Ohio, Pal. ii, p. 161, Pl. 13, fig. 4. Erie Shale, Waverly Gr. Bedford, Ohio.

1879. **Pl. bonoensis** White. Proc. Acad. Nat. Sci. Phila., p. 30; also 1880, Hayden's U. S. Geol. Surv. Invert. Pal., No. 8, p. 160, Pl. 40, fig. 5 a. Lower part of Keokuk limestone. Lawrence and Floyd Co., Ind.

1861. **Pl. brevinodus** Hall. Desc. New Sp. Crin., p. 4; also Bost. Jour. Nat. Hist. p. 286; separate photog. plate 2, fig. 5. Keokuk limestone. Keokuk, Iowa.

1850. **Pl. burlingtonensis** Ow. and Sh.† Jour. Acad. Nat. Sci. Phila. (new ser.), ii, pt. i; also 1852, U. S. Geol. Rep. Iowa, Wis. and Minn., p. 589, Pl. 5 a, fig. 5. Meek and Worthen, 1873, Geol. Rep. Ill., v, p. 452, Pl. 3, figs. 6 a, b, c. Lower Burlington limestone. Burlington, Iowa.

Syn. **Pl. exsertus** Hall. 1858, Geol. Rep. Iowa, i, pt. ii, p. 539. Described from a young specimen.

Syn. **Pl. inornatus** McChesney. 1860, Desc. New Pal. Foss., p. 6; also **Pl. burlingtonensis**, Chicago Acad. Sci., i, p. 9, Pl. 4, fig. 3.

1861. **Pl. calyculus** Hall. Desc. New Sp. Crin., p. 16. Burlington limestone. Burlington, Iowa. Hall's description is too imperfect for identification.

[1] In species marked †, an anal tube has been observed.

1861. **Pl. canaliculatus** Hall.† Geol. Rep. Iowa, i, pt. ii, p. 539. Upper Burlington limestone. Burlington, Iowa.

1858. **Pl cavus** Hall. (Pleurocrinus) Geol. Rep., Iowa, i, pt. ii, p. 527, Pl. 8, figs. 1 a, b. Upper Burlington limestone. Burlington, Iowa.

1836. **Pl. contractus** Phillips (Gilbertson). Geol. Yorkshire, p. 204, Pl. 3, fig. 25. McCoy, 1844, Carb. Foss. Ireland, p. 175; D'Orbigny, 1849, Prodr., i, p. 156. Mountain limestone. Ireland and England.

1863. **Pl. contritus** Hall. 17th Rep. N. Y. St. Cab., p. 54; also Geol. Rep. Ohio, Pal. ii, p. 166, Pl. 11, fig. 4. Waverly Gr. Richfield, Ohio.

1850. **Pl. corrugatus** Ow. and Sh. (Pleurocrinus). Jour. Acad. Nat. Sci. Phila. (new ser.), ii, pt. i; also 1852, U. S. Geol. Surv. Iowa, Wis. and Minn., p. 589, Pl. 5 a, figs. 2 a-e. Lower Burlington limestone. Burlington, Iowa.

Syn. **Pl. striobrachiatus** Hall. 1861, Desc. New Sp. Crin., p. 4; also Bost. Jour. Nat. Hist., p. 287, separate photogr. plate 2, figs. 2, 3.

1849. **Pl. diadema** McCoy. Ann. and Mag. Nat. Hist. (ser. 2), iii, p. 246. Mount limest. North Ireland.

1850. **Pl. discoideus** Ow. and Sh. (**Pleurocrinus**) Jour. Acad. Nat Sci. Phila. (new ser.), vol. ii, pt. i; also 1852, U. S. Geol. Surv. Iowa, Wisc. and Minn., p. 588, Pl. 5 a, figs. 1 a, b (not **Pl. discoideus** Hall, Geol. Rep. Iowa, i, pt. ii, Pl. 8, figs. 8 a, b = *Eucladocr. pleurovimenus* White). Lower Burlington limest. Burlington, Iowa.

Syn. **Pl. multibrachiatus** Meek and Worthen. 1861, Proc. Acad. Nat. Sci. Phila., p. 134.

Syn. **Pl. excavatus** Hall. 1861, Desc. New Sp. Crin., p. 7; also Bost. Jour. Nat. Hist., p. 286.

1862. **Pl. eboraceus** Hall. 15th Rep. N. Y. St. Cab., p. 119, separate photog. Pl. 1, figs. 16, 17; Bigsby, 1878, **Hexacr. eboraceus**. Thesaurus Devon., p. 18. Hamilton Gr. Livingstone Co., N. York.

1861. **Pl. elegans** Hall.† Desc. New Sp. Crin., p. 4; also Bost. Jour. Nat. Hist., p. 285. Upper Burlington limest. Burlington, Iowa.

1836. **Pl. ellipticus** Phillips. Geol. Yorkshire, p. 204, Pl. 3, fig. 19 (not fig. 21). D'Orbigny, 1849, Prodr. i, p. 156. Mount. limest. Bolland, England.

Probably synonym of **Pl. granulatus** Miller.

1861. **Pl. eminulus** Hall. Desc. New Sp. Crin., p. 17. Lower Burlington limest. Burlington, Iowa.

1862. **Pl. eriensis** Hall. 15th Rep. N. Y. St. Cab., p. 119. Hamilton Gr. Erie Co., New York.

This is the only species in which three radials have been observed, the upper evidently forming a syzygium. It may possibly belong to **Cordylocrinus**.

1844. **Pl. expansus** McCoy. Carb. Foss. Ireland, p. 175, Pl. 25, figs. 18, 19; D'Orbigny, 1849, Prodr, i, p. 156; Roemer, 1855, Lethæa Geogn. (Ausg. 3), 1st Periode, p. 245, Pl. 4^1, figs. 14 a, b. Mount. limest. Ireland.

1860. **Pl. Georgii** Hall. Sup. Geol. Rep. Iowa, p. 82, Pl. 1, fig. 7. Warsaw limest. Warsaw, Ill.

1836. **Pl. gigas** Gilbertson (Phillips). Geol. of Yorkshire, p. 204, Pl. 3, figs. 22, 23; Austin, 1842, Ann. and Mag. Nat. Hist., x, p. 108; also 1843, Mon. Rec. and Foss. Crin., p. 39, Pl. 4, figs. 1 a-c. Mount. limest. Bolland, England.

1861. **Pl. glyptus** Hall (**Pleurocrinus**). Desc. New Sps. Crin., p. 16. Upper Burlington limest. Burlington, Iowa.

A mere variety of **Pl. sculptus** Hall.

1853. **Pl. granosus** De Koninck and Lehon (**Pleurocrinus**). Recher. Crin. Carb. Belg., p. 183, Pl. 6, figs. 6 a-i. Mount. limest. Tournay, Belgium.

1821. **Pl. granulatus** Miller. Hist. Crinoidea, p. 81, Pl. 4, figs. 1-3; Schlotheim, 1822, Nachtr. zur Petref., i, p. 85; Ibid. ii, p. 97, Pl. 26, figs. 3 a, b, c; Blainville, 1830, Dict. des Sci. Nat., lx, p. 243; Agassiz, 1835, Mem. de la Soc. des Sci. de Neuchatel, i, p. 197; De Koninck, 1842, Desc. Anim. Foss. Carb. de Belg., p. 43, Pl. F, figs. 2 a, b; Portlock, 1843, Geol. of Londonderry, p. 350, Pl. 16, fig. 4; Austin, 1843, Mon. Rec. and Foss. Crin., p. 33, Pl. 3, figs. 2 i-o; McCoy, 1844, Carb. Foss. Ireland, p. 176; De Koninck and Lehon, 1853, Recherch. Crin. Carb. Belg., p. 179, Pl. 6, figs. 5 a-b. Mount. limest. England, Ireland and Belgium.

1863. **Pl. graphicus** Hall. 17th Rep. N. Y. St. Cab., p. 55; also 1875, Geol. Surv. Ohio, Pal. ii, p. 166, Pl. 11, fig. 2. Waverly Gr. Richfield, Ohio.

1865. **Pl. Halli** Shumard (**Pleurocrinus**). Catal. Pal. Foss. North America, p. 388 (Trans. Acad. Sci. St. Louis, vol. ii). Upper Burlington limest. Burlington, Iowa.

This species was at first described and figured by Hall as **Pl. planus** Ow. and Sh., Geol. Rep. Iowa, i, pt. ii, p. 533, Pl. 8, figs. 6 a, b. It resembles **Pl. incomptus** White, in form and lack of ornamentation, but the latter has six, or exceptionally seven to eight arms to each ray, while **Pl. Halli** has twelve or even sixteen arms to the ray.

Syn. **Pl. olla** Hall (not De Kon. and Lehon). Desc. New Sp. Crin., p. 16.

1873. **Pl. Haydeni** Meek. Hayden's U. S. Geol. Surv. for 1872, p. 469; also White, Ann. Rep. U. S. Geol. Surv. Terr. for 1878, p. 122, Pl. 33, fig. 7 a. Subcarboniferous.

1865. **Pl. hemisphericus** Meek and Worthen (**Pleurocrinus**). Proc. Acad. Nat. Sci. Phila., p. 162; also Geol. Rep. Ill., iii, p. 466, Pl. 16, fig. 9, and vol. v, p. 16, figs. 6 a, b, c. Keokuk limest. Crawfordsville, Ind.; also Burlington and Keokuk Transition beds at Burlington and Nauvoo.

1863. **Pl. incomptus** White. Bost. Jour. Nat. Hist., vii, p. 503; also Meek and Worth., 1873, Geol. Rep. Ill., v, p. 459, Pl. 3, fig. 7. Upper Burlington limest. Burlington, Iowa.

1836. **Pl. laciniatus** Gilbertson (Phillips). Geol. of Yorkshire, p. 204, Pl. 3, fig. 18; Austin, 1843, Ann. and Mag. Nat. Hist., x, p. 109, and Mon. Rec. and Foss. Crin., p. 42, Pl. 5, figs. 1 a-c; D'Orbigny, 1849, Prodr. i, p. 156. Mount. limest. Bolland, England.

1821. **Pl. lævis** Miller.† Hist. Crinoidea, p. 74, Pl. 1, fig. 1-9, and 13-18, and Pl. 2, figs. 1-4, and 52-56 (the other figures have been referred by De Koninck to several other species). Schlotheim, 1822, Nachtr. zur Petref., i, p. 84; Ibid., 1823, vol. ii, p. 94, Pl. 25, figs. 4 a and 4 e; Goldfuss, 1833, Petref. Germ., i, p. 188, Pl. 58, figs. 2 a-e; Blainville, 1834, Manuel de Actinocr., p. 262; Agassiz, 1835, Mem. Soc. de Neuchatel, p. 197; Bronn, 1835, Lethæa Geogn., i, p. 60; Milne-Edwards, 1836, Anim. s. vert. de Lamarck, ii, p. 665; De Koninck, 1842, Desc. Anim. Carb. de Belgique, p. 41, Pl. F, fig. 1 c and e (the others excluded); Austin, 1843, Monog. Rec. and Foss. Crin., p. 8, Pl. 1, figs. 1 a-n; McCoy, 1844, Syn. Carb. Foss. Ireland, p. 176; Pictét, 1846, Traite de Paléont., iv, p. 200, Pl. 9, fig. 18. Mountain limest. England, Ireland and Belgium.

1875. **Pl. lodensis** Hall. Geol. Surv. Ohio, Pal. ii, p. 168, Pl. 11, fig. 3. Waverly Gr. Medina Co., Ohio.

1849. **Pl. megastylus** McCoy. Ann. and Mag. Nat. Hist. (ser. ii), p. 248. Mount. limest. Bolland, Eng.

1836. **Pl. mycrostylus** Phillips. Geol. of Yorkshire, p. 204; Austin, 1842, Ann. and Mag. Nat. Hist., x, p. 109. Mount. limest. Bolland, England.

1842. **Pl. mucronatus** Austin. (Figured by Phillips as **Pl. lævis**, Geol. Yorkshire, Pl. 3, figs. 14, 15.) Ann. and Mag. Nat. Hist., x, p. 109, and xi, p. 199; also 1843, Mon. Rec. and Foss. Crin., p. 22, Pl. 2, fig. 1, and Pl. 5, fig. 2. Subcarboniferous. England.

1853. **Pl. Mullerianus** De Kon. and Leh.† Recher. Crin. Carb. Belg., p. 171, Pl. 5, figs. 4 a, b, c, d. Mount. limest. Tournay, Belgium.

1865. **Pl. niotensis** Meek and Worthen. Proc. Acad. Nat. Sci. Phila , p. 162; also Geol. Rep. Ill., p. 513, Pl. 20, fig. 3. Keokuk limest. Niota and Nauvoo, Ill.

1858. **Pl. nodulosus** Hall (not Goldfuss, 1833 = *Symbathocrinus*). Geol. Rep. Iowa, pt. ii, p. 541. Lower Burlington limest. Burlington, Iowa.

1858. **Pl. nodobrachiatus** Hall (not Hall, 1861). Geol. Rep. Iowa, i, pt. ii, p. 542. Burlington limest. Burlington, Iowa.

Described from a young specimen, probably of **Pl. americanus.**

1858. **Pl. nucleiformis** Hall. (**Pleurocrinus.**) Geol. Rep. Iowa, i, pt. ii, p. 540. Lower Burlington limest. Burlington, Iowa.

1853. **Pl. olla** De Kon. and Leh. (not **Pl. olla** Hall, 1861 = *Pl. Halli* Shum.). Recher. Crin. Cab. Belg., p. 172, Pl. 5, fig. 5. Mount. limest. Tournay, Belgium.

1844. **Pl. ornatus** McCoy (not **Pl. ornatus** Goldfuss, 1833 = *Hexacrinus*). Carb. Foss. Ireland, p. 176, Pl. 25, fig. 1. D'Orbigny, **Edwardsocrinus ornatus,** 1849. Prodr. i, p. 157; also Course Elém. ii, p. 145; **Pl. ornatus** De Kon. and Leh., 1853, Recher. Crin. Carb. Belg., p. 177, Pl. 6, figs. 4 a, b, c; Pictét, **Edwardsocr. ornatus,** 1857, Traité de Pal. iv, p. 330, Pl. 101, fig. 15. Mount. limest. Ireland, and Tournay, Belg.

This is evidently a young **Platycrinus,** with the arms as yet in an immature or embryonic state.

1860. **Pl. ornigranules** McChesney. Desc. New Pal. Foss., p. 5; also Chicago Acad. Sci., i, p. 3, Pl. 5, fig. 8. Lower Burlington limest. Burlington, Iowa.

1861. **Pl. parvinodus** Hall. Desc. New Sp. Crin., p. 17. Lower Burlington limest. Burlington, Iowa.

1865. **Pl. parvulus** Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 163; Geol. Rep. Ill., v, p. 555, Pl. 20, fig. 7. Chester limest. Pope Co., Ill.

1860. **Pl. penicillus** Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 380; also Geol. Rep. Ill., ii, p. 266, Pl. 19, figs. 6 a, b. Warsaw limest. Hardin Co., Ill.

1865. **Pl. perasper** Shumard. Catal. Pal. Foss. N. A., p. 389. Lower Burlington limest. Burlington, Iowa.

Syn. **Pl. nodobrachiatus** Hall, 1861 (not Hall, 1858). Desc. New Sp. Crin., p. 17.

1839. **Pl. pileatus** Goldf. (**Pleurocrinus.**) Acta Nov. ac. Leop., xix, p. 343, Pl. 31, fig. 7, a, b, c; Geinitz, Grundr. der Versteiner., Pl. 23, fig. 7; McCoy, 1851, Brit. Pal. Foss., Pt. ii, p. 119; De Kon. and Leh., 1853, Rech. Crin. Carb. Belg., p. 175, Pl. 6, figs. 3 a–e. Mount limest. England and Belg.

Syn. **Pl. anthleontes** Austin, 1842. Ann. and Mag. Nat. Hist., x, p. 69, and xi, p. 199; Mon. Rec. and Foss. Crin., p. 27, Pl. 2, figs. 3 k–r.

1858. **Pl. pileiformis** Hall. (**Pleurocrinus.**) Geol. Rep. Iowa, i, Pt. ii, p. 529, Pl. 8, figs. 3 a, b, c. Lower Burlington limest. Burlington, Iowa. This species is easily distinguished from the other species with smooth plates, by having only four arms to the ray.

1850. **Pl. planus** Ow. and Sh. Jour. Acad. Nat. Sci. Phila. (Ser. ii), vol. ii, p. 57; also, 1852, U. S. Geol. Surv. Iowa, Wis. and Minn., p. 587, Pl. 5 A, figs. 4 a, c (not b, nor Geol. Rep. Ill., iii, Pl. 16, fig. 6, which are both **Pl. Pratteni** Worthen; nor Geol. Rep. Iowa, i, Pt. ii, Pl. 8, figs. 6 a, b, which are **Pl. Halli** Shum.); Geol. Rep. Ill., v, Pl. 3, fig. 5. Lower Burlington limest. Burlington, Iowa.

1860. **Pl. plenus** Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 380; also Geol. Rep. Ill., ii, p. 267, Pl. 20, fig. 3. Warsaw limest. Hardin Co., Ill.

1858. **Pl. pocilliformis** Hall. (**Pleurocrinus.**) Geol. Rep. Iowa, i, Pt. ii, p. 528, Pl. 8, figs. 2 a, b. Lower Burlington limest. Burlington, Iowa.

Syn. **Pl. verrucosus** White, 1863. Bost. Jour. Nat. Hist., p. 502.

1878. **Pl. prænuntius** Wachsm. and Spr. Proc. Acad. Nat. Sci. Phila., p. 249, Pl. 2, figs. 1, 2. Upper Burlington limest. Burlington, Iowa.

1860. **Pl. Prattenanus** Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 379; also Geol. Rep. Ill, ii, p. 264, Pl. 20, fig. 2. St. Louis limest. Randolph Co., Ill.

1860. **Pl. Pratteni** Worthen. Trans. Acad. Sci. St. Louis, p. 569; Meek and Worthen, **Pl. planus.** Geol. Rep. Ill., iii, p. 469, Pl. 16, fig. 6. Lower Burlington limest. Burlington, Iowa.

Meek did not consider **Pl. Pratteni** distinct from **Pl. planus**, and Owen and Shumard seem to have been of the same opinion, for they figure in the U. S. Rep. Iowa, Wis. and Minn., Pl. 5 A, fig. 46 (not 4 a, e) a specimen, evidently of the former type, under the latter name.

1860. **Pl. pumilus** Hall. Supp. Geol. Rep. Iowa, p. 82, Pl. 1, fig. 6. Warsaw limest. Warsaw, Ill.

1844. **Pl. punctatus** McCoy. Carb. Foss. Ireland, p. 177, Pl. 25, figs. 15, 17. Mount. limest. Ireland.

1862. **Pl. quinquenodus** White. (**Pleurocrinus.**) Proc. Bost. Soc. Nat. Hist., ix, p. 18. Upper Burlington limest. Burlington, Iowa.

1861. **Pl. regalis** Hall. Desc. New Sp. Crin., p. 16, Separate Photog. Plate 2, fig. 6. Lower Burlington limest. Burlington, Iowa.

Syn. **Pl. Oweni** Meek and Worthen, 1861. Proc. Philad. Acad., p. 129.

1875. **Pl. richfieldensis** Hall. Geol. Rep. Ohio, Pal. ii, p. 167, Pl. 11, fig. 4. Waverly gr. Richfield, O.

1821. **Pl. rugosus** Miller (not Goldf. = *Storthingocrinus* Schultze). Hist. Crinoidea, p. 79, with plate. Figured by Cumberland in Trans. Geol. Soc., vol. v, Pl. 5, fig. 10; Phillips, 1836, Geol. of Yorkshire, p. 204, Pl. 2, fig. 20; Austin, 1842, Ann. and Mag. Nat. Hist., x, p. 109; Blainville, 1843, Man. d'Actin., Pl. 29, fig. 4; Austin, 1843, Mon. Rec and Foss. Crin., p. 40, Pl. 4, figs. 2 d–k; McCoy, 1844, Carb. Foss. Ireland, p. 177. Mount. limest. Caldy Island, Wales, also Mendip Hills, England.

1858. **Pl. Saffordi** Hall. Geol. Rep. Iowa, i, Pt. ii, p. 634, Pl. 18, figs. 5, 6. Lower part Keokuk limest. Nauvoo and Hamilton, Ill., and Keokuk, Iowa. Probably Syn. of **Pl. sculptus.**

1858. **Pl. Saræ** Hall. Geol. Rep. Iowa, i, Pt. ii, p. 673, Pl. 17, fig. 4. St. Louis limest. St. Louis, Mo.

1861. **Pl. scobina** Meek and Worthen. Proc Acad Nat. Sci. Phila., p. 129; also Geol. Rep. Ill., iii, p. 466, Pl. 16, fig. 9. Lower Burlington limest. Burlington, Iowa.

Syn. **Pl. clytis** Hall, 1861. Bost. Jour. Nat. Hist., p. 285, Separate photogr. plates, i, fig. 4.

1858. **Pl. sculptus** Hall. Geol. Rep. Iowa, i, Pt. ii, p. 536, Pl. 8, fig. 11. Lower Burlington limest. Burlington, Iowa.

1858. **Pl. Shumardianus** Hall. Geol. Rep. Iowa, i, Pt. ii, p. 532, Pl. 8, fig. 5. Lower Burlington limest. Burlington, Iowa.

1844. **Pl. similis** McCoy. Carb. Foss. Ireland, p. 177, Pl. 26, fig. 6; D'Orbigny, Prodr. i, p. 156. Mount. limest. Ireland.

1842. **Pl. spinosus** Aust. † Ann. and Mag. Nat. Hist., x, p. 109, and xi, p. 199; also Mon. Rec. and Foss. Crin., p. 19, Pl. i, figs. 2 k, o, p, q, r, s; De Kon. and Leh., 1853, Rech. Crin. Carb. Belg., p. 165, Pl. 6, fig. 2 a, b. Mount limest. Mendip Hills, Eng., and Tournay, Belg.

Syn. **Eugeniacrinites (?) hexagonus** Münster, 1839. Beitr. z. Petref. i, p. 4, Pl. 1, figs. 6 a, b; De Kon. 1842, Desc. Anim. Foss. Carb. Belg., p. 39, Pl. E, figs. 5 a, b, c.

Syn. **Pl. lævis** (in part) Miller. 1821, Hist. Crin., p. 74, Pl. 1, fig. 4 (not the other figures).

1821. **Pl. striatus** Miller. Hist. Crin., p. 82; Agassiz, 1835, Mem. Soc. des Sci. Nat., Neuchat. i, p. 196; Austin, 1842, Ann. and Mag. Nat. Hist., x, p. 109; Blainville, 1834, Man. d'Act., p. 262; De Kon., 1842, Desc. Anim. Foss. Carb. Belg., p. 44; Milne-Edwards apud Lamarck, ii, p. 666; Austin, 1843, Mon. Rec. and Foss. Crin., p. 37, Pl. 3, figs. 3 p–u. Mount. limest. Bristol, Engl.

1858. **Pl. subspinosus** Hall. Geol. Rep. Iowa, i, Pt. ii, p. 536, Pl. 8, figs. 9, 10; Meek and Worthen, 1866. **Pl. (Pleurocrinus) subspinosus**, Geol. Rep. Ill., ii, p. 173, Pl. 15, fig. 6, and vol. v, Pl. 11, fig. 2. Lower Burlington limest. Burlington, Iowa.

1860. **Pl. subspinulosus** Hall. Supp. Geol. Rep. Iowa, p. 81. Upper Burlington limest. Burlington, Iowa.

Syn. **Dichocrinus lachrymosus** Hall, 1860. Supl. Iowa Rep., p. 84.

1865. **Pl. tenuibrachiatus** Meek and Worth. Proc. Acad. Nat. Sci. Phila., p. 168; also Geol. Rep. Ill., v, p. 450, Pl. 3, fig. 4. Upper Burlington limest. Burlington, Iowa.

1842. **Pl. trigintidactylus** Austin (**Pleurocrinus**). Ann. and Mag. Nat. Hist., x, p. 69; also 1844, Mon. Rec. and Foss. Crin., p. 30, Pl. 3, figs. 1 b-h (not a = *Pl. austinianus*). Mount. limest. Bristol, Eng. and Tournay, Belg.

Syn. **Pl. triacontadactylus** McCoy. 1844, Carb. Foss. Ireland, p. 177, Pl. 25, figs. 2–7.

1858. **Pl. truncatulus** Hall. Geol. Rep. Iowa, i, pt. ii, p. 538. Lower Burlington limest. Burlington, Iowa.

1821. **Pl. tuberculatus** Miller.—**Pleurocrinus**—(not **P. tuberculatus** Phillips = *Hexacrinus*). Hist. Crin., p. 81, figs. 1, 2; Schlotheim, 1822, Nachtr. z. Petref. i, p. 85, and 1823, Ib. ii, p. 97, Pl. 26, figs. 2 a-b; Agassiz, 1835, Mem. de la Soc. Nat. Sci. Neuchat., i, p. 197. Mount. limest. Mendip Hills, Eng., and Tournay, Belg.

Syn. **Pl. ellipticus** (in part) Phillips. Geol. Yorkshire, ii, Pl. 3, fig. 19 (not 21); also Austin, Mon. Rec. and Foss. Crin, Pl. 4, figs. 3, p to u; McCoy, Carb. Foss. Ireland, p. 177.

1858. **Pl. tuberosus** Hall. Geol. Rep. Iowa, i, pt. ii, p. 534, Pl. 8, figs. 7 a, b; Meek and Worth., 1866, **Pleurocr. tuberosus**, Geol. Rep. Ill., ii, p. 172. Upper Burlington limest. Burlington, Iowa.

1849. **Pl. vesiculus** McCoy. Ann. and Mag. Nat. Hist., p. 246. Mount. limest. Derbyshire, Eng.

1875 (?). **Pl. vexabilis** White. Wheeler's U. S. Survey, West of 100th merid., iv, Pal. p. 81, Pl. v, fig. 2. We doubt if this is a Platycrinus.

1858. **Pl. Wortheni** Hall. Geol. Rep. Iowa, i, pt. ii, p. 530, Pl. 8, fig. 4. Burlington limest. Burlington, Iowa.

1850. **Pl. Yandelli** Ow. and Sh. Jour. Acad. Nat. Sci. Phila. (new ser.), ii, pt. i; also U. S. Geol. Surv. Iowa, Wisc. and Minn., p. 587, Pl. 5 A, figs. 6 a, b. Lower Burlington limest. Burlington, Iowa.

Subgenus **EUCLADOCRINUS** Meek.

1871. Meek. Hayden's Rep. U. S. Surv. of Terr., p. 373.
1878. Wachsm. and Spr. Proc. Acad. Nat. Sci. Phila., p. 243.
Syn. *Platycrinus* White, in part. Proc. Bost. Soc. Nat. Hist., p. 17.

The name *Eucladocrinus* was proposed by Meek in 1871 (Hayden's Rep. U. S. Survey of the Territories, p. 373) to designate a subgeneric group under *Platycrinus*, of which *Pl. pleuroviminus* White is the type.

In the structure of the calyx, this form presents no apparent difference from *Platycrinus*, and it embraces species with a low, broad cup shaped, and with an elongate body. It is characterized, however, by having the radial series of the body, both dorsal and ventral, greatly extended in the form of tubular free rays, which bear the arms alternately on either side throughout their entire length. These rays, in all the known species, divide on the second radial into two branches, which remain joined by their inner sides for the length of three or four plates, after which they become free, giving two free branches to each ray, or ten in all. A tubular passage, arched over by the extensions of the vault, runs the whole length of the rays, and these tubes, after uniting on the inside of the second radial, connect with the visceral cavity.

The arms are composed of a double series of interlocking joints, and bear slender, single-jointed pinnules.

This type bears the same relation to *Platycrinus* that *Steganocrinus* does to *Actinocrinus*, and *Melocrinus* to *Mariacrinus*; and the two are very closely connected by transition forms such as *Pl. prænuntius*, in which the free ray structure is clearly begun, the radial areas being produced to the extent of ten or twelve plates.

The subgenus evidently represents the mature and extreme form of the *Platycrinoid* type.

Geographical Position, etc.—Found as yet only in the Subcarboniferous of America, where the following species are known :—

1878. **Eucladocrinus millebrachiatus** Wachsm. and Spr. Proc. Acad. Nat. Sci. Phila., p. 245. Upper Burlington and Keokuk Transition bed, and lower part of the Keokuk limest. Burlington, Iowa, Nauvoo and Niota, Ill.

1871. **Eucladocr. montanaensis** Meek. Hayden's Geol. Rep. U. S. Surv. Terr., p. 373. Subcarb. Montana.

1862. **Eucladocr. pleuroviminus** White (**Platycr. pleuroviminus**). Type of the subgenus. Proc. Bost. Soc. Nat. Hist., ix, p. 17; Meek, 1870, Am. Jour. Sci. and Arts; Wachsm. and Spr., 1878, Proc. Acad. Nat. Sci. Phila., p. 249. Upper Burlington limest. Burlington, Iowa.

6. (?) COTYLEDONOCRINUS Casseday and Lyon.

1860. Casseday and Lyon. Proc. Acad. Arts and Sci., v, p. 26.
1865. Shumard. Catal. Pal. Foss. N. A. Trans. St. Louis Acad., ii, p. 360.
1877. S. A. Miller. Catal. Am. Pal. Foss., p. 74.
1879. Zittel. (*Dichocrinus.*) Handb. d. Pal., i, p. 365.

Casseday and Lyon proposed the above name for a crinoid which agrees in every respect with *Dichocrinus*, except that it has no anal plate in line with the first radials. According to the description, however, there is a deeper notch between the radials on the posterior side, and the question arises whether the type specimen was not an abnormal *Dichocrinus* in which the anal plate was wanting or imperfectly developed. The notch lies directly in line with one end of the suture which divides the basal disk, and hence the position corresponds to that of the anal in *Dichocrinus*. The bipartite base itself seems to indicate that there was normally a sixth plate above, for otherwise, according to the rule we have found to prevail among these Crinoids, one plate of the basal disk should be larger—while they are said to be equal in this form.

As described, *Cotyledonocrinus* agrees essentially in the form of the body with typical species of *Dichocrinus*, and like them has three primary radials, the first large and long, the two others small and supporting 2×10 secondary radials, succeeding radials forming parts of the free rays. There is a single interradial in connection with the first radials, two interradial plates above constitute a part of the vault.

The specimen has long delicate arms, which do not bifurcate, and which give off long pinnules, composed of a large number of short joints.

Column cylindrical.

Until other specimens are discovered, we must consider *Cotyledonocrinus* an abnormal form of *Dichocrinus*.

Casseday and Lyons' only species is:—

1860. **Cotyledonocrinus pentalobus.** Proc. Amer. Acad. Arts, and Sci., vol. v, p. 26. Warsaw limest. Grayson Co., Kentucky.

b. HEXACRINITES.

7. **HEXACRINUS** Austin.

1843. Austin. Mon. Rec. and Foss. Crin., p. 48.
1853. De Kon. and Leh. Rech. Crin. Carb. Belg., p. 160.
1855. F. Roemer. Lethæa Geogn. (Ausg. 3, Per. 1), p. 244.
1857. Joh. Müller. Neue Echin. Eifl. Kalk, p. 85.
1857. Pictet. Traité de Paléont., iv, p. 331.
1867. Schultze. Mon. Echinod. Eifl. Kalk, p. 71.
1879. Zittel. Handb. der Palæontologie, p. 365.

Syn. *Platycr.* Phil., 1841 (not 1836). Pal. Foss. Cornw., p. 28.
Syn. *Platycr.* Goldf. (in part), 1838. Nova Acta. Ac. Leop., xix, p. 343.
Syn. *Platycr.* Agas. (in part), 1835. Mem. Soc. Neuch., i, p. 197.
Syn. *Platycr.* Aust. (in part), 1842. Ann. and Mag. Nat. Hist., x, p. 109.
Syn. *Platycr.* F. A. Roemer, 1843. Verstein. d. Harzes.
Syn. *Platycr.* F. Roemer, 1851. Verh. naturh. Verein Rheinl., p. 362.
Syn. *Platycr.* D'Orbigny (in part), 1850. Prodr. Pal., i, p. 103.
Syn. *Platycr.* Lyon, 1860. Trans. Am Philos. Soc., p. 459.

Generic Diagnosis.—Body obconical, pear-shaped or subglobose; surface generally elaborately sculptured or nodose; symmetry decidedly bilateral.

Basal disk large, in form of a shallow cup; hexagonal; composed of three equal plates. Five of its sides support a first radial each, the sixth a large anal plate, which extends to the full height of the first radials. Primary radials 2×5, the first very large, apparently quadrangular but actually hexagonal; increasing in width from the base up; upper margin excavated. Second radials minute, triangular, rarely filling the whole excavation, which generally encloses a part of the first secondary radials, the latter forming the base of two free appendages to each ray. The free rays and the arms proper have been rarely observed, but were apparently constructed like those of *Eucladocrinus*. In *Hexacr. limbatus*, the free rays attain three or four times the length of the body, and each one consists of a row of short cylindrical joints, which give off laterally pinnule bearing arms. These arms originate on every fourth, fifth or sixth joint, according to position, and alternately from opposite sides. The free parts of the ray in *Hexacr. brevis*,[1] are apparently more like those of *Platycrinus*.

Anal plates generally narrower, but often higher than the first radials; wider towards the top than at its junction with the basals, the upper side supporting two or three plates. Interradial series composed of a single large plate, which rests within a notch between two radials.

Vault low, hemispherical, more or less flattened, composed of comparatively few and large pieces, which are nodose, or covered with a number of small tubercles. Apical dome plates large. Anus subcentral or lateral; in form of a simple opening through the vault, or supported by a small tubercular process composed of small polygonal pieces.

Column cylindrical, the larger joints nodose or sculptured after the style of the plates of the calyx; articulating face radicularly striated; central canal small, round.

Geological Position, etc.—*Hexacrinus* is strictly a Devonian genus, and almost exclusively European, only fragments of a single species having been discovered in America.

The following species have been described:—

1838. **Hexacrinus anaglypticus** Goldf. (**Platycr. anaglypticus.**) Nova Acta ac. Leop., xix, p. 348, Pl. 32, fig. 4; Schultze, 1867, **Hexacr. anaglypticus**, Mon. Echin. Eifl. Kalk, p. 72, Pl. 8, fig. 1. Devonian. Eifel, Germany.

Syn. **Platycr. frondosus** Goldf. Bonn Museum, undefined.

Syn. **Platycr annulatus** Goldf. Bonn Museum, undefined.

Syn. **Platycr. muricatus** Goldf. Bonn Museum, undefined.

1867. **Hexacr. bacca** Schultze. Mon. Echin. Eifl. Kalk, p. 83, Pl. 10, fig. 5. Devonian. Eifel, Germany.

1838. **Hexacr. brevis** Goldf. (**Platycr. brevis.**) Nova Acta ac. Leop., xix, i, p. 346, Pl. 32, fig. 2; Schultze, 1867, **Hexacr. brevis**, Mon. Echin. Eifl. Kalk, p. 79, Pl. 10, fig. 7. Devonian. Eifel, Germany.

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[1] We believe that *Hexacr. brevis* Goldf. (Mon. Echin. Eifl. Kalk, Pl. 10, fig. 7) is a young specimen of some other species. This is indicated not only by its small size, but also the immature character of the arms and column; it may even represent an entirely different genus.

1843. **Hexacr. Buchii** F. A. Roemer. (**Platycr. Buchii.**) Hartzgebirge, p. 9, Pl. 12, fig. 13. Devonian. Hartz, Germany.

1867. **Hexacr. callosus** Schultze. Mon. Echin. Eifel Kalk, p. 83, Pl. 9, fig. 3. Devonian. Eifel, Germany.

Syn. **Platycr. rosaceus** Goldf. (not Roemer = *Coccocrinus*). Bonn Museum, undefined.

1858. **Hexacr. costatus** Müller. Monatsb. Berl. Akad. Wissensch., p. 354; Schultze, 1867, Mon. Echin. Eifel, Kalk, p. 74. Devonian. Eifel, Germany. Probably a variety of **Hexacr. anaglypticus.**

1838. **Hexacr. elongatus** Goldf. (**Platycr. elongatus** Goldf. not Phillips.) Nova Acta ac. Leop., xix, i, p. 345, Pl. 32, fig. 1; Schultze, 1867, **Hexacr. elongatus,** Mon. Echin. Eifel Kalk, p. 74, Pl. 9, fig. 4. Devonian. Eifel, Germany.

Syn. **Platycr. Goldfussi** Münster. Beitr. z. Petrefactenk, i, p. 32, Pl. 1, figs. 2 a, b.

1838. **Hexacr. exsculptus** Goldf. (**Platycr. exsculptus.**) Nova Acta ac. Leop., xix, i, p. 347, Pl. 32, fig. 3; Schultze, 1867, **Hexacr. exsculptus,** Mon. Echin. Eifel Kalk, p. 77, Pl. 9, fig. 2. Devonian. Eifel, Germany.

1843. **Hexacr. granuliferus** F. A. Roemer. (**Platycr. granuliferus.**) Versteiner Nassau's, p. 397. Devonian. Lahnstein, Germany.

*1860 (?). **Pl. insularis** Eichwald. Lethæa Rossica, i, p. 612, Pl. 31, fig. 58. Devonian. Isle of Oesel.

There is some doubt, whether this is a *Hexacrinus*. Eichwald describes it with five radials, one of them much larger and apparently composed of two pieces, which are said to be soldered together. One of the other plates is represented as being much smaller.

1841. **Hexacr. interscapularis** Phillips. (**Platycr. interscapularis** not Miller.) Pal. Foss. Cornwall, p. 28, Pl. 14, fig. 39; D'Orbigny, 1849, Prodr. d. Paléont, p. 103; Austin, 1843, Ann. and Mag. Nat. Hist., x, p. 109; Schultze, 1867, **Hexacr. interscapularis,** Mon. Echin. Eifel Kalk, p. 79, Pl. 8, fig. 5. Devonian. Near Plymouth, Eng., and Eifel, Germany.

Syn. **Platycr. granifer** Roemer. 1852, Verh. Naturh. Verein Rheinl., ix, p. 281, Pl. 2, fig. 1; Schultze, **Hexacr. interscapularis,** Mon. Echin. Eifel Kalk, p. 79.

Syn. **Platycr. melo** Austin. 1843, Mon. Rec. and Foss. Crin., p. 48, Pl. 6, fig. 1; Schultze, **Hexacr. interscapularis,** Mon. Echin. Eifel Kalk, p. 79.

Syn. **Hexacr. depressus** Austin. 1843, Mon. Rec. and Foss. Crin., p. 49, Pl. 6, figs. 2 a-e; Schultze, **Hexacr. interscapularis,** Mon. Echin. Eifel Kalk, p. 79.

*1860. **Hexacr. Leai** Lyon. (**Platycr. Leai.**) Trans. Am. Philos. Soc., p. 259, Pl. 26, figs. g-g^1. Upper Helderberg, Dev. Louisville, Ky.

1857. **Hexacr. limbatus** Müller. Neue Echin. Eifel, p. 248, Pl. 2, fig. 1; Schultze, 1867, Mon. Echin. Eifel Kalk, p. 78, Pl. 9, fig. 1. Devonian. Eifel, Germany.

1857. **Hexacr. lobatus** Müller. Neue Echin. Eifel, p. 248, Pl. 1, figs. 10–12; Schultze, 1867, Mon. Echin. Eifel Kalk, p. 84, Pl. 10, fig. 6. Devonian. Eifel, Germany.

1843. **Hexacr. macrotatus** Austin. Mon. Rec. and Foss. Crin., p. 50, Pl. 6, figs. 3 a-d. Devonian. South Devon, England.

Syn. **Platycr. Phillipsii** D'Orbigny. 1850. Prodr. de Paléont., i, p. 103.

Syn. **Platycr. tuberculatus** Phillips, 1839 (not Miller, 1821). Pal. Foss. Cornwall, Pl. 60, fig. 39.

1867. **Hexacr. nodifer** Schultze. Mon. Echin. Eifel Kalk, p. 84, Pl. 10, fig. 3. Devonian. Eifel, Germany.

1838. **Hexacr. ornatus** Goldf. (**Platycr. ornatus** not McCoy.) Nova Acta Ac. Leop., xix, i, p. 347; Schultze, 1867, **Hexacr. ornatus**, Mon. Echin. Eifel Kalk, p. 82, Pl. 8, fig. 4, and Pl. 10, fig. 9. Devonian. Eifel, Germany.
Syn. **Hexacr. echinatus** Sandberger, 1856. Verstein. Nassau's, p. 398, Pl. 35, fig. 10.

1867. **Hexacr. pateræformis** Schultze. Mon. Echin. Eifel Kalk, p. 87, Pl. 10, fig. 4. Devonian. Eifel, Germany.

1867. **Hexacr. pyriformis** Schultze. Mon. Echin. Eifel Kalk, p. 76, Pl. 10, fig. 1. Devonian. Eifel, Germany.

1857. **Hexacr. spinosus** Müller. Neue Echin. Eifel, p. 248, Pl. i, figs. 13, 14; Schultze, 1867, Mon. Echin. Eifel Kalk, p. 75, Pl. 8, fig. 2. Devonian. Eifel, Germany.

1851. **Hexacr. stellaris** F. Roemer. (**Platycr. stellaris.**) Verh. Naturh. Verein f. Rheinl., viii, p. 362, Pl. 7, figs. 2 a, b, c; Schultze, 1867, **Hexacr. stellaris**, Mon. Echin. Eifel Kalk, p. 81, Pl. 8, fig. 3. Devonian. Eifel, Germany.

1867. **Hexacr. triradiatus** Schultze. Mon. Echin. Eifel Kalk, p. 86, Pl. 9, fig. 5. Devonian. Eifel, Germany.

1826. **Hexacr. ventricosus** Goldf. (**Platycr. ventricosus.**) Petref. Germ., i, p. 189, Pl. 58, fig. 4; Müller, 1856, Monatsb. Berl. Akad., p. 354, and 1857, Neue Echin. Eifl., p. 247, Pl. 1, figs. 3, 4; Schultze, 1867, **Hexacr. ventricosus**, Mon. Echin. Eifel Kalk, p. 85, Pl. 10, fig. 2. Devonian. Eifel, Germany.

8. DICHOCRINUS Münster.

1838. Münster. Beitr. zur Petrefactenk., i, p. 2.
1843. Austin. Mon. Rec. and Foss. Crin., p. 45.
1850. D'Orbigny. Prodr. de Paléont., i, p. 156.
1852. Owen and Shumard. U. S. Geol. Rep. Iowa, Wis. and Minn., p. 589.
1853. De Koninck and Lehon. Rech. Crin. Carb. Belg., p. 146.
1857. Pictét. Traité de Paléont., iv, p. 333.
1858. Hall. Geol. Rep. Iowa, i, pt. ii, p. 654 (not 689).
1860. Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 381.
1860. Hall. Supp. Geol. Rep. Iowa, p. 83.
1860. Casseday and Lyon (in part). Proc. Acad. Arts and Sci., v, p. 16.
1866. Meek and Worthen. Geol. Rep. Ill., ii, pp. 167 and 263.
1879. Zittel. Handb. der Palaeont., p. 365 (not Shumard, 1857, Trans. St. Louis Acad., i, p. 5).
Syn. (?) *Cotyledonocrinus* Cass. and Lyon. 1860, Proc. Am. Acad. Arts and Sci., v, p. 16.
Syn. *Platycrinus* Phillips (in part). Geol. of Yorkshire, ii.

There has been some difference of opinion as to the number of primary radials in *Dichocrinus*. Austin represents his *Dichocr. fusiformis*, Rec. and Foss. Crin., Pl. 5, fig. 6ᵇ, with three small plates above the first radials; De Koninck and Lehon, in their generic formula, fix the number of primary radials at 4×5, on the strength of Austin's figure. On the other hand, Shumard described his two species, *D. cornigerus* and *D. sexlobatus*, with a single large radial, and none above it. Casseday and Lyon state the number of radials as 1 to 3 × 5, in which opinion Meek and Worthen coincide.

We have no doubt that the latter statement is correct, and that Austin's species is incorrectly figured, and had actually but three radials; but we have ascertained from several excellent specimens loaned to us by Prof. Worthen, that the so-called *D. cornigerus* and *D. sexlobatus* of Shumard both have a very minute second radial, which is sometimes not visible externally. These two species, however, like some others described by Casseday and Lyon, differ from the typical *Dichocrinus* in several other important points, and this has led us to arrange them in a new generic group under *Talarocrinus*, which includes every species of this form with only two primary radials. We have examined all known American species of *Dichocrinus* proper, and find they all have three primary radials.

Revised Generic Diagnosis.—Calyx deeply cup-shaped; plates delicate, rarely ornamented; symmetry distinctly bilateral.

Basals two, hexagonal, forming together an obconical or rounded cup. Radials 3 × 5. The five plates of the first series very large, their sides straight and nearly parallel; two rest on each basal piece, the anterior plate in a notch at one end of the basal suture; against the opposite end there rests a large anal plate, which is placed in line with the first radials. Succeeding radials very small, occupying scarcely more than one-fourth the width of the first. The third radials are bifurcating plates which support either the arms, or in species with more than ten arms, the higher orders of radials. Secondary, tertiary, or even quarternary radials occur according to the number of arms. These higher orders are generally in series of two plates each, exceptionally three; they are similar in appearance to ordinary arm plates, but are easily distinguished by being single-jointed; while the arm plates, from the base up, are composed of a double series of pieces.

Arms rather delicate, but they give off very long and stout pinnules composed of large joints. The pinnules form a very characteristic feature of the genus.

Anal plate almost as large as the first radials, often narrower above than below; quadrangular. Interradial plate pushed upward to the ventral side of the body, resting upon two upper margins of the first radials, which are not indented; several interradial dome plates follow in succession.

Dome depressed, and so far as known, constructed, as in some species of *Platycrinus*, with a short excentric anal tube.

Column cylindrical, with a small round canal.

The genus is most closely related to *Talarocrinus*.

Geological Position, etc.—Dichocrinus is a Subcarboniferous genus, and is found in America from the Lower Burlington limestone up to the Warsaw, where it is succeeded by *Talarocrinus*. It is also represented by a number of species in the Mountain limestone of Belgium and Great Britain.

We recognize the following species:—

1862. **Dichocrinus angustus** White. Proc. Bost. Soc. Nat. Hist., ix, p. 19. Upper Burlington limest. Burlington, Iowa.

1860. **Dichocr. constrictus** Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 381; also Geol. Rep. Ill., ii, p. 263, Pl. 19, figs. 2 a, b, c. Warsaw limest. Bloomington, Ind.

1860. **Dichocr. conus** Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 381; also Geol. Rep. Ill., ii, p. 169, Pl. 16, figs. 5 a, b. Lower Burlington limest. Burlington, Iowa.

1862. **Dichocr. crassitestus** White. Proc. Bost. Soc. Nat. Hist., ix, p. 19. Upper Burlington limest. Burlington, Iowa.

1860. **Dichocr. dichotomus** Hall. Supp. Geol. Rep. Iowa, p. 85, Pl. 1, fig. 5. Warsaw limest. Warsaw, Ill.

1853. **Dichocr. elegans** De Kon. and Leh. (not Casseday and Lyon = *Talarocrinus elegans* Wachsm. and Spr.). Rech. Crin. Carb. Belg., p. 153, Pl. 4, figs. 13 a, b. Mountain limest. Tournay, Belg.

1836. **Dichocr. elongatus (Platycr. elongatus)** Phill. (not Goldf., 1838 = *Hexacrinus*). Geol. of Yorkshire, p. 204, Pl. 3, figs. 24, 26; Austin, 1843, Mon. Rec. and Foss. Crin. Mount. limest. Tournay, Belg.

1853. **Dichocr. expansus** De Kon. and Leh. (not Meek and Worthen = *Dichocr. polydactylus* Cass. and Lyon). Rech. Crin. Carb. Belg., p. 151, Pl. 4, fig. 10. Mount. limest. Belgium and England.

This species had been figured by Miller, 1821, among his **Pl. lævis** (figs. 4, 5), and by Austin as **D. radiatus**.

1860. **Dichocr. ficus** Casseday and Lyon. Proc. Am. Acad. Arts and Sci., v, p. 24; Meek and Worthen, 1873, Geol. Rep. Ill., v, p. 500, Pl. 14, fig. 1. Keokuk limest. Crawfordsville, Ind.

In their description, the above authors state that all of the six perisomic plates are arm bearing. This is a mistake, as the anal plate supports a narrow cylindrical tube somewhat resembling an arm.

1843. **Dichocr. fusiformis** Austin. Mon. Rec. and Foss. Crin., p. 47, Pl. 5, figs. 6 a-d; De Kon. and Leh., 1853, Rech. Crin. Carb. Belg., p. 148, Pl. 4, fig. 7. Mount. limest. Mendip Hills, Eng., and Tournay, Belg.

1853. **Dichocr. granulosus** De Kon. and Leh. Rech. Crin. Carb. Belg., p. 152, Pl. 4, fig. 12. Mount. limest. Tournay, Belg.

1853. **Dichocr. intermedius** De Kon. and Leh. Rech. Crin. Carb. Belg., p. 150, Pl. 4, fig. 9. Mount. limest. Tournay, Belg.

1853. **Dichocr. irregularis** De Kon. and Leh. Rech. Crin. Carb. Belg., p. 152, Pl. 4, figs. 11 a, b. Mount. limest. Tournay, Belg.

1860. **Dichocr. lævis** Hall. Supp. Geol. Rep. Iowa, p. 83. Lower Burlington limest. Burlington, Iowa.

1869. **Dichocr. lineatus** Meek. and Worth. Proc. Acad. Nat. Sci. Phila., p. 69; also Geol. Rep. Ill., v, p. 440, Pl. 3, fig. 1. Lower Burlington limest. Burlington, Iowa.

1861. **Dichocr. liratus** Hall. Desc. New Sp. Pal. Crin., p. 5; also Bost. Jour. Nat. Hist., p. 290, Photog. Pl. 2, figs. 7, 8. Upper Burlington limest. Burlington, Iowa.

*1881. **Dichocr. ornatus** Wachsm. and Spr. (**Dichocr. sculptus** Lyon and Cass., not De Kon. and Leh., 1853). Proc. Am. Acad. Arts and Sci., v, p. 25. Keokuk limest. Hardin Co., Ky. We propose the above name, **D. sculptus** being preoccupied.

1850. **Dichocr. ovatus** Ow. and Sh. Jour. Acad. Nat. Sci. Phila. (new sr.) ii, Pt. i; also U. S. Geol. Rep. Iowa, Wis. and Minn., p. 590, Pl. 5 A, figs. 9 a–b. Lower Burlington limest. Burlington, Iowa.

1869. **Dichocr. pisum** Meek and Worth. Proc. Acad. Nat. Sci. Phila., p. 69; also Geol. Rep. Ill., v, p. 440, Pl. 3, fig. 2. Lower Burlington limest. Burlington, Iowa.

1861. **Dichocr. plicatus** Hall. Desc. New Pal. Crin., p. 4; also Bost. Jour. Nat. Hist. p. 288, Phot. Pl. 2, figs. 9, 10. Upper Burlington limest. Burlington, Iowa.

1861. **Dichocr. pocillum** Hall. Desc. New Sp. Crin., p. 5; also Bost. Jour. Nat. Hist., p. 291, Phot. Pl. 2, figs. 15, 16 (Fig. 14 is evidently Meek and Worthen's **D. lævis**, which occurs in the Upper Burlington beds). Lower Burlington limest. Burlington, Iowa.

1860. **Dichocr. polydactylus** Casseday and Lyon. Proc. Am. Acad. Arts and Sci., v, p. 20. Keokuk limest. Crawfordsville, Ind.

Syn. **D. expansus** Meek and Worth (not De Kon. and Leh., 1853). Proc. Acad. Nat. Sci. Phila., p. 344; also Geol. Rep. Ill., v, p. 500, Pl. 14, fig. 1.

The original description by Cass. and Lyon is somewhat erroneous as to the arrangement of the arms, and this probably led Meek and Worthen to propose a new species. There is no doubt of the identity of the two.

1838. **Dichocr. radiatus** Münster. Type of the genus. Beitr. z. Petref., i, p. 2, Pl. 1, figs. 3 a–d; De Koninck, 1842, Desc. Anim. Foss., p. 40, Pl. i, figs. 6 a–d; Austin, 1843, Mon. Rec. and Foss. Crin., p. 45, Pl. 5, figs. 5 a–d; D'Orbigny, 1850, Prodr. de Paléont. i, p. 156; De Kon. and Leh., 1853, Rech. Crin. Carb. Belg. p. 149, Pl. 4, figs. 8 a–d; Pictét, 1857, Traité de Paléont. iv, p. 333, Pl. 101, fig. 18; Bronn, 1860, Klassen d. Thierreichs, ii, Pl. 28, figs. 9 a–b. Mount. limest. Mendip Hills, Eng., and Tournay, Belg.

1861. **Dichocr. scitulus** Hall. Desc. New Pal. Crin. p. 4; also Bost. Jour. Nat. Hist., p. 289. Lower Burlington limest. Burlington, Iowa.

1853. **Dichocr. sculptus** De Kon. and Leh. (not Cass. and Lyon, 1860). Rech. Crin. Carb. Belg., p. 154, Pl. 4, figs. 14 a, b, c. Mount. limest. Tournay, Belg.

1857. **Dichocr. simplex** Shumard. Trans. Acad. Sci. St. Louis, p. 74, Pl. 1, fig. 2; Hall, 1858, Geol. Rep. Iowa, i, Pt. ii, p. 654, Pl. 23, figs. 12 a, b. Warsaw limest. Spurgeon Hill, Ind.; also St. Mary's Landing, Mo., and Sparta, Tenn.

1850. **Dichocr. striatus** Ow. and Sh. Jour. Acad. Nat. Sci. Phila. vol. ii, Pt. i,; also U. S. Geol. Rep. Iowa, Wis. and Minn. p. 590, Pl. 5 A, figs. 10 a, b. Upper Burlington limest. Burlington, Iowa.

9. TALAROCRINUS, nov. gen.

(*τάλαρος* a small basket; *κρῖνον* a lily.)

Syn. *Dichocrinus* Shumard (in part) 1860 (not Münster). Trans. Acad. Sci. St. Louis.

Syn. *Dichocrinus* Cass. and Lyon (in part) 1860. Proc. Am. Acad. Arts and Sci., v, p. 16.

Among the species described by Shumard under *Dichocrinus* there are two, which differ materially from that genus and from *Pterotocrinus*, with which they are nearest related. Meek and Worthen, in their generic description of *Pterotocrinus* (Geol. Rep. Ill., ii, p. 290), recognized more than specific differences between the form represented by Shumard's *Dichocrinus cornigerus* and *D. sexlobatus*, and the genus *Pterotocrinus* with which these two species had been identified, and they proposed either to divide the genus into two sections, or to separate the above species from it sub-generically. Shumard afterwards and also S. A. Miller, in their catalogues placed both species under *Pterotocrinus*.

Wetherby (Cin. Journ. Nat. Hist., 1879, Apr. number) on the other hand, refers the above species to *Dichocrinus* and considers them altogether distinct from *Pterotocrinus*. In the latter conclusion he is undoubtedly correct, but we cannot see that their relations to *Dichocrinus* are any closer. They evidently form a little group by themselves, which in nature occupies a place between the two genera, forming a connecting link between them. We propose for this group the generic name *Talarocrinus* with *D. cornigerus* Shum. as the type.

Generic Diagnosis.—General form of body ovoid; composed of heavy plates. Calyx subconical; plates convex, deeply impressed at the suture lines, and hence more or less protuberant; surface smooth.

Basals two, pentagonal, precisely alike, the suture running from the posterior to the anterior side. First radials large, quadrangular, nearly as wide as high, aranged in line with the first anal plate, which is as large or larger than the radials, and of similar form. The upper edge is excavated, but not semicircular, there being an angular process in the middle. Second radials[1] very minute, often not visible externally, and resting from within against the median angular process within the articulating depression of the large radial. Their inner face is much larger, triangular in form, with concave sides. The arrangement is such that these sides, together with the outer portions of the articulating scar of the first plates, form two semicircular sockets, supporting each a small pentagonal bifurcating secondary radial, which here, as in *Pterotocrinus* and *Marsupiocrinus*, constitutes a part of the body, and in turn supports two arms, or twenty arms in all. Form of the arms unknown.

Vault generally of equal height with the calyx, decidedly lobed when viewed from above; composed of numerous small pieces, some of them spiniferous; toward the posterior side obliquely flattened, with a lateral anal aperture towards the upper end. Radial area elevated, and extending outward; interradial portions depressed, posterior side much wider. Central vault piece large, nodose or spiniferous. The four large proximal plates occupy in four of the interradial spaces the upper portion of the depression, while the two smaller ones rest partly against the radial portions of the dome, with several small anal plates and the anal aperture between them. Interradial vault pieces three, rather large, and much higher than wide. The first radial vault piece is spiniferous in most species, the succeeding plates small and nodose, arranged longitudinally in rows, forming together regular arches over the ambulacral passages within the body. There is a large elongate brachial piece between the two divisions of each ray, which at its lower end connects with the upper point of the second radial, thus giving origin to two arm openings in each ray. The anal area has three large pieces in the first series, which rest upon the anal plate of the calyx, the median one has form and size of the interradial plates, the two others are smaller. In the second series there are two plates, followed by a number of minute pieces surrounding the anal aperture, which is protuberant.

Column probably cylindrical and small, with a minute central canal.

Talarocrinus differs from *Dichocrinus* in the greater prominence of the plates in the calyx; its higher vault; in having the

[1] Shumard described *Dichocr. cornigerus* with a single radial, but the second is present in the species though hidden from view exteriorly.

secondary radials forming part of the calyx, and in having the anal opening through the vault, and not at the end of a tube. It differs from *Pterotocrinus* in the very different form of the calyx; in having no tertiary radials in the calyx; in the form of the dome, and the absence of lobed processes.

Geological Position, etc.—The genus is known only from the St. Louis and Kaskaskia groups of the United States.

We recognize the following species:—

*1857. **Talarocrinus cornigerus** Shumard. (**Dichocr. cornigerus.**) Type of the genus. Trans. Acad. Sci. St. Louis, i, p. 72, Pl. 1, figs. 1 a, b; **Pterotocr. cornigerus** Shumard, 1866, Cat. Pal. Foss. N. Amer., i, p. 393; S. A. Miller, **Pterotocr. cornigerus**, Catal. Pal. Foss., p. 89. Kaskaskia limest. Franklin Co., Ala.

*1860. **Talarocr. elegans** Cass. and Lyon. (**Dichocr. elegans.**) Proc. Am. Acad. Arts and Sci., v, p. 22. St. Louis limest. Edmonson Co., Ky.

*1857. **Talarocr. sexlobatus** Shumard. (**Dichocr. sexlobatus**). Trans. Acad. Sci. St. Louis, vol. i, p. 6, Pl. i, figs. 3 a, b, c; S. A. Miller (**Pterotocr. sexlobatus**), Catal. Pal. Foss., p. 89. Kaskaskia limest. Russelville, Ky.

*1860. **Talarocr. symmetricus** Cass. and Lyon. (**Dichocr. symmetricus.**) Proc. Am. Acad. Arts and Sci., vol. v, p. 22. Kaskaskia limest. Edmonson Co., Ky.

10. PTEROTOCRINUS Lyon and Casseday.

1859. Lyon and Casseday. Am. Journ. Sci. and Arts, xxix, p. 68.
1866. Meek and Worthen. Geol. Rep. Ill., ii, p. 288.
1879. Wetherby. Journ. Cin. Soc. Nat. Hist. (April).
1879. Wetherby. Ibid. (October No.).
1879. Zittel. Handb. d. Palaeont., i, p. 365.
Syn. *Asterocrinus* Lyon, 1857 (not Münster). Geol. Rep. Ky., iii, p. 472.

Pterotocrinus was first described in 1857 by Lyon under the name of *Asterocrinus*, which, being previously occupied by Münster, was changed to the former in 1859 by Lyon and Casseday.

Meek and Worthen, in revising the genus in 1866, indicated in their generic formula four series of interradial plates, which is evidently a mistake, as that order of plates is entirely absent in the calyx. They further changed the term "wings or lobed pieces" of Lyon into "interbrachial appendages."

In 1879. Prof. Wetherby, who had obtained very perfect specimens from Kentucky, published some new and interesting observations on the genus, and described in the April and October numbers of the Journ. of the Cincin. Soc. Nat. Hist., three new species. He considered the small plates which had been recognized by Meek and Worthen as second radials, to be mere accessory pieces. These plates are exceedingly small and rudimentary in this genus, sometimes almost obsolete; but in their minuteness they are clearly the analogues of the second primary radials in other genera, and should be so described.

Generic Diagnosis.—Calyx depressed, saucer-shaped, much wider than high; symmetry bilateral. Vault high, pyramidal, pentagonal in outline, crowned by five wing-like lateral extensions or processes, which form one of the most characteristic features of this remarkable genus. Plates without surface ornamentation.

Basals two, large, of similar form, pentagonal, the suture running from the anterior to the posterior side; they form a shallow cup, with a central depression for the attachment of the column. Posterior side of the cup angularly excavated for the reception of a rather large, lance-shaped, subtriangular anal plate, the opposite side of which is similarly excavated, supporting the anterior radial. First radials almost twice as wide as high, increasing rapidly in width from their lower suture upward. The anterior radial is heptagonal, the two adjoining radials hexagonal. The two posterior first radials are of somewhat different form on account of the triangular or quadrangular anal piece which is intercalated between them, and they are either heptagonal or hexagonal according as this plate is of equal height with them or shorter. The upper side of the first radials is excavated and more or less concave, it supports not only the second primary radials, but also the two secondary ones, and, what is most remarkable, one of the first series of tertiary radials; all of which plates, with $1 \times 2 \times 20$ additional tertiary radials, form part of the calyx. The second primary radial is placed within the concavity of the first plate; it is very minute, sometimes invisible externally, of triangular form, and supporting on each sloping face a single series of bifurcating plates, which rank as secondary radials. These latter meet above the apex of the small second radial, and rest by one side upon the large first radials, while their two upper faces support from 2 to 3×20 tertiary radials, or 2×4 to each ray. Of these plates, the two outer ones of each ray rest with one side upon the outer extremity of the margin of the first radials, with the outer side against one of the upper sloping faces of the secondary radials, the inner sides meet each other, while their upper faces support a second tertiary radial. The two plates toward the inner ray are narrower, truncate below, resting upon the longer upper face of the secondary radials, and support like the outer plates one or two plates in succession, which in turn support the arms. The radials of the higher orders are almost of equal size, and at least twice as wide as high. There is no interradial within the calyx, and no other anal plate but the one described.[1]

Dome highly elevated, pyramidal, pentagonal in outline. The angles which are radial, are excavated for the attachment of the large radial processes. The sides of the pentagon are the interradial spaces, which seem to have faint grooves, running longitudinally, wherein the arms rest. Four of the interradial spaces are of equal size, the fifth somewhat larger. All five are similarly constructed, and contain three plates in the lower series. The middle or first interradial plate is the larger, its two upper sides forming an angle. The two adjacent plates, as will be explained presently, are representations of radials of a second order. Above these and alternating with them, rests a second series of interradials, composed of two plates, larger than the first, and these meet laterally with corresponding plates of adjacent rays. The upper series, representing the proximal vault pieces, consists of a single plate in four of the spaces, and two slightly smaller ones in that of the posterior side, which all join laterally and form a continuous ring. In a few instances only, there appears to be a small anal plate located between the two smaller proximal plates.

The first radial dome plates are enormously developed in the form of wing-like processes which form the most characteristic feature of the genus. Succeeding these outward, toward the rim, are two small secondary radial dome-plates, one on each side of the lower interradial, and two still smaller plates bifurcating from the last, which are tertiary radial dome plates, but which are rarely observed. Besides these there is a rather large, very peculiar interbrachial plate, beneath the winged first radial. The winged extensions of the first radial dome plate are very variable in form. They are, according to Wetherby, either spatulate, claviform, or cuneiform; in some species thin and knife-like throughout their

[1] In one of Wetherby's specimens which he kindly loaned us, we found a little triangular piece resting upon the anal plate. Whether this is abnormal, or a deviation from the general rule and of specific importance, we are as yet unable to say.

length; in others thickened and rounded above, and slightly thinner below; in some terminating in thin round edges, in others tapering almost to a point; while still others are bifurcate at the extremities. The monstrous plates, which rise to the full height of the summit, and laterally extending far beyond it, rest chiefly upon the surface of the vault, within grooves, bordered by elevated ridges along the interradial and proximal dome plates, and only a small portion at the lower end is wedged in between other plates. The ridges continue along the interbrachial plate, which for a plate of that order is unusually large. The interbrachial plates, together with the secondary radials and lower interradials, form the base of the dome.

The summit leans somewhat to the posterior side, more especially the upper portion, which in the best specimens consists of a small cone, composed of a number of small plates, which decrease in size upward, leaving a minute anal opening at the upper end of the cone.[1]

In front of the anal opening, and in the radial centre, there is a pentagonal plate which is at once recognized as the central dome plate. To this plate converge not only the radial grooves in which the winged processes rest, but also the smaller grooves within the interradial spaces which receive the arms. These latter pass into the ambulacral or arm openings, which are rather large, and have an upward direction.

The arms are short, simple, gradually diminishing in size upward, extending to the top of the vault, but not beyond it. They are twenty in number, divided by the winged processes into groups of four, each containing two arms of two different rays. They are constructed of two rows of short interlocking joints, moderately convex on the dorsal side. Ambulacral furrows, wide and deep. Pinnules short, stout, composed of five or six joints.

The visceral cavity, as seen from one of Wetherby's specimens, (vertical section) is deeper than would be expected from the form of the body. The basal plates are very thin, while the radials, to the top of the third order, increase rapidly in thickness.

Column slender, round; central perforation small.

[1] It is very possible that in some of the species the anus is not thus extended into a tube-like cone, but this is the case in *Pterotocrinus depressus* Lyon and Cass. The anal aperture is but rarely observed, being generally covered by the shell of a Gasteropod.

Geological Position, etc.—*Pterotocrinus* is the last survivor of the Platycrinidæ, and occurs only in the Kaskaskia limestone of America.

The following species are known:—

1879. **Pterotocrinus acutus** Wetherby. Journ. Cin. Soc. Nat. Hist. (Oct. No.), p. 1, Pl. 11, figs. 2 a, b, c. Kaskaskia limest. Pulaski Co., Ky.

1879. **Pterotocr. bifurcatus** Wetherby. Journ. Cin. Soc. Nat. Hist. (Oct. No.), p. 3, Pl. 11, figs. 1 a, b, c. Kaskaskia limest. Pulaski Co., Ky.

1857. **Pterotocr. capitalis** Lyon. (**Asterocr. capitalis**). Type of the genus. Ky. Geol. Surv., iii, p. 472, Pl. 3, figs. 1 a–k; Lyon and Cass., 1859, **Pterotocr. capitalis,** Am. Journ. Sci. and Arts, vol. xxix, p. 68. Kaskaskia limest. Crittenden Co., Ky.

1860. **Pterotocr. Chesterensis** Meek and Worth. Proc. Acad. Nat. Sci. Phila., p. 383; and 1866, Geol. Rep. Ill. ii, p. 292, Pl. 23, figs. 1 a, b, c. Kaskaskia limest. Hardin Co., Ill.

1857. **Pterotocr. coronatus** Lyon (**Asterocr. coronatus**). Ky. Geol. Surv, iii, p. 476, Pl. 1, figs. 1, 1 a. Kaskaskia limest. Crittenden Co., Ky.

1860. **Pterotocr. crassus** Meek and Worth. Proc. Acad. Nat. Sci. Phila. p. 382, and 1866, Geol. Rep. Ill, ii, p. 240, Pl. 23, figs. 2 a, b. Kaskaskia limest. Hardin Co., Ill.

1859. **Pterotocr. depressus** Lyon and Cass. Am. Journ. Sci. and Arts, vol. xxix. p. 68. Kaskaskia limest. Grayson Springs, Ky.

*1858. **Pterotocr. protuberans** Hall. (**Dichocr. protuberans**). Geol. Rep. Iowa, i, Pt. 2, p 689, Pl. 25, fig. 7. Kaskaskia limest. Chester, Ill.

1859. **Pterotocr. pyramidalis** Lyon and Cass. Am. Journ. Sci. and Arts, xxix, p. 69. Kaskaskia limest. Grayson and Edmonson Cos., Ky.

This species is evidently identical with **P. depressus,** and was described from a specimen showing the vault in place of the arms.

1879. **Pterotocr. spatulatus** Wetherby. Journ. Cin. Soc. Nat. Hist. (Oct. No.), p. 4, Pl. 11, figs. 3 a, b, c. Kaskaskia limest. Pulaski Co., Ky.

B. ACTINOCRINIDÆ Roemer and Zittel.

(Amend. Wachsm. and Spr.)

The name Actinocrinidæ was first employed by Roemer in 1855, who arranged under it *Actinocrinus*, *Amphoracrinus*, *Dorycrinus* and *Batocrinus*, genera without underbasals, with three basal plates, and in which the first anal piece extends to the line of the first radials. He placed *Melocrinus* and all genera with four basals and no anal plate within the first radial ring under his Melocrinidæ, not including, however, *Eucalyptocrinus* nor *Ctenocrinus*, which latter, as he supposed, had only three basals. *Periechocrinus* (*Pradocrinus* and *Saccocrinus*), which he thought differed in the anal area, and *Ctenocrinus*, he placed with *Glyptocrinus*—of which the under basals had not been discovered—under the Ctenocrinidæ; while *Carpocrinus* and *Macrostylocrinus* were referred to the Cyathocrinidæ.

Zittel amended Actinocrinidæ by admitting *Periechocrinus*, *Eretmocrinus*, *Alloprosallocrinus*, *Strotocrinus*, *Steganocrinus*. *Agaricocrinus* and *Megistocrinus*, partly, however, as subgenera of *Actinocrinus*. He, like Roemer and Angelin, separated the genera with four basals, and ranged *Stelidiocrinus* and *Harmocrinus*, which have five basal pieces, under a distinct family. Zittel further excluded *Carpocrinus*, *Habrocrinus* and *Desmidocrinus*, species with single arm joints, for which he proposed the name Carpocrinidæ, and he placed under the Dimerocrinidæ *Marcostylocrinus* and *Dolatocrinus*, genera with three basals and no anal plate in line with the first radials, and among these he admitted *Cytocrinus*, which we have ascertained has four and not three basals, and *Dimerocrinus*, which has underbasals.

The fact that in those classifications the least mistake or misconception as to the number of the basals, a diversity in the position or distribution of the anal plates, or a slight variation in the form of the arm joints, throws the genus from one family into another, is in itself sufficient proof, that the divisions are arbitrary and artificial. A classification based upon fossils should be as simple as possible, resting upon a broad basis, and the family divisions should express important and evident structural features, and be not dependent upon such trifling variations as the number of basal plates, etc.

We place among the Actinocrinidæ all genera of the Sphæroidocrinidæ, which are constructed of basals (without underbasals); 3×5—rarely 2×5—primary radials, all forming a part of the calyx; one or more higher orders of radials, with at least one, but generally several additional interradial pieces beneath the arm regions; a vault composed of a large number of heavy plates in contact with each other; and we include species both with single and double jointed arms.

For greater convenience of study we arrange the genera under six sections.

a. Stelidiocrinites: The simplest form of the sub-family. General symmetry more or less perfectly pentahedral; calyx low; basals five or three; second radials short; anal and interradial area scarcely distinct; arms single or double jointed.

b. Agaricocrinites: Symmetry decidedly bilateral; calyx low;

basals three; second primary radials quadrangular and short; the first anal plate in line with the first radials; arms heavy, simple, composed of single or double joints.

c. *Melocrinites:* Symmetry more or less uniformly pentahedral; calyx large; basals four or three; second radials comparatively high and generally hexagonal; interradials numerous; anal side but little distinct and its plates not extending to the line of the first radials; interaxillaries sometimes present; arms given off laterally; columnar canal pentalobate and rather large.

d. *Periechocrinites:* General symmetry bilateral; calyx very large; basals four or three; second radials large, frequently higher than wide; interradials and interaxillaries numerous; first anal plate in line with the first radials, succeeded by three plates in the second series; arms branching; column large, and with a wide pentalobate canal.

e. *Actinocrinites:* Symmetry slightly bilateral; calyx large; basals three; second primary radials nearly as high as wide, hexagonal; higher orders of radials numerous, composed of one series of plates each, which give off the arms alternately from opposite sides; interradials in two rows; the first anal plate enclosed between the first radials, supporting only two plates in the second series; interaxillaries generally present; arms long, double jointed.

f. *Batocrinites;* symmetry more or less bilateral; calyx large; basals three; second radials short, linear; higher orders of radials rarely exceeding three, the plates of the last order touching laterally all around the body, except sometimes over the anal area. Interradials few; interaxillaries absent; first anal plate in line with the first radials, second series composed of three plates; arms short, double jointed.

These groups are founded upon the construction of the anal area, in connection with the form and arrangement of the radial plates and the arms. A division merely based upon the construction of the anal area, as we have adopted among Platycrinidæ, would bring together the *Stelidiocrinites* and *Melocrinites* as opposed to the *Agaricocrinites*, *Periechocrinites* and *Batocrinites*, while the *Actinocrinites* would occupy a place somewhat between the two. A separation by means of the second primary radials brings into closer proximity *Stelidiocrinites* and *Agaricocrinites*, in which those plates are short, linear and quadrangular, against the three other sections in which they are comparatively high and hexagonal. An exception is here found in *Dolatocrinus* and *Stereocrinus*, in which the second radials are quadrangular or even absent, and which should perhaps be placed more properly in a group by themselves.

The form of the second radials is no doubt of some importance in the structure of these crinoids. In species in which they are quadrangular and linear, the second and third radials together very often fail to attain the size of the first radial plate. In various cases of *Dolatocrinus*, *Alloprosallocrinus* and *Batocrinus*, the second radials are so small that they are discovered with difficulty, and are not unfrequently in single rays entirely absent. In species in which the plates of the calyx are tuberculous, they are often the only plates which bear no tubercle. All this hints at the conclusion that the second and third radials, which combined take the form of a single bifurcating plate, here take the place of a single plate joined by syzygy, with the epizygial part bearing an arm instead of a pinnule, and that in species which as a rule have only two primary radials, but otherwise agree with some other genus, the joints became perfectly anchylosed. Such was evidently the case with *Dolatocrinus* and *Stereocrinus*, *Eucrinus* and *Anthemocrinus*, *Lecanocrinus* and *Pycnosaccus*. In *Platycrinus*, which also has only two primary radials, the division appears yet frequently in form of a shallow groove at the surface of the plate, where the earlier Platycrinidæ have a regular suture.

In species with more than ten arms, the rays are generally composed of two main divisions, of which each side gives off arms in opposite directions. The only exception is *Steganocrinus sculptus* Hall, in which the ray is undivided (Pl. 18, fig. 3). In this species, the third primary radials, like all succeeding plates (radials of superior orders), take the form of pinnule-bearing plates, which, instead of bifurcating, give off laterally arms in the same manner as the others do pinnules.

This is of interest, as it leads to the conclusion that probably the secondary radials—the distichalia of Müller—made their appearance in the young crinoid in form of a pinnule given off from the radials which at first formed the only arms of the ray.

We have already shown in our general remarks on the family that the higher orders of radials were in the young animal free arm plates, and we have proved by many examples that the arms spring off in exactly the same manner as the pinnules, and they evidently were pinnule-like in their earlier form.

The earliest Actinocrinidæ known to us are found in the Upper Silurian, but the species and even genera which already occur there are so numerous, and show such variety of form, and some of them appear to be so highly developed, that evidently the family had been represented at a much earlier epoch. It is possible that *Schizocrinus* Hall of the Lower Silurian, which is imperfectly known, should be referred to the Actinocrinidæ, but it may have underbasals. In the earlier representatives of this family, the underbasals form the criterion by which alone the Actinocrinidæ and Rhodocrinidæ can be distinguished, and as these plates in the earlier types are very minute, it is often exceedingly difficult to make the separation. In *Glyptocrinus* the underbasals may perhaps be absent in some species, but when visible they are exceedingly rudimentary. Species without them might be referred, almost with the same propriety to the Actinocrinidæ, and indeed, they have a remarkably close resemblance to species of *Melocrinus* and *Mariacrinus* with four basal plates. A similar relation exists between *Dimerocrinus* and *Stelidiocrinus*, *Glyptaster* and *Periechocrinus*, which can be distinguished only by the underbasals.

In *Stelidiocrinus* and *Melocrinus*, we recognize representatives of two of the four divisions of the Actinocrinidæ which occur in the Upper Silurian. The two differ essentially in the relative size of their body, and in the number and distribution of the plates in the calyx, but agree in the arrangement of their anal area. *Carpocrinus* and *Periechocrinus*, which belong to the same geological age, are separated by the very same characters, the former agreeing closely with *Stelidiocrinus*, the latter with *Melocrinus*, but both are readily distinguished by having a special anal plate in line with the first radials.

The *Stelidiocrinites* disappear in the Upper Silurian, where they are first known. The *Periechocrinites* and *Agaricocrinites* survived to the Subcarboniferous, the former to the Burlington, the latter to the Keokuk epoch. The *Melocrinites* became extinct in the Devonian. The *Actinocrinites* and *Batocrinites* are restricted almost exclusively to the Subcarboniferous; a few aberrant forms are known from the Hamilton group. The *Actinocrinidæ* became altogether extinct after the age of the Warsaw limestone.

We arrange the six sections as follows:—

a. STELIDIOCRINITES.

1. *Briarocrinus* Angelin.
2. *Stelidiocrinus* Angelin.
3. *Patelliocrinus* Angelin.
4. *Macrostylocrinus* Hall.
   Subgenus *Centrocrinus* Wachsmuth & Springer.

b. AGARICOCRINITES.

5. *Carpocrinus* Müller.
   Subgenus *Desmidocrinus* Angelin.
6. *Agaricocrinus* Troost.
   Subgenus *Alloprosallocrinus* Lyon & Casseday.

c. MELOCRINITES.

7. *Mariacrinus* Wachsm. & Spr.
8. *Technocrinus* Hall.
9. *Melocrinus* Goldfuss.
10. *Scyphocrinus* Zenker.
11. *Dolatocrinus* Lyon.
    Subgenus *Stereocrinus* Barris.

d. PERIECHOCRINITES.

12. *Periechocrinus* Austin.
13. *Abacocrinus* Angelin.
14. *Megistocrinus* Owen & Shumard.

e. ACTINOCRINITES.

15. *Actinocrinus* Miller.
16. *Teleiocrinus* Wachsm. & Spr.
17. *Steganocrinus* Meek & Worthen.
18. *Amphoracrinus* Austin.
19. *Physetocrinus* Meek & Worthen.
20. *Strotocrinus* Meek & Worthen.
21. *Gennaocrinus* Wachsm. & Spr.

f. BATOCRINITES.

22. *Batocrinus* Casseday.
23. *Eretmocrinus* Lyon & Casseday.
24. *Dorycrinus* F. Roemer.

a. STELIDIOCRINITES.

1. BRIAROCRINUS Angelin.

1878. Angelin. Iconog. Crin. Suec., p. 1.
1879. Zittel. Handb. der Palæont., i, p. 367.

Briarocrinus represents the simplest conceivable form that can be admitted among the Actinocrinidæ. It has two interradial plates, and these, in the typical species, are situated above the line of the third primary radials. Its perfectly straight arm joints suggest an immature crinoidal structure.

B. angustus Angl. is too plainly distinct from *B. inflatus* Angl., in the construction of the plates of the calyx, and particularly in the interradial portions, to be admitted into the same genus, and as it agrees with no other, we should propose it as the type of a new genus, if we had before us specimens instead of a single figure. For want of material, we leave it here for the present.

Angelin and Zittel arranged *Briarocrinus* under a separate family, in which the latter includes *Culicocrinus*. It is true that *B. inflatus* deviates from all other Actinocrinidæ in its interradial parts, but it differs fully as much from *Culicocrinus* in the same characters, the latter being decidedly a Platycrinoid. *Briarocrinus*, in our opinion, leans rather toward the Ichthyocrinidæ, with which it agrees in the alternate arrangement of the radial plates, but it has evidently not their pliant body.

Generic Diagnosis.—Calyx cup-shaped; symmetry pentahedral, with some inequality in the sides due to irregularities in the radial series.

Basals three, usually large, two of them equal and larger than the third. Primary radials 3 × 5, wider than high, joining laterally. The third is a bifurcating plate with very obtuse upper angles, supporting in almost vertical succession 3 × 10 secondary radials, which are half the width of the primary radials, and interlock up to the second plate; the third pair being separated by a small axillary piece. The radials are generally irregular in form, even those of a like order or series are differing markedly among each other in height and width. In some of the rays, the first radials are larger by half than in others, and in these the second radials are much higher and generally wider; in others only one side of the plate is lower, a construction producing a sort of alternate arrangement of the plates, which extends up to the secondary radials. The plates of this second order are separated from each other, laterally, by a line of two small interradial pieces, which in alternate rays, respectively, rest upon the upper corners of two of the third primaries, or upon the upper sloping side of the first secondary radial.

Arms ten, supported directly upon the secondary radials; heavy, simple, composed of single transverse round joints, with parallel sutures and long pinnules.

Posterior or anal side, so far as known, not distinct.

Column round.

In the absence of interradial plates between the primary radials, and in the alternate arrangement of the latter, this genus differs from all others of the family.

Geological Position, etc.—Found thus far only in the Upper Silurian of Sweden.

1878. **Briarocrinus inflatus** Angelin. Iconogr. Crin. Suec., p. 1, Pl. 10, fig. 23. Upper Silur. Gothland, Sweden.

[?] 1878. **Briarocr. angustus** Angelin. Iconogr. Crin. Suec., p. 1, Pl. 10, fig. 22. Upper Silur. Gothland, Sweden.

2. STELIDIOCRINUS Angelin.

(Amend. Wachsmuth and Springer.)

1878. Angelin. Iconogr. Crin. Suec., p. 21.
1879. Zittel. Handb. der Palæont., i, p. 345.
Syn. *Harmocrinus* Angelin. Iconogr. Crin. Suec., p. 22.

We are obliged to include Angelin's genus *Harmocrinus* in *Stelidiocrinus*. A few additional interradial or interaxillary plates do not alone warrant a generic or even subgeneric separation. According to Angelin and Zittel, *Stelidiocrinus* and *Harmocrinus*, with Hall's *Schizocrinus*, form a distinct family.

The genus now under consideration is in more than one respect an interesting form with reference to the Palæontologic history of the Crinoids. It is the only genus of the Actinocrinidæ which has five basal plates, none of them being anchylosed, and as this is one of their earliest representatives, there can be little doubt that the basals in this family, whether composed of a single piece or of three or four, were derived originally from five. The relations also between this genus and *Dimerocrinus* of the Rhodocrinidæ are so close, that it may be asked whether the presence of underbasals, which form the only distinction, should be considered of more than generic importance. It shows, at all events, the very close relations that exist between the two sub-families. There is also to be seen within the limits of this genus, a modification of the arms from interlocking single joints to a double series of plates.

Generic Diagnosis.—Body small. Calyx subturbinate or subovate, without surface ornamentation; radial plates prominently elevated above the interradial areas, but not producing sharp carinæ.

Basals five, equal, quadrangular, upper angles acute. Primary radials 3×5; the first large, wider than high, lunate, hexagonal; the second quadrangular, shorter and much narrower; the third pentagonal, almost as wide but not as high as the first. Secondary radials 2 to 4 $\times$ 10, wider than high, supporting in direct line a single rather stout arm or ten in all. It is possible that the number of secondary radials varies with age, and that there are four in the adult.

Arms composed either of a single row of cuneiform plates slightly interlocking, or of two rows of short plates alternately arranged.

Interradials four to eight; the first large, resting upon the sloping sides of the first radials and between the second and third of adjacent rays, the succeeding plates much smaller and connecting with the vault pieces. Posterior area wider; the first anal piece in line with the first interradials, the second and third ranges consisting of two instead of three pieces. Anus in form of a simple lateral opening similar to *Dorycrinus.*

Vault compressed, composed almost exclusively of the apical dome plates, which are unusually large. In *Stelidiocr. capitulum*, the vault is constructed of only twenty-three pieces, the smallest possible number of which a species with ten arms can be composed in accordance with the rule prevailing among these crinoids. It consists of the central piece, the six proximal plates, a single anal, and three radials to each ray. The two secondary radials of the dome are exceedingly small, while the proximal vault pieces occupy almost three-fourths of the entire summit.

Column round, articulating faces crenulated.

The genus resembles *Patelliocrinus*, but differs from it and all similar genera in the number of basal plates.

Geological Position, etc.—Restricted to the Upper Silurian of Europe.

We recognize the following species.—

1878. **Stelidiocrinus capitulum** Angelin. Type of the genus. Iconogr. Crin. Suec., p. 21, Pl. 17, figs. 5a-g. Upper Silur. Gothland, Sweden.

*1878. **Stelidiocr. longimanus** Angel. (**Harmocr. longimanus**). Iconogr. Crin. Suec., Pl. 21, figs. 6, 7. Upper Silur. Gothland, Sweden.

1878. **Stelidiocr. lævis** Angelin. Iconogr. Crin. Suec., p. 21, Pl. 15, figs. 20, 20a; also Pl. 27, figs, 3, 3a, (not Pl. 28, figs. 7, a, b). Upper Silur. Gothland, Sweden.

Angelin's figures are not so reliable as could be wished. Those of *S. lævis* on Pl. 15 have single jointed arms, while those on Pl. 27 have a double series of plates. It may be possible that the former are taken from a young specimen. The figures 7 a b, on Pl. 28 are evidently referred to this genus by oversight, as they are clearly of *Desmidocrinus macrodactylus.*

1878. (?) **Stelidiocr. ovalis** Angelin. Iconogr. Crin. Suec., p. 21, Pl. 19, fig. 6. Upper Silur. Gothland, Sweden.

This species differs from *Stelidiocrinus* in several important points and ought to be separated from it. To judge from the construction of the anal plates it should be removed to the Agaricocrinites, but it is possible, if the figure is correct, and the interradial plates, as there represented, extend to the basals in all five areae, that it possesses underbasals, and properly belongs to the Rhodocrinidæ. We refrain from proposing new generic names for these straggling forms, as we cannot altogether depend upon the figures, and we hope they will be taken up by investigators more familiar with these types, and who have access to the specimens.

3. PATELLIOCRINUS Angelin.

1878. Angelin. Iconogr. Crin. Suec., p. 1.
1879. Zittel. Handb. der Palæont, p. 368.

Several of these species referred by Angelin to this genus belong, in our opinion, to very distinct genera. His *Pat. duplicatus* has not only four arms to the ray, but as we judge from the shape and size of the basals, evidently had underbasals; also the first anal plate is in line with the first radials, while in all other species of *Patelliocrinus* those plates are ranged with the second radials. In *Pat. fulminatus* the calyx is but imperfectly preserved, but we judge from what is exposed, that this species was closely allied to another figured in Iconogr., Pl. 18, fig. 16, as *Melocr. Volborthi.*[1] Both species have branching arms, unlike *Patelliocrinus*, and are probably generically identical. We should propose for them a new genus, if we had more perfect figures for description.

Zittel made *Patelliocrinus* a synonym of *Dimerocrinus* Phill., which, however, has five basals instead of three, and underbasals. In his classification he arranges *Dimerocrinus* with *Dolatocrinus*, *Cytocrinus* with *Macrostylocrinus*, and all under the Patelliocrinidæ.

Patelliocrinus is one of those genera in which the arms as a rule are neither single- nor double-jointed, and sometimes scarcely interlocking at all, resembling herein *Eupachycrinus* and *Erisocrinus* of the Cyathocrinidæ.

Generic Diagnosis—General form oblong. Calyx patelliform; symmetry almost perfectly equilateral.

[1] We take it that *Melocr. Volborthi* is represented by Pl. 7, figs. 7 to 11, which is an entirely different thing from Pl. 18, fig. 16.

Basals three, unequal; two of them pentagonal, the third smaller by one-half, and quadrangular. Primary radials 3×5; the first ones forming laterally a continuous ring, larger than those succeeding, heptagonal, the lateral margins very long; the second quadrangular, wider than high; the third axillary of medium size, upper angle obtuse. Secondary radials 2×10, which directly support the arms, or sometimes the second plate is the bifurcating piece, and supports upon the inner and wider sloping side an arm; upon the smaller side an extraordinary large pinnule, which takes the direction of the arm, being more erect than the succeeding pinnules, and twice as heavy. The arms are large, heavy at the base, and towards the tips gradually tapering into a sharp point. The proximal arm plates are large, resembling secondary radials, and like them are decreasing in height upward; succeeding joints cuneate, gradually passing into two rows of interlocking pieces. In *P. pinnulatus* they pass scarcely beyond the earliest stage of interlocking arms; in *P. chiastodactylus* the arms remain single-jointed throughout, but the joints are strongly cuneiform. Pinnules long, rather strong, and composed of single joints.

Interradials three, the first very large, with a small one in the second, and a still smaller triangular one in the third series, the latter abutting against the large proximal arm-like pinnules. There are some species with five interradials, having two plates in the second, and two in the third range. Anal side not structurally distinct.

Vault unknown, anal aperture apparently lateral.

Column cylindrical.

This genus, in its general habitus, resembles *Agaricocrinus*, particularly its earlier and smaller species; but the two genera are very distinct in the construction of the anal area.

Geological Position, etc.—*Patelliocrinus*, so far as now known, is confined to the Upper Silurian of Europe.

We recognize the following species:—

1878. **Patelliocrinus chiastodactylus** Angelin. Icongr. Crin. Suec., p. 1, Pl. 19, fig. 12. Upper Silur. Gothland, Sweden.

1878. **Patelliocr. interradius** Angelin. Iconogr. Crin. Suec., p. 2, Pl. 22, fig. 10. Upper Silur. Gothland, Sweden.

1878. **Patelliocr. leptodactylus** Angelin. Iconogr. Crin. Suec., p. 2, Pl. 16, figs. 26, 31. Upper Silur. Gothland, Sweden.

1878. **Patelliocr. pachydactylus** Angelin (type of the genus). Iconogr. Crin. Suec., p. 1, Pl. 16, figs. 24, 25. Upper Silur. Gothland, Sweden.

1878. **Patelliocr. pinnulatus** Angelin. Iconogr. Crin. Suec., p. 2, Pl. 24, fig. 5 and Pl. 26, fig. 18. Upper Silur. Gothland, Sweden.

1878. **Patelliocr. plumulosus** Angelin. Iconogr. Crin. Suec., p. 2, Pl. 22, figs. 8, 9. Upper Silur. Gothland, Sweden.

1878. **Patelliocr. punctuosus** Angelin. Iconogr. Crin. Suec., p. 2, Pl. 23, fig. 26. Upper Silur. Gothland, Sweden.

The two following species, which were described by Angelin under this genus, cannot be brought with satisfaction under this or any other established generic form.

(?) 1878. **Patelliocr. duplicatus** Angelin. Iconogr. Crin. Suec., p. 1, Pl. 19, fig. 5. Upper Silur. Gothland, Sweden.

(?) **Patelliocr. fulminatus** Angelin. Iconogr. Crin. Suec., p. 2, Pl. 26, figs. 14, 14 a b. Upper Silur. Gothland, Sweden.

4. MACROSTYLOCRINUS Hall.

1852. Hall. Paleont., New York, vol. ii, p. 203.
1863. Hall. Trans. Albany Inst., p. 207.
1879. Hall. 28th Rep. New York St. Cab. Nat. Hist. (2d ed.), p. 129.
1879. Zittel. Handb. der Paleont., p. 368.

This genus has been frequently identified with *Ctenocrinus* Bronn,[1] and with *Cytocrinus* Roemer.[2]

It has been shown, however, by Schultze (Mon. Echin. Eifel Kalk. p. 62), that *Ctenocrinus* has four, and not three or five basal plates as supposed by previous authors,[3] and we can state positively, that we have also found four instead of three in *Cytocrinus lævis* Roemer. This discovery leaves no doubt that the two genera are identical with each other, as well as with *Melocrinus* Goldfuss, but distinct from *Macrostylocrinus.*

In the construction of the calyx, *Macrostylocrinus* resembles the preceding genus, the two varying only in the proportionate size of the different plates; but this gives them a totally different appearance.

In its general habitus *Macrostylocrinus* approaches the *Periechocrinites*, while *Patelliocrinus* is a step in the direction of the *Agaricocrinites.* We are sure that the vault of *Macrostylocrinus* when found, will prove to be constructed of a great number of minute pieces, while we shall expect in *Patelliocrinus* a summit

[1] Bronn's Jahrbuch, 1840, p. 252.
[2] Silur. Fauna, West Tenn., p. 46.
[3] Compare our notes on *Melocrinus.*

more like that of *Stelidiocrinus*, which is composed of but few and large plates.

Zittel places *Macrostylocrinus* with *Dimerocrinus*, *Dolatocrinus* and *Cytocrinus* under the Dimerocrinidæ.

Generic Diagnosis.—Calyx subglobose to urn-shaped, as high or higher than wide; surface granulose-striate, or only granulose: the five sides almost perfectly equilateral.

Basals three, comparatively large, forming a more or less shallow cup, two of them equal and pentagonal, the third smaller by half and quadrangular. Primary radials 3 × 5; the first series large; the second hexagonal, less than half, sometimes scarcely one-third the size of the first, wider than high; the third pentagonal, smaller than the second, supporting one or more secondary radials in a direct line, which support the arms. Arms only known in *M. ornatus*, where they are long, simple, composed at the base of a single row of alternately arranged wedge-form pieces, which, from the sixth or seventh plate up, interlock with each other, and gradually pass into a double series.

Interradial area more or less depressed, deeper between the arm-bases, in consequence of which the radial portions of the calyx, and especially the secondary radials, are somewhat lobed, which is characteristic of this genus, and which distinguishes it readily from the related form *Patelliocrinus*. First interradial large, hexagonal, supporting two small plates in the second series. Anal area slightly wider, and with three plates in place of two in the second range.

Geological Position, etc.—*Macrostylocrinus* is confined to the Niagara group of America.

The following species are known:

?1864. **Macrostylocrinus Meeki** Lyon. (**Actinocr. Meeki**). Proc. Acad. Nat. Sci. Phila., p. 411, Pl. 4, figs. 4 a b. Niagara gr. Jefferson Co., Ky.

Syn. **Cyathocr. fasciatus** Hall. 28th Rep. New York St. Cab. Nat. Hist. (1st ed.), Pl. 13, figs. 5 and 6; Wachsm. and Spr. Revision i, p. 85. Waldron, Ind.

Syn. **Macrostylocrinus fasciatus** Hall. Ib. (2d edit.), p. 130.

1852. **Macrostylocr. ornatus** Hall (Type of the genus). Paleont., New York, ii, p. 204, Pl. 46, figs. 4 a–g. Niagara gr. Lockport, N. Y.

1863. **Macrostylocr. striatus** Hall. Trans. Albany Inst., iv, p. 207; also 20th Rep. New York St. Cab. Nat. Hist., 1867, p. 327, Pl. 10, fig. 7. Niagara gr. Waldron, Ind., and Racine, Wis.

Subgenus **CENTROCRINUS** Wachsm. and Spr.

This genus should not be confounded with *Centrocrinus* Austin,[1] which in 1843, was proposed to distinguish a certain form of *Platycrinus*, but based altogether upon conjecture and incorrect observation.

The generic form now suggested embraces at present only two species, Lyon's *Actinocrinus pentaspinus* and his *A. multicornus*, of which we propose the former as the type. The two differ from *Actinocrinus* essentially in the construction of the anal area, having no plate in line with the first radials. The nearest allied genus, and under which we place it subgenerically, is *Macrostylocrinus*, but this has three anal plates in the second series, in place of two, while in *Centrocrinus* the posterior side is not in any way distinct from the other four. The spiniferous form of some of the body plates has suggested the name.

Generic Diagnosis.—Calyx subcylindrical; symmetry perfectly pentahedral; the principal plates produced into spines; the calyx in its lower portions almost resembling *Platycrinus*, owing to the form and size of basals and first radials.

Basal disk large, pentagonal, composed of three unequal pieces, two of them pentangular, and twice the size of the third, which is quadrangular.

Primary radials 3×5; the first very large and spiniferous; second radials much smaller than the first, short and quadrangular or nearly so; third radials pentangular, sometimes triangular, as short as—and occasionally narrower—than the second. Secondary radials 1×10, bent abruptly outward and supporting the arms. There are, so far as known, two arms to each ray.

Interradials four to five; the first large and frequently spiniferous, deeply inserted between the first radials, in which the upper lateral margins are exceptionally long; second series composed of two plates, much smaller than the first; third series consisting of one or two plates, located between the arm bases. Anal area not distinct. Construction of vault and arms unknown.

Column round, central canal round.

Geological Position, etc.—Only known from the Devonian of America.

[1] Mon. Rec. and Foss. Crin., p. 6, proposed for species of *Platycrinus* "with central valvate unobtrusive mouths, or mouths capable of being withdrawn into the visceral cup."

*1860. Centrocr. multicornus Lyon (Actinocr. multicornus). Trans. Amer. Philos. Soc., vol. 13, p. 455, Pl. 27, fig. c; also Hall, Paleont. N. Y., vol. v, Pt. ii, p. 6, (advance sheets 1878). Nucleocrinus bed. Falls of the Ohio.

*1860. Centrocr. pentaspinus Lyon (Actinocr. pentaspinus). Type of the subgenus. Trans. Amer. Philos. Soc., vol. 13, p. 453, Pl. 27, figs. d, d 1; also Hall, Paleont. N. Y., vol. v, Pt. ii, p. 6, (advance sheet). Nucleocrinus bed. Falls of the Ohio.

b. Agaricocrinites.

5. CARPOCRINUS Müller.

(Amend. Wachsm. and Spr.)

1841. Müller. Monatsb. Berl. Akad. Wissensch., i, p. 208.
1855. Müller. Verhandl. naturh. Verein, xii, p. 19.
1855. F. Roemer. Lethæa Geogn. (Ausg. 3), p. 237.
1857. Pictét. Traité de Paléont., iv, p. 328.
1879. Zittel. Handb. d. Palæont, i, p. 19.

Syn. *Phoenicocrinus* Aust. 1843, Ann. and Mag. Nat. Hist., xi, p. 205.
Syn. *Abracrinus* D'Orb. 1850, Prodr. de Paléont., i, p. 47. (Not Ibid. p. 156); also Course élém. de Paléont., ii, p. 144.
Syn. *Habrocrinus* Angelin, 1878, Iconog. Crin. Suec., p. 3.
Syn. *Pionocrinus* Angelin. Ibid., p. 4.

Angelin and the two Austins, in proposing their genera *Pionocrinus* and *Phoenicocrinus*, were evidently not acquainted with the genus *Carpocrinus*, which had previously been described by Müller. Under *Carpocrinus*, Müller placed *Actinocrinus simplex* and *A. expansus* Phill., but as the two species represent different generic forms, as a rule, the first becomes the type of the genus, and *C. simplex* has been recognized as such in 1855 by Roemer. Neither can we accept, not even subgenerically, *Habrocrinus* (*Abracrinus*) D'Orbigny, which differs from *Pionocrinus* solely in having a few more interradial plates. Closely allied is also *Desmidocrinus* Angelin, which, however, has an additional arm to each ray, with slight deviations in the arm-structure. Whether this is sufficient for a separation from *Carpocrinus*, we do not wish to decide, but it should clearly be no more than subgeneric.

Pictet places *Carpocrinus* with *Forbesiocrinus*, *Taxocrinus*. *Graphiocrinus*, *Lyriocrinus* and *Scyphocrinus* under the *Carpocriniens;* while D'Orbigny and Roemer connect it with the Cyathocrinidæ. Austin combines *Phoenicocrinus* with *Dimerocrinus* and *Tetramerocrinus* under his Merocrinidæ.

Zittel unites *Habrocrinus*, *Carpocrinus*, *Desmidocrinus* and *Leptocrinus* under Carpocrinidæ.

The pinnules in this genus are exceedingly interesting. In some of the species (compare Angelin's figures), we find toward the interradial side the proximal pinnule much larger. It is given off from a second secondary radial, which is converted into a regular bifurcating plate; it stands more erect than the other pinnules, its lower portions embraced within the body walls, its upper and free parts following the direction of the arms. The construction is such that we cannot doubt these large pinnules form a link between arms and pinnules, which finally in *Desmidocrinus* became transformed into regular arms.

Generic Diagnosis.—General form oblong; calyx short, cyathiform; symmetry bilateral

Basals three, short; two of them equal, the third smaller by one-half. Primary radials 3×5; the first larger than the other two; the second short, quadrangular or hexagonal; the third axillary giving off two, rarely 3×10 secondary radials. The latter are rounded at the dorsal side, in form almost resembling arm-joints, but larger, especially higher. The secondary radials support directly the arms, of which there are ten to the entire individual, and these remain simple throughout.

The arms are long, heavy, cylindrical, tapering at their tips, and are composed of short single joints, with parallel sutures. Pinnules long, thread-like, composed of a great number of joints.

Interradials from two to three in two series; the first plate large, the upper series generally very small and indistinct. Some of the larger species have a third series with their plates decreasing in size upward.

Anal area considerably wider, and composed of many more plates. The first anal plate in line with the first radials, and fully as large and even larger. There are three plates in the second series, somewhat smaller than those of the first, and generally three in each succeeding series, all arranged in longitudinal rows.

Interaxillary plates from none in the very small species, to one or three in larger ones.

Vault only partly known. In *Carpocrinus ornatus* (Iconogr. Crin., Pl. 27, fig. 5) it seems to have been composed of a large number of plates, among which the apical dome plates are easily distinguished by their larger size: radial portions covered by two rows of low transversed pieces; interpalmar fields paved by somewhat larger and elongate plates.

Column cylindrical, strong.

Carpocrinus differs from all preceding genera in having a spherical anal plate in line with the first radials, and from *Agaricocrinus* in having single arm joints.

Geological Position, etc.—From the Upper Silurian of England and Sweden.

We place here the following species:

*1878. **Carpocrinus affinis** Angelin (**Pionocr. affinis.**) Iconogr. Crin. Suec., p. 5, Pl. 22, fig. 7. Upper Silur. Gothland, Sweden.

*1878. **Carpocr. annulatus** Angel. (**Habrocr. annulatus.**) Iconogr. Crin. Suec., p. 4, Pl. 22, fig. 15. Upper Silur. Gothland, Sweden.

*1878. **Carpocr. cariosolus** Angel. (**Habrocr. cariosolus.**) Iconogr. Crin. Suec., p. 3, Pl. 3, figs. 7, 7 a. Upper Silur. Gothland, Sweden.

*1878. **Carpocr. comptus** Angel. (**Habrocr. comptus.**) Iconogr. Crin. Suec., p. 4, Pl. 22, fig. 13. Upper Silur. Gothland, Sweden.

*1878. **Carpocr. decadactylus** Angel. (**Habrocr. decadactylus.**) Iconogr. Crin. Suec., p. 4, Pl. 15, figs. 18, 19. Upper Silur. Gothland, Sweden.

*1878. **Carpocr. elongatulus** Angel. (**Pionocr. elongatulus.**) Iconogr. Crin. Suec., p. 5, Pl. 22, figs. 16, 17. Upper Silur. Gothland, Sweden.

*1878. **Carpocr. farctus** Angel. (**Pionocr. farctus.**) Iconogr. Crin. Suec., p. 5, Pl. 16, fig. 23, and Pl. 22, figs. 5, 6. Upper Silur. Gothland, Sweden.

*1878. **Carpocr. grandis** Angel. (**Habrocr. grandis.**) Iconogr. Crin. Suec., p. 4, Pl. 26, fig. 10. Upper Silur. Gothland, Sweden.

*1878. **Carpocr. granulatus** Angel. (**Habrocr. granulatus.**) Iconogr. Crin. Suec., p. 4, Pl. 19, figs. 13, 13 a. Upper Silur. Gothland, Sweden.

*1878. **Carpocr. lævis** Angel. (**Habrocr. lævis**) Iconogr. Crin. Suec., p. 4, Pl. 19, figs. 21, a, b. Upper Silur. Gothland, Sweden.

*1878. **Carpocr. longimanus** Angel. (**Harbrocr. longimanus.**) Iconogr. Crin. Suec., p. 4, Pl. 22, figs. 11, 12. Upper Silur. Gothland, Sweden.

*1878. **Carpocr. ornatissimus** Angelin. (**Habrocr. ornatissimus.**) Iconogr. Crin. Suec., p. 4, Pl. 6, fig. 9. Upper Silur. Gothland, Sweden.

*1878. **Carpocr. ornatus** Angel. (**Habrocr. ornatus.**) Iconogr. Crin. Suec., p. 4, Pl. 21, figs. 19, 20 and Pl. 26, figs. 11, 12 and Pl. 27, fig. 5. Upper Silur. Gothland, Sweden.

Figs. 12 a, b, on Pl. 26, represent the convoluted digestive organ of this species. Its lateral sides are enclosed by a delicate intervisceral network of pentangular outline. A similar plexus has been observed in Subcarboniferous genera, but always parallel with the walls of the body.

*1879. **Carpocr. pinnulatus** Angel. (**Habrocr. pinnulatus.**) Iconogr. Crin. Suec., p. 4, Pl. 22, fig. 14. Upper Silur. Gothland, Sweden.

This species differs from the typical form by having in two rays an additional arm.

*1878. **Carpocr. pulchellus** Angel. (**Pionocr. pulchellus.**) Iconogr. Crin. Suec., p. 5, pl. 3, figs. 9, 9 a. Upper Silur. Gothland, Sweden.

*1878. **Carpocr. robustus** Angel. (**Habrocr. robustus.**) Iconogr. Crin. Suec., p. 4, pl. 22, fig. 19. Upper Silurian. Gothland, Sweden.

1839. **Carpocr. simplex** Phill. (**Actinocr, simplex.**) Apud Murchison, Silur. Syst., p. 673, Pl. 18, fig. 8; Austin, 1843, **Phoenicocrinites simplex,** Ann. and Mag. Nat. Hist., xi, p. 205; D'Orbigny, 1850, **Abracrinus simplex,** Prodr. Paleont., i, p. 47; Roemer, 1855. **Carpocrinus simplex,** Lethæa Geogn., (Ausg. 3), p. 237; Salter, 1870, **Taxocr. simplex,** Cat. Geol. Mus. Cambr., p. 125; Angelin, 1878, **Pionocr. simplex,** Iconogr. Crin. Suec., p. 5, pl. 15, 15 a. Dudley, England and Gothland, Sweden.

Syn. (?) **Actinocr. tesseracontadactylus,** Hisinger, 1837, (not Goldf.), Lethæa Succia, p. 90, Pl. 35, figs. 4, a-b; D'Orbigny, 1850. **Ichthyocr. tesseracontadactylus,** Prodr. Paléont. i, p. 46; Salter, 1847, **Cyathocr. tesseracontadactylus,** Murchison's Siluria, (ed. iv), Pl. 14, fig. 4. (We follow Angelin in placing this species a synonym under **Carpocrinus simplex.**)

*1878. **Carpocr. tenuis** Angel. (**Habrocr. tenuis.**) Iconogr. Crin. Succ., p. 4, Pl. 26, figs, 9, 9 a. Upper Silur. Gothland, Sweden.

*1878. **Carpocr. umbonatus** Angel. (**Habrocr. umbonatus.**) Iconogr. Crin. Suec., p. 4, Pl. 26, figs 13, 13 a. Upper Silur. Gothland, Sweden.

Subgenus **DESMIDOCRINUS** Angelin.

1878. Angelin. Iconogr. Crin. Suec., p. 5.

General form oblong to subovoid. Calyx short, saucer- or cup-shaped; symmetry bilateral.

Basals three, small, scarcely projecting laterally. Radials 3×5; the first large, polygonal; the second short, linear; the third transverse, pentagonal. Secondary radials 2×10, one side of each ray bifurcating again giving off two arms, the other a single one.

In *D. pentadactylus* both halves branch again, thus making three arms to one half, and two arms to the other half division, or five arms to the ray, and twenty-five to the individual.

Arms long, heavy, cylindrical, composed of very short joints, which sometimes become wedge-form and almost interlocking. Pinnules very long, largely articulated.

Interradial and anal plates not differing from *Carpocrinus.*

Column strong, round, composed of alternate large and smaller joints; central perforation pentagonal.

The subgenus *Desmidocrinus* differs from the typical form in the greater number of arms, and that these are given off unequally from the ray, also in having somewhat longer arms with shorter joints.

Geological Position, etc.—Only found in the Upper Silurian of Europe. Angelin refers to it the following species:

1878. **Desmidocrinus heterodactylus** Angel. Iconogr. Crin Suec., p. 5. Pl. 16, 16 a, Upper Silur. Gothland, Sweden.

1878. **Desmidocr. macrodactylus** Angel. Iconogr. Crin. Suec., p. 5, Pl. 16, figs. 20, 21. Upper Silur. Gothland, Sweden.

1878. **Desmidocr. pentadactylus** Angel. Iconogr. Crin. Suec., p. 5, Pl. 16, figs. 15, 22. Upper Silur. Gothland, Sweden.

1878. **Desmidocr. tridactylus** Angel. Iconogr. Crin. Suec., p. 5, Pl. 16, figs. 4, 4 a. Gothland, Sweden. (Probably identical with *D. macrodactylus.*)

6. AGARICOCRINUS Troost.

1850. Troost. List. Crin. Tenn. (Proc. Amer. Association).
1858. Hall (Subgenus of *Actinocr.*). Geol. Rep. Iowa, i, Pt. ii, p. 560.
1866. Shumard (Subg. of *Actinocr.*). Cat. Pal. Foss., Pt. i, p. 350.
1873. Meek and Worthen. Geol. Rep. Ill., v, p 397.
1878. Wachsm. and Spr. Proc. Acad. Nat. Sci. Phila., p. 350.

Syn. *Amphoracrinus* Roemer (not Austin), 1855. Leth. Geogn. (Ausg. 3), p. 250.

Syn. *Amphoracrinus* Hall (not Austin), 1861. Bost. Jour. Nat. Hist., p. 280.

Syn. *Actinocrinus* Hall (in part), 1858. Geol. Rep. Iowa. i, Pt. ii.

Some authors have confounded *Agaricocrinus* with *Amphoracrinus* Austin, with which it agrees in the depressed form of the calyx and in the elevated dome, but while in *Agaricocrinus* the calyx or its equivalent extends to the secondary radials, that of *Amphoracrinus* is properly composed of few plates, all the upper radials, from the third primary up, being parts of free rays. *Amphoracrinus* differs also in the form of the dome, in the spiniferous proximal vault pieces, in having an anal tube, in the surface ornamentation, and in the arms.

Hall, who first defined Troost's genus *Agaricocrinus*, placed it subgenerically under *Actinocrinus*, and referred to it exclusively species with a broadly truncate or concave dorsal side, leaving all similar types with a convex calyx under *Actinocrinus*. This cannot be sustained, as we find among the species of this group all intermediate gradations in this feature, while at the same time they agree most remarkably in all other important characters. The structure of *Agaricocrinus* is so marked that we do not hesitate to rank it as a distinct genus. The differences in the form of the calyx are modifications in geological succession. Species with convex sides are confined to the Waverly group and to the Burlington limestone; species from the Upper Burlington are truncate below, or slightly convex, rarely concave; while the Keokuk species, without exception, are deeply concave in the basal regions.

We place under *Agaricocrinus*, subgenerically, *Alloprosallo-*

crinus Lyon and Casseday, which agrees with the latter in all essential points, but differs in having an anal tube in place of an opening directly through the vault.

Generic Diagnosis.—General form of the body pyramidal, wider than high; symmetry decidedly bilateral; plates without surface ornamentation. The form of the apical side varies from a shallow basin to an inverted cup, and hence from convex to deeply concave; the concavity sometimes involving the third primary and even partly the secondary radials. Dome surpassing the calyx in height, composed of large nodose or tuberculous plates, which are surrounded by smaller scarcely convex pieces.

Basal disk in form of a hexagon with nearly straight sides, composed of three equal plates, very small, frequently hidden from view by the column, spread out horizontally, and forming a small concavity. Primary radials 3×5; the first comparatively small, hexagonal, the upper lateral sides shorter than the other sides; second radials quadrangular or nearly so, smaller than the first, transversely arranged; third pentagonal, wider than high, larger than either of the others. The latter support upon each of their upper sloping faces a wide but short secondary radial, which is succeeded by still shorter plates which gradually interlock and become regular arm plates. All plates above the third radials project at nearly right angles to the vertical axis, their faces directed laterally. This gives to the apical side, when viewed from the column, a pentalobate outline, and the latter plates appear as parts of the free rays. The plates, however, are wedge-shaped, knife-like toward the inner side, and the ambulacral passages within the body communicate directly with the arm furrows. In species with tertiary radials, and consequently a larger number of arms, the last bifurcation takes place upon the first secondary radials, but generally only upon one side and in the posterior rays. There seems to be one or two undescribed species in which the postero-lateral rays have normally four arms. We have in our possession a specimen from Canton, Ind., in which also the antero-lateral rays have an additional arm.

Arms robust, long, simple, gradually tapering and terminating in a sharp point. They are constructed of two rows of pieces, which are alternately arranged, very wide, exceedingly short and linear. Arm furrows wide but shallow; pinnules slender, thread-like, composed of cylindrical joints covering the arm furrows like a roof.

Interradials three, elongate; the first generally the largest plate of the calyx, much narrower than wide, frequently extending in length to the secondary radials. The two plates in the second series are often as long as the first, but rarely of more than half the width, and hence exceedingly narrow; they rest mainly on the outer edges of the secondary radials, and curving upward rise to the level of the top of the arm bases.

First anal plate higher than the first radials, sustaining upon its upper truncate edge a large plate, and on its lateral oblique sides partially supporting two plates which extend upwards, adjoining the secondary radials; these in turn are followed by a large number of small plates, which are more properly ranked as vault pieces.

Dome high, more or less pyramidal, somewhat inflated toward the posterior side. Apical dome plates very large and prominent, and with rare exceptions tuberculiform. The central piece is the largest plate of the entire body; the six proximal plates somewhat smaller, frequently separated from the central piece by a circlet of small irregular plates, and in old specimens and very large species, occasionally isolated laterally. First radial dome plates very large, the two of the second order small. In rays with three arms, one plate of the latter is large and succeeded by two small ones in a third range. Posterior side of the dome composed of small plates, protruding in a rounded ridge with a depression on either side; anal aperture at the upper part of the vault, directed laterally.

Column round, consisting of joints with rounded margins and intermediate thinner joints.

Geological Position, etc.—*Agaricocrinus* is a strictly Subcarboniferous genus, and is only found in America. It first appears in the Waverly group, attains its maximum in the Upper Burlington, and becomes extinct at the end of the Keokuk period, where it attains enormous dimensions.

We arrange under it the following species:—

1855. **Agaricocrinus americanus** Roemer (**Amphoracr. americanus**). Lethaea. Geogn. (Ausg. 3), p. 250, Pl. 4[1], figs. 15, a, b; Shumard, 1866, **Agaricocr. americanus**, Cat. Pal. Foss. N. Amer., pt. i, p. 351; Wachsm. and Spr., 1878, Proc. Acad. Nat. Sci. Phila., p. 239.

This species is very variable, and has a great vertical range, as well as a wide geographical distribution, being found from the upper portion of the Upper Burlington to the middle part of the Keokuk limestone, and it occurs in rocks of that age in Iowa, Indiana, Illinois, Missouri, Kentucky and Tennessee.

Syn. **Agaricocr. tuberosus** Troost, 1850 (catalogue name); Hall, 1858, Geol. Rep. Iowa, i, pt. ii, p. 617.

Syn. **Agaricocr. bullatus** Hall. 1858, Geol. Rep. Iowa, i, pt. ii, p. 562, Pl. 9, figs. 11, a, b, c.

Syn. **Agaricocr. (Amphoracr.) excavatus** Hall. Desc. New Spec. Crin., p. 3; also Bost. Journ. Nat. Hist., p. 282.

Syn. **Agaricocr. nodosus** Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 167; also Geol. Rep. Illinois, vol. v, p. 387, Pl. 10, fig. 7.

*1858. **Agaricocr. brevis** Hall (**Actinocr. brevis**). Geol. Rep. Iowa, i, pt. ii, p. 567, Pl. 10, figs. 3, a, b. Lower Burlington limest. Burlington, Iowa.

Syn. **Actinocr. corniculus** Hall. Geol. Rep. Iowa, i, pt. ii, p. 566, Pl. 10, figs. 1, a, b, c.

*1860. **Agaricocr. convexus** Hall (**Agaricocr. pentagonus** (var.) **convexus**). Supp. Geol. Rep. Iowa, p. 58. Upper Burlington limest. Burlington, Iowa.

This form differs from **A. pentagonus** considerably, and proves to be a good species.

*1864. **Agaricocr. eris** Hall (**Actinocr. eris**). 17th Rep. N. York St. Cab. Nat. Hist., p. 53; also Geol. Rep. Ohio Paleont., ii, p. 164, Pl. 11, figs. 9, 10. Waverly gr. Richfield, Ohio. A variety of **Agaricocr. helice**.

*1861. **Agaricocr. fiscellus** Hall. (**Actinocr. fiscellus**). Desc. New Pal. Crin., p. 2; also Bost. Journ. Nat. Hist., p. 272. Lower Burlington limest. Burlington, Iowa.

Possibly a mere variety of **A. brevis**, having an additional arm in the postero-lateral rays.

1860. **Agaricocr. geometricus** Hall. Suppl. Geol. Rep. Iowa, p. 56. Upper Burlington limest. Quincy, Ill.

1861. **Agaricocr. gracilis** Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 135. Upper Burlington limest. Burlington, Iowa.

*1864. **Agaricocr. helice** Hall (**Actinocr. helice**). 17th Rep. N. York St. Cab. Nat. Hist., p. 53; also Geol. Rep. Ohio, Paleont., ii, p. 163, Pl. 11, figs. 5–8. Waverly gr. Richfield, Ohio.

1861. **Agaricocr. inflatus** Hall (**Agaricocr.—Amphoracr.—inflatus**, not **Amphoracr. inflatus** Hall). Descr. New Pal. Crin., p. 4; also Bost. Journ. Nat Hist., p. 284. Upper Burlington limest. Burlington, Iowa.

1861. **Agaricocr. ornotrema** Hall (**Agaricocr.—Amphoracr.—ornotrema**). Desc. New Spec. Crin., p. 3. Upper Burlington limest. Burlington, Iowa.

Syn. **Agaricocr.—Amphoracr.—bellatrema** Hall. Bost. Journ. Nat. Hist., 1861, p. 281.

1860. **Agaricocr. pentagonus** Hall. Supp. Geol. Rep. Iowa, p. 57. Upper Burlington limest. Burlington, Iowa.

1861. **Agaricocr. planoconvexus** Hall (**Agaricocr.—Amphoracr.—planoconvexus**). Desc. New Spec. Pal. Crin., p. 3; also Bost. Journ. Nat. Hist., p. 280. Lower Burlington limest. Burlington, Iowa.

*1858. **Agaricocr. pyramidatus** Hall (**Actinocr. pyramidatus**). Geol. Rep. Iowa, i, pt. ii, p. 565. Lower Burlington limest. Burlington, Iowa.

Syn. **Agaricocr. (Amphoracr.) corrugatus** Hall. 1861, Desc. New Spec. Pal. Crin., p. 4; also Bost. Journ. Nat. Hist., p. 283. (Hall described here a more mature specimen).

1881. **Agaricocr. Springeri** White. Indiana Rep. for 1881 (now in press). Keokuk limestone. Crawfordsville, Ind.

1858. **Agaricocr. stellatus** Hall. Geol. Rep. Iowa, i, pt. ii, p. 564. Upper Burlington limest.—Burlington, Iowa.

1850. **Agaricocr. Whitfieldi** Troost. List. Crin. Tenn.; Hall, 1858, Geol. Rep. Iowa, i, pt. ii, p. 621; Supp. Iowa, Rep. 1860, Pl. 3, fig. 5; Meek and Worthen, Geol. Rep. Ill., vol. v, p. 499, Pl. 12, fig. 1, and Pl. 15, fig. 8. Keokuk limest. Green Co., Ill.

1858. **Agaricocr. Wortheni** Hall. Geol. Rep. Iowa, i, pt. ii, p. 619, Pl. 14, fig. 1; Wachsm. and Spr., 1878, Proc. Acad. Nat. Sci. Phila., p. 240. Upper portions of Keokuk limest. Iowa, Illinois and Missouri.

Subgenus **ALLOPROSALLOCRINUS** Lyon and Cass.

1860. Lyon and Casseday. Am. Acad. Arts and Sci., vol. v, p. 29.
1866. Shumard. Cat. Pal. Foss. N. Amer., pt. i. p. 353.
1873. Meek and Worth. (in part). Geol. Rep. Ill., vol. v, p. 368.
1879. Zittel. Handbuch der Palæontologie, i, p. 370. (Not Meek and Worth., 1865, Proc. Acad. Nat. Sci. Phila., p. 164).

Syn. *Conocrinus* Troost, 1850. List of Crin. Tenn. (not defined).

Lyon and Casseday in defining the genus *Alloprosallocrinus* placed under it two species: their type *A. conicus* and *A. depressus*. the latter probably an *Agaricocrinus*. With this genus *Alloprosallocrinus* has close affinities; it differs, however. in having an almost central anal tube and not a lateral opening through the vault. The tube which extends from an elevated tuberculous dome. gives to *A. conicus* a superficial resemblance to some of the later forms of *Batocrinus*, and this induced Meek and Worthen to place Lyon's genus a mere subgenus under the other.

Meek and Worthen added a new species, but we doubt from their description of *A. euconus*, if they correctly identified Lyon's typical form, or they would have found the two species to be, superficially at least, very distinct. The form of the plates in the calyx, and particularly of those near the arm regions, is in Meek and Worthen's species like in *Batocrinus*, but in *A. conicus* almost identical with *Agaricocrinus*. We refer the former to *Batocrinus*, and place *Alloprosallocrinus* subgenerically under *Agaricocrinus*. Lyon and Casseday describe the primary radials as being composed of only 2 × 5 pieces. This is sometimes abnormally the case, but there are always as a rule three plates in each ray, of which the second are exceedingly short, linear and easily overlooked.

Amended Diagnosis.—General form turbinate; calyx truncate. slightly convex. Basals and primary radials like those of *Agaricocrinus*., with 2 × 10 narrow secondary radials succeeding them; the interradial and anal plates also similar in their form and arrangement; but the first interradial and the second series of anal plates extend to the top of the tertiary radials, and support directly the vault pieces.

Dome elevated, conical, extended into a large, almost central anal tube; vault pieces more or less nodose, the apical plates somewhat larger, but not so distinct as in *Agaricocrinus*, and pushed more towards the anterior side. Length of anal tube unknown.

Arms large, simple so far as known; two arms from each ray, with sometimes three on one or both posterior rays.

Geological Position, etc.—The only known species occurs in the Warsaw limestone.

1860. **Alloprosallocrinus conicus** Lyon and Cass. (type). Proc. Am. Acad. Arts and Sci., vol. v, p. 29. Shumard, 1866, **Alloprosallocr.** (subg. of **Actinocr.**) **conicus**, Cat. Pal. Foss., pt. 1, p. 352. Warsaw limest. Hardin and Allen Cos., Ky.

c. Melocrinites.

7. MARIACRINUS Hall.

(Revised by Wachsm. and Spr.)

1859. Hall. Paleont. New York, vol. iii, p. 104.

Mariacrinus in its original form, with *M. nobilissimus*, *M. paucidactylus* and *M. pachidactylus* Hall as types, were shown by Schultze, Mon. Echin. Eifel. Kalk., p. 61, to be identical with *Melocrinus* Goldfuss. This is undoubtedly correct with regard to those species, but Hall described two other species, *M. plumosus* and *M. ramosus*, which in their arm-structure differ so essentially from the former, that we think it proper to separate them and reconstruct the genus *Mariacrinus* with *M. plumosus* as the type. To these two species we add *Melocrinus angustatus* Angl., and *Glyptocrinus Carleyi* Hall, which latter we find to have four basal plates instead of five, and no underbasals.

The genus *Mariacrinus*, as we propose to define it, includes only species in which the two main divisions of the ray are longitudinally separated, forming two free and equal parts, contrary to *Melocrinus*, in which the main branches are laterally connected. Hall already noticed this peculiarity in the arm-structure of *Melocrinus plumosus*, and he very correctly homologized the two inner divisions of the ray, which give off exclusively the branches, with the double-jointed brachial extensions in the ray of *M. pachydactylus*, and the outer arms of the former with the branchlets of the latter.

Zittel takes *Mariacrinus* Hall to be a synonym of *Ctenocrinus* Bronn, which we refer to *Melocrinus*, following Schultze. Hall's *M. macropetalus* will be arranged under *Corymbocrinus* Angelin, and among the Calyptocrinidæ. Its arms are yet unknown, but the arrangement of its plates agrees perfectly with that genus. *Mariacrinus stoloniferus* Hall is described only from fragmentary columns.

Amended Diagnosis.—Form of calyx obconical; general aspect and surface ornamentation similar to *Glyptocrinus;* radiating striæ passing from plate to plate; radials all along their median line elevated into high rounded ridges, somewhat resembling recumbent arms; interradial and interaxillary areæ large and depressed.

Basals four, small, almost of equal size, the one facing the anal area largest. Primary radials 3×5, nearly as wide as high, decreasing in size upwards; the first set joining laterally; the second enclosing the first anal and first interradial plates; the third supporting 3×10 secondary radials, which are generally of uniform size and vertically separated by six or more interaxillary plates. The secondary radials are followed by several tertiary radials, which vary in number with the age of the individual—mature specimens having five and even more—all placed in a direct line with the arms and somewhat resembling arm plates.

Arms four to each ray, the inner ones branching, but rarely more than once or twice, the outer arms remaining simple throughout, and taking a somewhat lateral course. The inner arms are placed close together, almost parallel with each other, their branches given off to the outer sides of the ray. Both inner and outer arms are composed of quadrangular single joints, with straight, sometimes slightly oblique sutures: the arm-bearing joints subpentagonal; main arms and branches fringed with pinnules.

Interradial areæ large, composed of a great number of plates; the first wedged in between the upper sloping sides of two first radials and two second radials; second interradial series consisting of two plates; each succeeding series of two or three.

Anal area wider; the first plate in line with the first interradials, perhaps a little larger, succeeded by three plates in the second, and a like number in all superior series.

Vault only known in *M. Carleyi*, where it is low, scarcely rising beyond the horizon of the calyx.

Interradial regions depressed and excavated between the rays, thereby giving to the form a pentalobate outline.

Radial portions prominent, toward the margin of each arm distinctly elevated and formed into a rounded ridge.

Arm openings arranged along the margin of the vault, directed upwards. The vault is composed of very minute, irregular pieces without definite arrangement, even the apical dome plates are obscure.

Anal aperture excentric, opening directly through the vault.

Form of column unknown; central canal subpentagonal and of more than medium size.

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

We recognize the following species:—

*1878. **Mariacrinus angustatus** Angelin. (**Melocr. angustatus.**) Iconogr. Crin. Suec., p. 20, Pl. 26, fig. 22. Upper Silur. Gothland, Sweden.

*1863. **Mariacr. Carleyi** Hall. (**Glyptocr. Carleyi.**) Trans. Albany Inst., iv, p. 203; also 28th Rep. N. Y. St. Cab. Nat. Hist., 1875, Pl. 14, figs. 7–10. Niagara gr. Waldron, Ind.

*1863. **Mariacr. obconicus** Hall. (**Melocr. obconicus.**) Trans. Albany Inst., p. 206; also 28th Rep. N. York St. Cab. Nat. Hist., 1875, Pl. 14, figs. 11–14. Niagara gr. Waldron, Ind.

1859. **Mariacr. plumosus** Hall. (Type of the genus.) Paleont. N. York, iii, p. 110 Pl. 3, figs. 6-11. Lower Helderberg gr. Herkimer Co., N. Y.

1859. **Mariacr. ramosus** Hall. Paleont. N. York, iii, p. 147, Pl. 2, figs. 2, 3. Lower Helderberg gr. Herkimer Co., N. Y.

8. TECHNOCRINUS Hall.

1859. Hall. Paleont. New York, iii, p. 139.
1879. Zittel. Handb. der. Palæontologie, i, p. 372.

According to Hall, *Technocrinus* differs from *Mariacrinus* only in the arm structure, he therefore at first arranged it subgenerically under that genus. A careful comparison of *Technocrinus*, not only with that section of Hall's *Mariacrinus* which we have referred to *Melocrinus*, but also with *Mariacrinus plumosus* the present type, has convinced us that *Technocrinus* differs in several additional points, and sufficiently, so to make it an independent genus.

Technocrinus differs from *Mariacrinus*, as now amended, in having 1 × 10 secondary radials, instead of 3–4 × 10, and these connected laterally without the interposition of interaxillaries; in having the arms given off in an almost continuous ring around the body, and not in clusters; in the straight upward direction of all the arms, contrary to *Mariacrinus* in which the outer arms are given off obliquely, and only the inner ones run parallel with each other; in that its arms are strong, simple, composed of single joints, instead of being slender, branching and double jointed. It further differs from *Melocrinus* in giving off the arms straight and directly from the body, instead of obliquely from the free rays; in the absence of interaxillaries, and in other minor characters.

Generic Diagnosis.—Form of calyx similar to *Melocrinus.* Symmetry, except in the basal portions, perfectly pentahedral.

Basals four, one of them larger and placed longitudinally in line with the primary radials of one of the lateral rays. Primary radials 3 × 5; the first two hexagonal; the third pentagonal and supporting 1 × 10 large secondary radials, which are all axillary, each supporting 2 × 2 tertiary radials, of which the upper part of the second row is laterally disconnected and free. They are succeeded by several wedge-form plates, which gradually interlock, and which are followed, rather abruptly, by two series of narrow, alternately arranged arm plates. The arms are long, simple, straight, placed around the body in a continuous ring, and at almost equal distances from each other. Pinnules apparently thin, thread-like, their sides abutting.

Interradials three to four; the first resting against the oblique upper sides of the first radials, and between the second. Anal area, so far as known, not distinct from the other interradial ones. Construction of the vault unknown. Column round.

Geological Position, etc.—*Technocrinus* has been found only in the Oriskany Sandstone of Maryland.

*1859. **Technocrinus Andrewsi** Hall. (Type of the genus.) (**Mariacr.—Technocr.—Andrewsi.**) Paleont. N. York, iii, p. 141, Pl. 86, figs. 1-4. Oriskany Sandstone. Cumberland, Md.

*1859. **Technocr. spinulosus** Hall. (**Mariacr.—Technocr.—spinulosus.**) Paleont. N. York, iii, p. 140, Pl. 85, figs. 1-18. Oriskany Sandstone. Cumberland, Md. (**Mariacr.—Technocr. sculptus** and **T. striatus** Hall, are known from the basals only).

9. **MELOCRINUS** Goldfuss.

1826. Goldfuss. Petrefacta Germaniæ, i, p. 197.
1835. Agassiz. Mem. d. l. Soc. des Sci. Natur. de Neuchatel, i, p. 196.
1841. Müller. Monatsb. Berl. Akademie, i, p. 209.
1850. D'Orbigny. Prodr. de Paléont., i, p. 103.
1852. D'Orbigny. Course Élément., ii, p. 140.
1855. Roemer. Lethæa Geogn. (Ausg. 3), p. 250.
1857. Pictet. Traité de Paleont., iv, p. 325.
1867. Schultze. Mon. Echin. Eifel Kalk., p. 61.
1875. Hall. Geol. Rep. Ohio, Paleont., ii, p. 158.
1878. Angelin. Iconogr. Crin. Suec., p. 19.
1879. Zittel. Handbuch d. Palæontologie, i, p. 371.

Syn. *Ctenocrinus* Bronn, 1840. Jahrbuch, p. 54.
Syn. *Ctenocrinus* Müller, 1855. Verhandl. Naturh. Verein, xii, p. 16.
Syn. *Castanocrinus* Roemer, 1855. Lethæa Geogn., ii, p. 252.
Syn. *Mariacrinus* Hall (in part), 1857. Paleont. N. York, iii, p. 104.
Syn. *Cytocrinus* Roemer, 1860. Silur. Fauna West. Tenn., p. 46.
Syn. *Clonocrinus* Oehlert, 1879 (not Quenstedt). Bull. Soc. Geol. de France (ser. 3), vol. vii.
Syn. *Turbinocrinites* Troost. List. Crin. Tenn., 1850 (not defined).
Syn. *Astrocrinites* Conrad. Cat. Geol. Rep. of 1840 41 (not Cumberland, 1826; nor Austin, 1843; nor *Asterocrinus* Lyon, 1857; nor Münster, 1839).

The genus *Melocrinus* holds the same relation to *Mariacrinus* as *Steganocrinus* to *Actinocrinus*, and as *Eucladocrinus* to *Platycrinus*. In all of them the construction of the body remains almost unchanged, while a remarkable modification takes place in the brachial appendages, which are extended into free rays with an indefinite number of radials, which give off the arms laterally. This character separates the genera of the three groups very distinctly and uniformly.

Several attempts have been made to establish sub-divisions for *Melocrinus*. Roemer, in 1855, proposed the name *Castanocrinus* for species with a central or subcentral anal opening, retaining *Melocrinus* with *M. hieroglyphicus* Goldf. for species with a lateral opening. A critical comparison of all the species leads us to doubt whether that division can be carried out practically. We agree with Shultze, Mon., p. 63, that the proboscis—anal tube—is never central, and in this genus in no case actually lateral; but that its direction is more or less excentric in all species. Neither can the presence or absence of interaxillary plates, unless accompanied by other distinctive characters, be considered for a moment as sufficient for generic separation, as had been proposed in the case of *Ctenocrinus* Bronn,[1] those plates are mere accessory pieces, and may be present or absent in the same species.

Turbinocrinites Troost was proposed in MS. (according to Hall) for a species which was said to have the first anal plate in line with the first radials, but Troost's typical species *Melocr. Verneuili*, which was subsequently defined by Hall, seems not to have possessed such a plate, as Hall himself mentions expressly that the anal area is but slightly distinct from the regular interradial ones.

Cytocrinus Roemer was described by its author with probably three (?) basal plates—the exact number had not been ascertained. A good specimen in our collection from Louisville, Ky., which in every respect agrees with *C. lævis* Roemer, shows that it has four basals, and that the genus is identical with *Melocrinus*. Roemer himself gave for locality both Western Tennessee and Louisville.

Phillipsocrinus McCoy, which was described with four basals, has been frequently connected with *Melocrinus*. The generic description was made from a single specimen, and this was evidently abnormal, as indicated by having two additional plates in line with the first radials (seven in all), and we think it probable that the abnormal seventh plate in this case rendered the presence of the fourth basal plate necessary. We take it to be an abnormal specimen of *Actinocrinus*, and this is far more consistent with the given geological position.

Generic Diagnosis.—Body obconical, subglobose or pear-shaped, with five free rays extended upward and giving off arms laterally. Calyx highly ornamented with radiating ridges, some-

[1] The genus *Ctenocrinus* was at first incorrectly defined. It was described by Bronn (Jahrbuch, 1840, p. 542) with three basal plates, which was confirmed by Roemer (Leth. Geogn., 1855, p. 251), and subsequently de Koninck considered the genus identical with *Pradocrinus* de Verneuil (Crin. du terr. Carb. Belg., p. 147). Joh. Müller (Verhandl. naturh. Verein, 1855), admits more than three basals, probably five, and in 1857 (Neue Echin. Eifel Kalk, p. 255), he mentions positively five basals, and compares *Ctenocrinus* with *Glyptocrinus* Hall, asserting that it had also parabasalia. Schultze afterwards in his Monograph, p. 63, proved from more perfect specimens that *Ctenocrinus typus* has only four basals and no underbasals, which is evidently correct. One of us had an opportunity several years ago to study the Schultze collection in the Museum of Comparative Zoology of Cambridge, which contains specimens showing only four basals like *Melocrinus*.

times with little nodules, in some species with all the plates strongly nodose, or almost spiniferous; symmetry slightly bilateral.

Basals four, three of them equal and pentagonal, the fourth larger and hexagonal, the latter directed to the left antero-lateral ray, not posteriorly.

Radials 3 × 5; the five first hexagonal and joining laterally; the plates of the second series hexagonal, the first interradial and anal plate interposed between them; the third pentagonal and bifurcating. They support on their upper sloping sides two to three secondary radials (2–3 × 10), with one or more—though sometimes none—in the axil. The secondary radials are succeeded in a direct line by two rows of plates, which sometimes interlock, but which more frequently are placed side by side. The plates which represent higher orders of radials, are separated by a deep vertical suture, and formed into a long brachial appendage or free ray, which terminates in an arm.

The free rays give off laterally, throughout their length at certain intervals, from each third or fourth joint, or less often, and from opposite plates (not alternately), small armlets, composed of two rows of interlocking plates, with short pinnules on alternate sides. The plates which compose the appendages are wider than high, their upper and lower sides parallel, except the arm-bearing pieces which are depressed pentagonal. The length of the armlets differs according to their position; all extend to the same general height, and hence those nearer the body are longer, the length decreasing proportionately upward.

In young specimens, all arms are given off from the free rays; while in the adult, the lower portion of the proximal arm is often enclosed within the calyx, and sometimes even separated from the main trunk by small plates.

There is only one brachial appendage to each ray, and this, as stated before, is composed of two rows of plates which rest upon a bifurcating plate. This construction leaves no doubt that the two rows, which are separated by a deep longitudinal suture, often by interaxillary plates and small intermediate pieces scattered between them, represent two distinct brachial appendages, which became anchylosed throughout their length, contrary to *Mariacrinus*, in which under similar conditions, the equivalent parts remained detached.

Anal plates numerous. The first interradial placed upon the upper sloping sides of the first radials and between the second; the second series composed of two plates, and there are three in each succeeding series.

The posterior or anal side is but slightly distinct from the other four, but it has generally three plates in the second, and three or four in each succeeding series.

Vault very variable, highly elevated to low hemispherical; the plates comparatively large and more or less nodose, but sometimes small and scarcely convex; the interradial regions depressed. Anal aperture subcentral or almost lateral, and extended generally —if not always—into a tube, whose length is unknown.

Apical dome-plates conspicuous, particularly in species with an excentric anus.

Column round, composed alternately of longer and shorter joints; central canal small, round, or obtusely pentagonal.

Geological Position, etc.—*Melocrinus* ranges from the Upper Silurian to near the close of the Devonian, and is represented both in America and Europe.

We place here the following species:—

*1875. **Melocrinus Bainbridgensis** Hall (**Melocr.—Centrocr.—Bainbridgensis.**) Geol. Rep. Ohio Paleon. ii, p. 158, Pl. 13, figs. 2, 3, above Huron Shales, Devonian. Ross Co., Ohio.

*1879. **Melocr. Bigsbyi** Oehlert. (**Clonocr. Bigsbyi.**) Bull. Soc. de France (Ser. 3) vol. vii, p. 4, Pl. 2, figs. 2–4. Devonian. St. Germain, France.

(?) 1872. **Melocr. breviradiatus** Hall and Whitfield. Hamilton gr. (We have not seen the description.)

1838. **Melocr. decadactylus** Goldfuss. (**Actinocr. decadactylus.**) Nova Act. Ac. Leop. xix, p. 343, Pl. 31, fig. 5; F. Roemer, **Ctenocr. decadactylus**, Rhein. Uebergangsgeb. p. 61. Grauwacke, near Coblentz, Germ.

(**Ctenocr. decadactylus** Ad. Roemer 1850, Hartzgebirge, p. 2, Pl. 1, fig. 1. From the Devonian of the Hartz. This is probably different from the Coblentz specimens.

1833. **Melocr. gibbosus** Goldf. Petref. German. i, p. 211, Pl. 64, figs. 2; Austin, 1842, Ann. and Mag. Nat. Hist. x, p. 109; Schultze, 1867, Mon. Echin. Eifel Kalk, p. 64, Devonian. Eifel, Germ.

Syn. **Melocr. lævis** Goldf. (not F. Roemer). Petref. German., i, p. 197, Pl. 60, fig. 2.

(?) 1878. **Melocr. grannulatus** Angelin. Icon. Crin. Suec., p. 20, Pl. 26, figs. 21 and 21 a. Upper Silur. Gothland, Sweden. (This is certainly not *Melocrinus* and we doubt that it is has four basals; it differs materially in the arrangement of the anal plates.)

1826. **Melocr. hieroglyphicus** Goldf. Type of the genus. Petref. German. i, p. 197, Pl. 60, figs. 1 A–E; also Nova Act. Ac Leop., xix, p. 339; also Lethaea. Geogn., i and ii, p. 63; Roemer, 1855, Lethaea Geogn., Pl. 4, figs. 10 a, b, c. Rhein. Uebergangsgebirge. Devon. Belgium and Germany.

*1860. **Melocr. lævis** Roemer (not Goldf.)—**Cytocrinus lævis**. Silur. Fauna, West Tenn., p. 56, Pl. iv, figs. 2 a, b. Niagara gr. West.-Tennessee.

*1859. **Melocr. nobilissimus** Hall. (**Mariacr. nobilissimus**) Paleont. N. York, iii, p. 105, Pl 2, figs. 1–4, and Pl. 2 A, fig. 1. Pentamerus limest. Litchfield, Herkimer Co., N. Y.

1861. **Melocr. nodosus** Hall. Geol. Surv. Wis. (Rep. of Progress), p. 19. Devonian. Iowa City.

1865. **Melocr. obpyramidalis** Winchell and Marcy. (**Actinocr. obpyramidalis**) Mem. Bost. Soc. Nat. Hist., vol. i, p. 87, Pl. 2, fig. 4. Niagara gr. Near Chicago, Ill. Miller, 1881, Cincin. Soc. Nat. Hist. (July No.).

This species was described from an imperfect cast. Hall takes it to be a synonym of **Melocr. Verneuili** Troost.

*1841. **Melocr. pachydactylus** Conrad. (**Astrocrinites pachydactylus**) Ann. Rep. Paleont. N. York, p. 34; Mather, 1843, Geol. Rep. N. York, p. 246; Hall, 1859, **Mariacr. pachydactylus,** Paleont. N. York, iii, p. 107, Pl. 3, figs. 1–4 A. Lower Helderberg gr. Schoharie, N. Y.

Syn. **Actinocr. polydactylus** (1837) Bonny (not Miller). (Schenectady Reflector.)

*1859. **Melocr. paucidactylus** Hall. Paleont. N. York, iii, p. 109, Pl. 3, fig. 5. Lower Helderberg gr. Herkimer Co., N. York.

1860. (?) **Melocr. Pratteni** McChesney. (**Forbesiocr. Pratteni**) Desc. New Pal. Foss., p. 29; 1867, **Melocr. Pratteni** Chicago, Acad. Sci., p. 22, Pl. 5, fig 4. (Geological position and locality unknown, and described from imperfect specimens.)

1838. **Melocr. pyramidalis** Goldfuss. Nova Acta Ac Leop., xix, i, p. 339, Pl. 31, fig. 1; D'Orbigny, 1850, Prodr., i, p. 103; Schultze, 1867, Mon. Echin. Eifel Kalk, p. 66, Pl. 4, fig. 5. Devonian. Eifel, Germ.

Syn. **Melocr. fornicatus** Goldfuss. Ibid., p. 340, Pl. 31, fig. 2.

(?) 1878. **Melocr. rigidus** Angelin. Iconogr. Crin. Suec., p. 20, Pl. 21, fig. 3. Upper Silur. Gothland, Sweden.

(This is an entirely different form, and probably belongs to a different family.)

1878. **Melocr. spectabilis** Angelin. Iconogr. Crin. Suec., p. 20, Pl. 21, figs. 1–2. Upper Silur. Gothland, Sweden.

1852. **Melocr. stellaris** Roemer. (**Ctenocr. stellaris**) Verhandl. Naturh. Verein. f. Rheinl., ix, p. 283, Pl. 2, figs. 2 a, b, c; also Schultze, 1867, Mon. Echin. Eifel Kalk, p. 65, Pl. 4, fig. 3. Devonian. Eifel, Germ.

1840. **Melocr. typus** Bronn. (**Ctenocr. typus**) Jahrb. f. Mineralogie, p. 542, Pl. 8 B; also D'Orbigny, 1850, Prodr., i, p. 103, and F. Roemer, 1844, Rhein. Uebergangsgeb., p. 60, Pl. 1, fig. 1. Grauwacke, near Coblentz, Germ. Probably identical with **Melocr. decadactylus** Goldf.

1864. (?) **Melocr. Verneuili** Troost. (**Actinocr. Verneuili**) List of Crin. Tenn., 1850; 1868, Hall, 20th Rep. N. York St. Cab. Nat. Hist., p. 327, Pl. 10, fig. 5 (Advance Sheets, 1864). Niagara gr. Decatur Co., Tenn., and Racine, Wis.

This species is only known from natural casts, hence an accurate comparison is impossible, but from all appearances it is identical with **Melocr.** (**Cytocr.**) **lævis** Roemer.

1838. **Melocr. verrucosus** Goldf. Nova Acta Ac Leop. xix, i, Pl. 31, fig. 3; also Schultze, 1867, Mon. Echin. Eifel Kalk, p. 65, Pl. 4, fig. 4. Devonian. Eifel, Germ.

1878. **Melocr. Volborthi** Angelin. Iconogr. Crin. Suec., p. 20, Pl. 7, figs. 8–11, and Pl. 23, figs. 30–32. Upper Silur. Gothland, Sweden.

(Angelin figures under this name at least two different species, his Pl. 18, fig. 16, represents even another genus; the latter possibly goes together with the specimen on Pl. 26, fig. 26, referred to **Patelliocr. fulminatus.**)

10. SCYPHOCRINUS Zenker.

1833. Zenker. Beitr. Naturgesch. d. Urwäld., p. 26.
1839. Münster. Beitr. z. Petrefactenk., iii, p. 112.
1850. Quenstedt. Handbuch der Petrefactenk., p. 621.
1855. F. Roemer. Lethæa Geogn. (Ausg. 3), p. 255.
1878. Zittel. Handbuch der Palaeontologie, i, p. 372.
(Not *Scyphocrinus* Hall, 1847. Paleont. N. York, i, p. 85.)
(Not *Scyphocrinus* Pictét, 1857. Traité de Paléont., iv, p. 320.)

The genus under consideration is not to be confounded with *Scyphocrinus* Hall, 1847, which is an entirely different thing, and as we believe, a synonym of *Schizocrinus* Hall. *Scyphocrinus* Zenker, is imperfectly known, but Zittel is probably correct in grouping it with *Melocrinus*, although it has in the form of its radials, and in the large number of interradial plates, close affinities with *Periechocrinus*, from which it differs in the construction of the anal area. Pictet's identification of *Scyphocrinus* is evidently not correct; he describes it with four under basals and five basals, arranged like in *Cyathocrinus*, and otherwise resembling *Actinocrinus*.

Generic Diagnosis.—Calyx very large, composed of numerous thin plates, which are beautifully sculptured; posterior side somewhat wider, and hence the general symmetry slightly bilateral.

Basals, according to Roemer and others, five. Zittel gives their number at four. Primary radials 3 × 5, nearly of equal size and varying but little in form, all higher than wide; the two lower hexagonal; the third heptagonal and supporting two rows of secondary radials, each consisting of from four to five plates, longitudinally arranged and separated by interaxillary pieces. The radials support ten arm-trunks, which give off numerous branches, the latter closely placed together, the lower ones crossing each other and forming in the interradial and interaxillary spaces an unbroken pavement; higher up, however, the arms become free and diverge, giving off long slender branches, which in turn throw off pinnule-like armlets (Zittel), but probably true pinnules. The main trunks and branches consist of short single joints with deep ventral furrows, their articulating faces provided with radiating striæ.

Interradial series constructed of numerous plates, the first resting upon the posterior lateral sides of the first radials, and between the second radials. There are two interradials in the second series, three in the third, and others above. The posterior side differs in having three plates in the second, and four to five in the succeeding series. Construction of vault, and form and position of the anus, unknown.

Column long, round, slender, composed of short joints; central perforation round and unusually large.

Geological Position, etc.—The only known species occurs in the Upper Silurian of Bohemia.

1833. **Scyphocrinus elegans** Zenker. Beitr. Naturgesch. Urw., p. 26, Pl. 4, figs. A–F; Münster, 1839, Beitr. zur Petrefactenk., p. 112, Pl. 9, fig. 8; Quenstedt, 1850, Handb. d. Petref. p. 621, Pl. 55, figs. 1-3; F. Roemer, 1855, Lethaea Geogn. (Ausg. 3). p. 255, Pl. 4, figs. 5 a. b; Zittel, 1879, Handb. d. Palaeont. i, p. 372. Upper Silur. Karlstein, Bohemia.

11. DOLATOCRINUS Lyon.

1857. Lyon. Geol. Rep. Kentucky, iii, p. 482.
Syn. *Cacabocrinus* Troost. List of Crin. Tenn., 1850.
Syn. *Cacabocrinus* Hall. 15th. Rep. N. York, St. Cab. Nat. Hist., p. 137.

The name *Cacabocrinus* was proposed by Troost in his catalogue, but the genus was not defined until 1862 by Hall. Lyon's *Dolatocrinus*, which is identical with *Cacabocrinus*, was described in 1857 and hence has priority. Lyon described the genus with three basals. Hall with five, but we doubt if either of them ever found the sutures. The basal pieces are so closely anchylosed, that we give them simply as constituting a solidly anchylosed disk. *Dolatocrinus* differs from most allied genera in the anal area, which in its construction is not distinct from the regular interradial fields, but in this respect it resembles *Stereocrinus*, which we place subgenerically under it.

Generic Diagonis.—Body spheroidal, depressed at both poles; wider than high. Calyx forming a low spreading basin, of which the basals, the first, and partly the second radials form the bottom part; symmetry regularly pentahedral, the anal area not distinct from the other interradial series.

Vault hemispherical, depressed in the interradial portions, the radial zones elevated, giving to the summit, viewed from that side, a pentalobate aspect.

Basals united by anchylosis, without visible suture lines, and forming a pentagon; small, often barely extending beyond the circumference of the column; the median part strongly concave or the entire base funnel-shaped; central perforation or passage for the columnar canal very large, pentalobate.

Radials 3 × 5; the first large, hexagonal; the second quadrangular, generally with convex sides, narrower than either second or third, but much wider than high. The third pentagonal, and supporting at each side two secondary radials, which give off two arms to each ray. In the majority of species, however, there are two pairs of tertiary radials above the second order, or four arms to the ray. The secondary radials, and the tertiary ones if these are present, are almost as large as the second and third primaries. The arms, on becoming free, bifurcate two or three times, and it appears that they were constructed sometimes of a single series of cuneiform pieces alternately arranged, but more generally of two series of interlocking plates. Pinnules long, slender jointed.

Interradials three or more—their number greater in species with four arms than in those with two arms to the ray—generally arranged in three series. The first interradial plate very large, the largest plate in the calyx; subcircular to subovoid; resting between the upper sides of the first radials, against the sides of the second and third, and between the lower sloping sides of the first secondary radials. The second interradial series is composed of one or two plates, smaller than the first. The third series consists of two or three much smaller plates, sometimes with a fourth series above. There are generally a few interaxillary plates between the secondary radials.

Vault composed of rather large plates, ornamented with coarse granules or small irregular nodes. The apical dome plates well defined, the radial pieces slightly tuberculous, and the entire radial portions elevated; the interradial regions depressed. Anal aperture subcentral, evidently extended into a slender tube.

Column unknown, its form however was circular, and it had an unusually large, pentalobate central canal.

Geological Position, etc.—In the Upper Helderberg and lower beds of the Hamilton group, Devon., and only found in America.

1862. **Dolatocrinus glyptus** Hall. (**Cacabocr. glyptus**). 15th Rep. N. York St. Cab. Nat. Hist., p. 140; **Dolatocr. glyptus** S. A. Miller, Cat. Pal. Foss., p. 72. Hamilton gr. Genessee Co., N. Y.

1862. **Dolatocr. glyptus** var. **intermedius** Hall. (**Cacabocrinus**). 15th Rep. N. York St. Cab. Nat. Hist., p. 141. Hamilton gr. Livingston Co., N. Y.

1857. **Dolatocr. lacus** Lyon. (Type of the genus). Geol. Rep. Ky., iii, p. 482, Pl. 4, figs. 2 a, b, c. Encrinal limest. Beargrass quarries, Louisville, Ky.

1862. **Dolatocr. lamellosus** Hall. (**Cacabocr. lamellosus**). 15th Rep. N. York St. Cat. Nat. Hist., p. 141; **Dolatocr. lamellosus** S. A. Miller, Cat. Pal. Foss, p. 72. Western N. Y. Upper Helderberg gr.

1862. **Dolatocr. liratus** Hall. (**Cacabocr. liratus**). 15th Rep. N. York St. Cab. Nat. Hist., p. 139; **Dolatocr. liratus** S. A. Miller, Cat. Pal. Foss., p. 72. Western N. Y. Hamilton gr.

1862. **Dolatocr. liratus** var. **multilira** Hall. (**Cacabocrinus**). 15th Rep. N. York St. Cab. Nat. Hist., p. 139. Hamilton gr. Western N. Y.

1869. **Dolatocr. Marshi** Lyon. Trans. Am. Philos. Soc., vol. 13, p. 461, Pl. 27, figs. n, 1, 2. Upper Helderberg gr. Falls of the Ohio.

1862. **Dolatocr. speciosus** Hall. (**Cacabocr. speciosus**). 15th Rep. N. York St. Cab. Nat. Hist., p. 137; **Dolatocr. speciosus** S. A. Miller, Cat. Pal. Foss., p. 72. Upper Helderberg. Schoharie, N. Y.

1862. **Dolatocr. Troosti** Hall. (**Cacabocr. Troosti**). 15th Rep. N. York St. Cab. Nat. Hist., p. 138; **Dolatocr. Troosti** S. A. Miller. Cat. Pal. Foss., p. 72. Hamilton gr. Western N. Y.

Subgenus **STEREOCRINUS** Barris.

1878. Proceed. Davenport Acad. Nat. Sci., vol. ii, p. 282.

Stereocrinus in general form, mode of ornamentation, and in the construction of the plates, resembles the simpler form of *Dolatocrinus*. It differs from it in having two, instead of 3×5, primary radials, and the basal plates, although closely anchylosed, distinctly divided into three pieces.

Through the kindness of Rev. Dr. Barris, we examined a large number of specimens from Davenport, and became satisfied that the reduction in the number of radials is not accidental, but a constant character, which extends to more than one species. Other specimens have since been found by Dr. Barris in the Lake Superior region, which confirm this opinion. The upper radials in *Stereocrinus* are of the same size, and nearly of the same form, as the second and third radials combined in *Dolatocrinus*, and this suggests a modification from the two pieces in the one, to a single plate in the other. It is very possible that in *Dolatocrinus* the two pieces were united by syzygie,[1] while in *Stereocrinus* they became perfectly anchylosed.

[1] In our general remarks upon the Actinocrinidæ, we have suggested that probably in genera, in which the second radial is quadrangular and transversely arranged like in *Batocrinus* and *Dolatocrinus*, this plate represents a mere hypozygial joint, which with the axillary plate forms a syzygie.

This seems to us sufficient to separate the two forms, but in other respects the relations with *Dolatocrinus* are so close, that they justify only a subgeneric division, for which we propose the following:—

Diagnosis.—Body depressed; calyx truncate up to the second radials, the latter bending abruptly and forming a low basin with straight sides. Dome but slightly elevated, its interradial portions depressed and deeply grooved toward the arm bases, giving to the radial regions a certain prominence, and to the body, viewed from the summit, a somewhat lobed appearance; symmetry strictly pentahedral.

Basal disk small, scarcely projecting beyond the column, funnel-shaped, composed of three closely anchylosed pieces. Primary radials 2 × 5; the first hexagonal; the second pentagonal, supporting two radials of the second order, the latter supporting the arms. So far as the specimens are preserved, there are only two arm openings to each ray, these, however, are so large that they may form the inner cavity of free brachial appendages with numerous arms. Arms entirely unknown.

Interradials two, large, with several small plates above; the two former in series of one each; the first the largest plate of the body, heptagonal; the second hexagonal, smaller than the radial plates; succeeding pieces placed within the depressions between the arm bases; anal side not distinct.

Vault composed of a moderate number of medium-sized pieces; apical dome-plates easily recognized by their larger size. Anal opening subcentral, extended into a tube.

Column round; central canal large, pentalobate.

Geological Position, etc.—Upper Helderberg group of America.

1878. **Stereocrinus triangulatus** Barris. Davenport Acad. Nat. Sci., p. 283, Pl. 11, figs. 1, 2. Encrinal limest. Near Davenport, Iowa.

1878. **Stereocr. triangulatus** var. **liratus** Barris. Ibid. p. 284, Pl. 11, fig. 3. Encrinal limest. Near Davenport, Iowa.

d. PERIECHOCRINITES.

12. **PERIECHOCRINUS.** Austin.

1842. Austin. Ann. and Mag. Nat. Hist., x, p. 109 (no definition).
1843. Austin. Ibid., xi, p. 203.
1843. Morris. Cat. Brit. Foss. (ed. 1st), p. 56.
1857. Pictét. Traité de Paléont., iv, p. 323.
1878. Angel. Iconogr. Crin. Suec., p. 6.

1879. Zittel. Handb. der Palæontologie, i, p. 368.

Syn. *Actinocrinus* Miller, 1821 (in part). Hist. Crinoidea, p. 116.
Syn. *Actinocrinus* Phillips, 1839. Murchis. Silur. Syst., p. 57.
Syn. *Trochocrinites* Portlock, 1848. Geol. of Londonderry, p. 345.
Syn. *Pradocrinus* De Verneuil, 1850. Bull. Soc. Geol. France (sér. ii), vol. vii, p. 184.
Syn. *Geocrinus* d'Orbigny, 1850. Prodr. de Paléont., i, p. 46.
Syn. *Saccocrinus* Troost, 1850. List. Crin. Tenn.
Syn. *Saccocrinus* Hall, 1852. Paleont. New York, ii, p. 205.
Syn. *Pyxidocrinus* Müller (in part), 1857. Neue Echin. Eifel Kalk, p. 253.
Syn. (?) *Trochocrinites* Pander, 1858. Helmerson's Geol. Bermerk. auf einer Reise in Schweden, etc., p. 20.
Syn. *Saccocrinus* Roemer, 1860. Silur. Fauna West. Tenn., p. 42.
Syn. *Actinocr.* (*Megistocrinus*) Hall, 1861. Bost. Journ. Nat. Hist., p. 271.
Syn. *Actinocr.* (*Pradocrinus*) Meek and Worth., 1861. Proc. Acad. Nat. Sci. Phila., p. 133.
Syn. *Actinocrinus* Hall, 1863. Trans. Albany Inst., v, p. 196.
Syn. *Megistocrinus* Winchell and Marcy, 1865 (not Ow. and Shum.). Mem. Bost. Soc. Nat. Hist., i, p. 87.
Syn. *Saccocrinus* Meek and Worth., 1869. Geol. Rep. Ill., iii, p. 347.
Syn. *Actinocr.* (*Saccocrinus*) Meek and Worth., 1869. Geol. Rep. Ill., iii, p. 470.
Syn. *Megistocr.* (*Saccocrinus*) Meek and Worth., 1873. Geol. Rep. Ill., vol. v, p. 397.
Syn. *Actinocrinus* Angelin, 1878 (in part). Iconogr. Crin. Suec., p. 6.
Syn. *Saccocrinus* S. A. Miller. Journ. Cincin. Soc. Nat. Hist. (July No.).

Austin's definition of *Periechocrinus* is not so clear as might be wished, but sufficiently distinct to imply that he described a group of Crinoids of which Miller's *Actinocrinus moniliformis* is the type. None of Austin's species were figured; the first, *P. articulosus*, is but little known, the second, *P. costatus* has been regarded a synonym of *Actinocr. moniliformis*, while the third, *P. globulosus*, has not been defined. The species are characterized by their elongate sack-like form, the thinness of their body plates, the exceedingly high radials, the conspicuous elevated ridges along the radials, the large interradial and interaxillary spaces, the wide anal area with a plate in line with the first radials, and the large, slender, more or less branching arms. This includes the American species for which Troost and Hall proposed the genus *Saccocrinus*.

It makes but little difference whether the arms in *Saccocrinus speciosus* (Hall's type) branch again after they become free, or exclusively within the body as in the case of *Periechocrinus moniliformis*, provided their mode of branching and their construction otherwise is similar, and this is evidently here the case. There are among the European species several in which the arms branch in their free state, and we find among them all possible intermediate gradations, from two simple arms in the ray to eight, and these either simple or branching. Angelin refers species with only two and four arms, if remaining simple, to *Actinocrinus*, but it seems to us, that a generic separation, based upon the number of arms, cannot be upheld in a group in which a branching of the arms is not only admitted, but very characteristic.[1]

Angelin's *Actinocr. medius* and *A. major* have underbasals, and are referred by us to the Rhodocrinidæ.

We place here with doubt Angelin's *Periechocr. Gothlandicus* and *P. radiatus*, which both differ in the secondary radials and in the style of ornamentation from all other species, while they agree on the same points and in their general aspect with *Glyptocrinus*. None of the figured specimens show the anal side, and it seems quite possible that the two species, like *Glyptocrinus*, had no anal plates in line with the first radials.

Periechocrinus grandiscutatus, *P. multicostatus*, *P. undulatus*, *P. annulatus* and *P. geometricus*, Angelin's species, were described from fragmentary plates, and their identification is doubtful, the latter even, if correctly figured, had underbasals. In that species only the plates of the two proximal rings are known, those of the second ring are angular above, instead of truncate, and hence the succeeding ring must have been alternately arranged.

According to our interpretation, *Periechocrinus* includes also several species from the lower Subcarboniferous, which heretofore have been variously referred to *Actinocrinus*, *Megistocrinus*, or *Pradocrinus*, but only species with thin plates and elongate body, leaving those with heavy plates, depressed body, and short radials under *Megistocrinus*.

We are aware that we include in this genus some species which

[1] In *Actinocrinus* the case is similar, some species having four, others eight simple arms, and the last survivors of the genus have their arms branching in the free state as in species of *Periechocrinus*.

possess a simple anal opening, others with apparently a small ventral tube, but we were obliged to do so, because the construction of the ventral disk is so little known, that a subgeneric division in this case could not as yet be carried out practically.

Pradocrinus de Verneuil, 1850, is identical with Austin's genus, also *Geocrinus* d'Orbigny, which was proposed the same year, and based upon Miller's *Actinocr. moniliformis.* Joh. Müller referred *Pradocrinus* to his *Pyxidocrinus*, a genus in which he proposed to embrace those species of the *Actinocrinus* group which possess interaxillary plates. Angelin identifies *Trochocrinus* Pander with *Periechocrinus*, while Bigsby takes it to be a synonym of *Glyptocrinus. Trochocrinites Gothlandicus.* certainly differs in several respects from typical species of *Periechocrinus.*

The name *Trochocrinites* was preoccupied by Portlock in 1848. His only species *P. lævis* was described from a very imperfect specimen, and we cannot accurately determine its relations, though it seems to be allied to the group of *P. Gothlandicus.* It is certainly quite distinct from Angelin's *P. lævis.* We should be inclined to place this species with *P. Gothlandicus*, *P. radiatus*, and *P. pulcher* in a separate group under Portlock's name, but it is possible they all belong to *Glyptocrinus*, and we dislike to encumber the subject with generic separations based upon such imperfect data.

Austin made *Periechocrinus* the type of a distinct family, and included in it *Sagenocrinus*, while Pictét and Zittel refer it to the Actinocrinidæ.

Generic Diagnosis.—Body large, elongate and somewhat urnshaped; composed of thin, almost smooth or delicately sculptured plates; radials marked along their centres with a conspicuous elevated ridge, passing from plate to plate, which divides upon each axillary piece, and which toward the arm-bases increases in prominence, until it gradually becomes identified with the free arms. Symmetry bilateral.

Basals three, of equal size, united into a spreading cup; articulating facets for the reception of the column wide.

Primary radials 3×5, comparatively long and narrow, connecting line unusually short, sometimes joining only by the point of an angle. The first radials large, alternately hexagonal or heptagonal; the second hexagonal and smaller; the third smaller than the second, hexagonal or heptagonal, with an obtuse upper angle supporting the secondary radials. The latter usually consist of 2 × 10 plates, the upper row, in some species, curving outward and supporting the free arms, in others straight, axillary, and supporting the higher orders of radials, which give off the arms from every second plate, and alternately from opposite sides. The arms in either case are simple or branching, long, slender, rounded, decreasing in width upward. They are from the body up composed of two series of small alternating pieces, and the bifurcating takes place after the arms have passed into a double series of interlocking pieces.

Pinnules slender, closely abutting.

Interradial plates numerous; the first one large, generally hexagonal, supporting two plates in the second, and two in the third range, with several series above, each containing from two to three plates, which gradually decrease in size toward the summit. The posterior side much wider; first anal plate heptagonal, equal in form to the first radials and in line with them, followed by three plates in the second series, and by a large number of small plates above.

Interaxillaries numerous. Vault depressed, from moderately convex to almost flat; composed of small, irregularly arranged, smooth pieces, among which the apical plates are indistinctly represented. Anus subcentral, either in form of an opening through the vault, or in some species probably extended into a small tube.

Column large, round, central canal moderately wide and round.

Geological Position, etc.—*Periechocrinus* occurs from the Upper Silurian to the base of the Subcarboniferous (Burlington Limest.), and is found both in America and Europe.

We recognize the following species :—

*1861. **Periechocrinus amplus** Meek and Worth. (**Actinocr. Pradocr. amplus**), Proc. Acad. Nat. Sci. Phila., p. 133; also 1868, Geol. Rep. Ill., iii, p. 470, Pl. 16, fig. 2. Upper Burlington limest. Burlington, Iowa.

1843. **Periechocr. articulosus** Austin. Ann. and Mag. Nat. Hist., xi, p. 204. Upper Silur. Dudley, Eng.

*1850. **Periechocr. Baylii** de Verneuil. (**Pradocr. Baylii**) Bull. Soc. Géol. de France (ser. ii), vol. vii, p. 184, Pl. 4, figs. 11 a, b, c. Devonian. District Sabero, Spain.

*1878. **Periechocr. brevimanus** Angel. (**Actinocr. brevimanus**) Iconogr. Crin. Suec., p. 6, Pl. 18, fig. 12. Upper Silur. Gothland, Sweden.

*1863. **Periechocr. Christyi** Hall. (**Actinocr. Christyi**—not Shum., 1855) Trans. Albany Inst., iv, p. 196; (Abstr., p. 2); Meek and Worth, 1868, **Saccocr. Chrystyi**, Geol. Rep. Ill., iii, p. 347, Pl. 5, fig. 1; also Hall, 1879, 28th Rep. N. Y. St. Cab. Nat. Hist. (ed. ii), p. 127, Pl. 13, figs. 12–20. Niagara gr. Waldron, Ind., near Chicago, Ill.; and Racine, Wis.

Syn. **Actinocr. Whitfieldi** Hall, 1868. 20th Rep. N. York St. Cab. Nat. Hist., p. 326; **Actinocr. (Saccocr.) Whitfieldi** Hall. Ibid. (Revised Ed.), 1870, pp. 370 and 430.

Syn. **Megistocr. Marcouanus** (1860) Winchell and Marcy. Mem. Bost. Soc. Nat. Hist., i, p. 87, Pl. 2, fig. 5. S. A. Miller, Journ. Cincin. Soc. Nat. Hist. (July number), considers it a good species.

Syn. **Megistocr. infelix** Winch. and Marcy, 1866. Ibid., p. 7.

*1858. **Periechocr. Gothlandicus** Pander. (**Trochocrinites Gothlandicus**) Helmerson's Geol. Bemerk. auf einer Reise in Schweden und Norwegen, p. 20, Pl. 3, figs. a, b, d, e (not c); Angelin, 1878, **Periechocr. gothlandicus**, Iconogr. Crin. Suec., p. 7, Pl. x, figs. 3, 4. Upper Silur. Gothland, Sweden.

This species and **P. radiatus** differ from the typical form of the genus.

1878. **Periechocr. interradiatus** Angl. Iconogr. Crin. Suec. Figured without description, Pl. 19, fig. 15. Upper Silur. Dudley, Eng.

*1848. **Periechocr. lævis** Portlock. (**Trochocrinites lævis**) Geol. of Londonderry, p. 345, Pl. 15, fig. 1. Silurian. Tyrone, Ireland.

*1880. **Periechocr. Lindströmi** Wachsm. and Spr. (Described by Angelin as **Actinocr. interradiatus** = **Periechocr. interradiatus**—not the previous species from Dudley). Iconogr. Crin. Suec., p. 6, Pl. 26, fig. 15. Upper Silur. Gothland, Sweden.

This species was named in honor of Prof. Lindström of Stockholm.

*1878. **Periechocr. longidigitatus** Angel. (**Actinocr. longidigitatus**) Iconogr. Crin. Suec., p. 6, Pl. 26, figs. 19, 19 a. Upper Silur. Gothland, Sweden.

*1878. **Periechocr. longimanus** Angel. (**Actinocr. longimanus**). Iconogr. Crin. Suec., p. 6, Pl. 15, fig. 17 and Pl. 26, fig. 16; Pl. 28, figs. 5 and 6. Upper Silur. Gothland, Sweden.

*1878. **Periechocr. minor** Wachsm. and Spr. (Desc. by Angel. as **P. lævis**, not **P. lævis** Portlock's sp.) Iconogr. Crin. Suec., p. 7, Pl. 18, fig. 11. Upper Silur. Gothland, Sweden.

1821. **Periechocr. moniliformis** Miller. (**Actinocr. moniliformis**). Type of the genus, Nat. Hist. Crinoidea, p. 116; Phillips, 1839, Murchison's Silur. Syst., p. 673, Pl. 18, fig. 4; d'Orbigny, 1850, **Geocr. moniliformis** Prodr., i, p. 46; Angel., 1878, Iconogr. Crin. Suec., Pl. 19, figs. 14, a, b, c. Upper Silur. Dudley, Eng.

Syn. **Periechocr. costatus** Austin, 1843. Ann. and Mag. Nat. Hist., xi, p. 204.

*1878. **Periechocr. nubilus** Angelin. (**Actinocr. nubilus**). Iconogr. Crin. Suec., p. 6, Pl. 18, fig. 14. Upper Silur. Gothland, Sweden.

*1875. **Periechocr. ornatus** Hall. (**Saccocr. ornatus**). Geol. Rep. Ohio Paleont., ii, p. 126, Pl. 6, figs. 7, 9. Niagara gr. Yellow Springs, O.

*1854. (?) **Periechocr. pulcher** (Salter MS.) McCoy. (**Actinocr. pulcher**). Synop. Brit. Pal. Foss., p. 55, Pl. 1 d, fig. 3. Upper Silur. Wales.

(This species is not well known, and may possibly belong to a separate group with **P. radiatus**, **P. gothlandicus**, or may be a **Glyptocrinus**.)

*1878. **Periechocr. quinquangularis** Angel. (**Actinocr. quinquangularis**). Iconogr. Crin. Suec., p. 6, Pl. 16, figs. 27, 27 a, 28. Upper Silur. Gothland, Sweden.

1878. (?) **Periechocr. radiatus** Angel. Iconogr. Crin. Suec., p. 7, Pl. 10, figs. 1 and 2, and Pl. 23, fig. 3; and Pl. 27, figs. 6, 7. Upper Silur. Gothland, Sweden.

This form differs in the size, in the style of ornamentation, and the greater number of secondary radials, from the typical species.

1878. **Periechocr. scanicus** Angel. Iconogr. Crin. Suec., p. 7, Pl. 19, figs. 16, 16 a. Upper Silur. Gothland, Sweden.

*1878. **Periechocr. Schultzianus** Angel. (**Actinocr. Schultzianus**). Iconogr. Crin. Suec., p. 6, Pl. 18, fig. 13. Upper Silur. Gothland, Sweden.

*1867. (?) **Periechocr. semiradiatus** Hall. (**Saccocr. semiradiatus**). 20th Rep. N. Y. St. Cat. Nat. Hist., p. 37, Pl. 10, fig. 1. Niagara gr. Racine, Wis. Desc. from natural casts.

*1862. **Periechocr. speciosus** Hall. (**Saccocr. speciosus**). Paleont. N. Y., ii, p. 205, Pl. 44, figs. 1 and 2; also Roemer, 1860, Silur. Fauna West. Tenn., p. 42, Pl. 3, fig. 4. Niagara gr. Western Tennessee.

*1861. **Periechocr. tenuidiscus** Hall. (**Actinocr.** (?) **tenuidiscus**). Desc. New Spec. Pal. Crin., p. 14. Lower Burlington limest. Burlington, Iowa.

*1861. **Periechocr. Whitei** Hall. (**Actinocr.—Megistocr.—Whitei**). Desc. New Spec. Pal. Crin., p. 2; also Bost. Journ. Nat. Hist., p. 271; Meek and Worthen, 1873, **Megistocr. Saccocr.** Whitei, Geol. Rep. Ill., v, Pl. 6, fig. 1. Lower Burlington limest. Burlington, Iowa.

The name of this species was printed originally **Actinocr. Megistocr. olliculus**, but Hall changed it before publication in writing as given above. Among the Photogr. Plates subsequently published by Hall of some of his new species (drawn by Whitfield and photographed by Haines), we find that through mistake fig. 6 on Pl. 4 has been referred to **Megistocr. Whitei.** This is beyond doubt Hall's **Actinocr. glans,** an entirely different form, which has a long slender anal tube and *simple* arms, the reverse of **Megistocr. Whitei,** which has an anal opening *through the test* and branching arms. The original, formerly in the collection of Rev. Wm. H. Barris, and now in the Museum of Comp. Zoology at Cambridge, was returned by Hall labeled **Actinocr. eryx,** which is identical with **Actinocr. glans.** The type specimen of **Megistocr. Whitei** is in the Museum at Ann Arbor.

13. ABACOCRINUS Angelin.

1878. Angelin. Iconogr. Crin. Suec., p. 19.

1879. Zittel. Handbuch der Palæontologie, i, p. 373.

Syn. *Actinocrinus* Goldfuss (in part), 1826. Petref. Germ., i, p. 194.

Abacocrinus has its closest affinities with *Megistocrinus* Owen and Shum., from which it differs in the number of basals, and perhaps (?) in the construction of the vault, which in the former is not known. It differs from *Periechocrinus* in being composed of heavier plates, and in the number of basals.

Angelin places *Abacocrinus* with *Corymbocrinus* into a separate family. The two agree remarkably in the arm structure, and both have four basals; but the latter plates which in *Abacocrinus* are large and formed into a cup, in *Corymbocrinus* are very small, hidden from view, and located within a deep funnel as in the case of *Eucalyptocrinus*. With this genus and the allied *Callicrinus*, *Corymbocrinus* agrees in the general construction of the calyx so closely, that it would be difficult to distinguish them even generically, unless the vault and arms were preserved. We therefore arrange *Corymbocrinus* with the Calyptocrinidæ.

Zittel places *Abacocrinus* and *Cromycrinus* both under the Melocrinidæ.

Generic Diagnosis.—Body large, oblong. Calyx ovoid to subglobose; composed of numerous, rather heavy and convex plates; symmetry bilateral.

Basal disk convex, largely extending beyond the column; composed of four unequal plates, with a shallow concavity for the reception of the column. Primary radials 3×5, the two proximal ones much wider than high; the first pentagonal or hexagonal, and owing to the irregular number of basals, differing somewhat in form. The second radials are hexagonal, except the posterior ones which are pentagonal, smaller than the first. The third irregularly pentagonal or hexagonal, depending on the relative size of adjoining interradials, sometimes even heptagonal.

Secondary radials 2×10; comparatively large, supporting two rows of from five to six plates each, transversely arranged, alternating with each other, and laterally interlocking. The first series comparatively higher, the succeeding plates gradually decreasing in length but increasing in width. The two rows resemble, and evidently were, interlocking arm plates, which in geological times and by age became fixed and enclosed within the body; they form the two main trunks of the ray, which divides on becoming free, each branch dividing several times again, but irregularly at uneven intervals.

Arms branching, long, gradually tapering, from the base up composed of two rows of plates, which increase to four when the bifurcation takes place. Pinnules long.

Interradials numerous, with one plate in the first, two in the second, and generally a single one in the third series, all large and nearly of equal size. The fourth series has generally but one plate, which is followed by several other series of smaller plates, each composed of from two to three pieces. The first anal plate is octangular, exceedingly large, larger even than the first radials.

It lies directly above one of the basals, resting upon its truncate upper side. Second series composed of three plates, the middle one extending beyond the other two; the two outer ones in line with the second series of interradials (not the first as is usually the case), and rests against the superior edges of the second (not the first radials), these again are followed by five or six rows of plates, generally of three each, which decrease in size upward. The plates of the interaxillary areæ are numerous.

There is a single large plate in each of the two first series, which, together with the upper interradial plates, connect the two main arm-trunks with the body walls. Construction of the vault unknown.

Column large, composed of rather high, alternately thicker and thinner joints.

Geological Position, etc.—Abacocrinus, so far as known, is confined to the Upper Silurian of Europe.

Angelin places here the following species:

1878. **Abacocrinus Cappelleri** Angelin. Iconogr. Crin. Suec., p. 19, Pl. 3, figs. 8, 8 a. Upper Silur. Gothland, Sweden.

1878. **Abacocr. medius** Angelin. Iconogr. Crin. Suec., p. 19, Pl. 24, fig. 1. Upper Silur. Gothland, Sweden.

1878. **Abacocr. tessellatus** Angl. Iconogr. Crin. Suec., p. 19, Pl. 18, fig. 6, and Pl. 23, figs. 24, 25. Upper Silur. Gothland, Sweden.

1826. **Abacocr. tesseracontadactylus** Goldf. (**Actinocrinus tesseracontadactylus**), Petref. German, i, p. 194, Pl. 59, fig. 5; Angelin, 1878, **Ababocrinus**, (type of the genus). Iconogr. Crin. Suec., p, 19, Pl. 18, figs. 2, 5, and Pl. 23, figs. 23, 23 a. Upper Silur. Gothland, Sweden.

14. MEGISTOCRINUS Owen and Shumard,

1852. Ow. & Shum. U. S. Geol. Rep. Iowa. Wis. & Minn., p. 594.
1857. Lyon. Proc. Acad. Nat. Sci. Phila., p. 412.
1858. Hall. Geol. Rep. Iowa. i., pt. ii, p. 479.
1859. Lyon & Casseday. Amer. Jour of Sci., vol. 28, p. 243.
1862. White. Proc. Bost. Soc. Nat. Hist., p. 16.
1869. Meek & Worth. (in part). Proc. Acad. Nat. Sci. Phila., p. 163.
1873. Meek & Worth. (in part). Geol. Rep. Ill, v, p. 393.
1876. White. Proc. Acad. Nat. Sci., Phila., p. 29.
1878. Barris. Proc. Davenport. Acad. Nat. Sci., ii, p. 285.
1879. Zittel. Handbuch der Palæontologie, i, p. 371 (not Hall, 1861, Bost. Journ. Nat. Hist., p. 271; nor Winchell and Marcy, 1866, Mem. Bos. Soc. Nat. Hist., pp. 87 and 110 = *Periechocrinus*),

Syn. *Actinocrinus* Hall, 1858. Geol. Rep. Iowa, i, pt. ii, pp. 571 and 573.

Syn. *Actinocrinus* Lyon, 1857. Geol. Rep. Ky., iii, p. 479.

Syn. *Sagenocrinus* Angelin, 1878 (in part). Iconogr. Crin. p. 8.

This genus is closely allied to *Abacocrinus*, but differs essentially in the number of basals, and in the disposition of the anal plates. It differs from *Periechocrinus* in the depressed form of the body, in the robust nature of its plates, and in the construction of the vault.

By former authors, and originally by Owen and Shumard, *Megistocrinus* was referred subgenerically to *Actinocrinus*. It was thereby sufficiently distinguished as long as the majority of all Actinocrinidæ were referred to the genus *Actinocrinus*, but since this has been subdivided and restricted to a limited group, it is evident that *Megistocrinus* should form a distinct genus. Angelin made it a synomym of *Sagenocrinus* but this has underbasals and single-jointed branching arms.

Generic Diagnosis.—Species generally large. Body depressed, wider than high; calyx in form of a cup or basin, of which the lower portions, up to the middle of the first radials, form the bottom part; plates heavy; dome not much elevated; symmetry bilateral.

Basals three, of equal size, spreading horizontally and producing an equilateral, hexagonal disk, which is either on the same plane with the surrounding radials and first anal plate, or, which forms between those plates a sunken area without any further concavity. Primary radials 3×5, almost of like form, slightly decreasing in size upward; all wider than high, and generally hexagonal. The third radials have an obtuse angle, and support from their sloping sides a single secondary radial, which is either axillary and succeeded by $1 \times 2 \times 10$ tertiary radials, or is followed by two rows of plates which are arranged transversely, alternating with each other and interlocking, and which, as in *Abacocrinus*, form the main trunks of the arms. In species with tertiary radials these support two rows of plates, similar to those of the preceding order, and there are within the body three or four arm trunks instead of two.

Arms bifurcating throughout their length, and in a similar manner as in the preceding genus. The arms, from the body up, are composed of two rows of short joints, and are fringed with long, round pinnules.

Interradials numerous; one in the first, two in the second, and three in the third series, with several more ranges of minute pieces above. First anal plate in line with the first radials, and of the same form and proportions; succeeded by three plates in the second, three or four in the third, and a number of irregular small plates above. Axillary pieces three or more, which, with the upper interradial pieces, connect the lower portions of the arms with the body.

Vault depressed, slightly convex, composed of a great number of pieces, irregularly arranged, which surround the considerably larger, and generally nodose or spiniferous apical plates. The central plate is always very conspicuous, and is enclosed either directly by the proximal dome plates (but only in very small pieces and in young specimens), or it is, more frequently, separated from the others by a broad ring of small pieces, which also separate the proximal plates from each other. The first radial dome plates are large, isolated and pushed near the margin of the ventral disk. Anal opening on top of a short proboscidiform protuberance, which in Devonian species is placed more or less excentric, while in all species from the Subcarboniferous it is strictly lateral and located within the horizon of the arm-bases.

Column round, very strong, composed of alternately thicker and thinner joints, with large lateral cirrhi toward the lower end, and an enormous root; articulating faces of all columnar joints strongly marked with radiating lines; central canal very large and decidedly pentalobate.

Geological Position, etc.—*Megistocrinus* ranges from almost the base of the Devonian to the Burlington limestone, where it becomes extinct. It is only known from America.

We recognize the following species:—

1857. **Megistocrinus abnormis** Lyon. (**Actinocr. abnormis**). Geol. Rep. Ky., iii, p. 479, Pl. 4, figs. 1 a, b. Encrinal limest. Devonian. Louisville, Ky.

*1858. **Megistocr. brevicornis** Hall. (**Actinocr. brevicornis**). Geol. Rep. Iowa, i, pt. ii, p. 571, Pl. 10, figs. 4 a, b. Lower Burlington limest. Burlington, Iowa.

Syn. **Actinocr. superlatus** Hall, 1858. Geol. Rep. Iowa, ii, p. 572.

Syn. **Actinocr. minor** Hall, 1858. Ibid., p. 573.

1862. **Megistocr. crassus** White. Proc. Bost. Soc. Nat. Hist., ix, p. 17. Lower Burlington limest. Burlington, Iowa.

1862. **Megistocr. depressus** Hall. 15th Rep. N. York St. Cab. Nat. Hist., p. 134. Hamilton gr. Western N. York.

1850. **Megistocr. Evansii** Owen and Shum. (Type of the genus). **Actinocr. Evansii.** Jour. Acad. Nat. Sci. Phila. (new ser.), vol. i, pt. ii, p. 68; **Megistocr. Evansii,** 1852, U. S. Geol. Rep. Iowa, Wisc. and Minn., p. 594, Pl. 5 A, figs. 3 a, b. Lower and Upper Burlington limest. Burlington, Iowa.

Syn. **Megistocr. plenus** White. Proc. Bost. Soc. Nat. Hist., ix, p. 16.

Syn. **Megistocr. parvirostris** Meek and Worth. Proc. Acad. Nat. Sci. Phila., p. 165; Geol. Rep. Ill., vol. v, p. 396, Pl. 6, fig. 7.

Megistocr. Evansii was described from the Lower, and **M. plenus**, and **M. parvirostris** from the Upper Burlington limestone. The latter is evidently only a young specimen of **M. plenus**, which cannot be distinguished sufficiently from the lower bed form. It is highly probable that **M. brevicornis** is likewise a young stage of **M. Evansii**.

1876. **Megistocr. Farnsworthi** White. Proc. Acad. Nat. Sci. Phila., p. 29. Hamilton gr., Devon. Solen and Iowa City, Iowa.

1857. **Megistocr. Knappi** Lyon. Proc. Acad. Nat. Sci. Phila., p. 412, Pl. 4, figs. 6 a, b. Upper Helderberg, Louisville, Ky.

1858. **Megistocr. latus** Hall. Geol. Rep. Iowa, vol. i, pt. ii, p. 480, Pl. 1, figs. 1 a, b. Hamilton gr. New Buffalo, Iowa.

1878. **Megistocr. nodosus** Barris. Proc. Davenport Acad. Nat. Sci., vol. ii, p. 285, Pl. 2, fig. 4. Encrinal limest. Near Davenport, Iowa.

1862. **Megistocr. Ontario** Hall. 15th Rep. N. York St. Cab. Nat. Hist., p. 136. Hamilton gr. Western New York.

1859. **Megistocr. rugosus** Lyon and Cass. Amer. Journ. Sci., vol. 28, p. 243. Encrinal limest. Louisville, Ky.

1861. **Megistocr. spinosulus** Lyon. Proc. Acad. Nat. Sci. Phila., p. 413, Pl. 4, figs. 7 a, b. Upper Helderberg gr. Louisville, Ky.

Either this species is incorrectly figured, or it does not belong here. It slightly resembles **Hadrocrinus** Lyon.

e. Actinocrinites.

15. ACTINOCRINUS Miller.[1]

1821. Miller. History of the Crinoidea, p. 90.
1844. McCoy. Synop. Carb. Foss. Ireland.
1853. De Koninck and Lehon. Rec. Crin. Belg., p. 125.
1855. Roemer. Lethæa Geogn. (Ausg. 3), p. 246.
1866. Meek and Worthen. Geol. Rep. Ill., ii, p. 149.
1869. Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 153.
1873. Meek and Worthen. Geol. Rep. Ill., v, p. 340.
1878. Wachsm. and Spr. Proc. Acad. Nat. Sci. Phila., p. 241.
1878. Zittel. Handb. der Palæontologie, i, p. 369.

Not Angelin, 1878. Iconogr. Crin. Suec., p. 6.

Under *Actinocrinus* a very large number of forms have been described from America and Europe, and from the Upper Silurian to near the close of the Subcarboniferous, which were afterwards referred to independent genera. There can be, however, no doubt as to the group which should keep the name, as fortunately all of

[1] In the list of references we quote only those publications which have a direct or indirect bearing upon the present, greatly restricted form of the genus. The following writers embraced with it, more or less, the entire family: Agassiz, 1835; Goldfuss, 1826-1831; Phillips, 1836-1839; McCoy, 1844; Austin, 1842; D'Orbigny, 1850; Owen and Schumard, 1850-1852; de Kon. and Lehon, 1853; Shumard, 1855 and 1866; Pictet, 1857; Joh. Müller, 1857; Hall, 1858, 1860 and 1861; McChesney, 1860; Schultze, 1867.

Miller's typical species, with a single exception, belong to the same division, and his *A. triacontadactylus* and *A. polydactylus* must form the types.[1] The genus *Actinocrinus*, as amended by Meek and Worthen, and as it is now understood, embraces almost the majority of all European Actinocrinidæ, while it includes in this country, although represented by even more species, only a comparatively small portion of the general representation of the family.

Meek and Worthen, after carefully restricting the genus, separate it in vols. ii and v of the Illinois Report into two sections:

A. The arms given off directly from the body and forming a continuous ring around it; the divisions of the ray taking place in the calyx proper, which has a more or less subconical form.

B. The radials, from the third primary up, bend abruptly outward, forming protruding lobes, which at the interradial spaces produce deep sinuses. The divisions take place in the lobes, which frequently are extended into free rays, and these giving off the arms.

Looking at the species of the two sections, and particularly at *A. proboscidialis* with only twenty arms on the one hand, and *A. Lowei* with fifty or sixty arms on the other; these distinctions seem to acquire almost generic value; but comparing species with a more nearly equal number of arms, it will be found that the division cannot be carried out practically, at least not among the European species, which in the majority of cases form a link between the two extremes of the American species.

The genus *Actinocrinus* has frequently been confounded with *Batocrinus*, and neither Casseday, the founder of the latter, nor Meek and Worthen, who recognize it, have pointed out any distinctions which warrant their generic division. Such, however, do exist, as we hope to prove.

In *Actinocrinus* and other Actinocrinites, the anal area, as a rule, has but a single special anal plate, and this located between the two first primary radials. There are two plates in the second series which are in line with—and take the place of—the larger first

[1] Roemer in 1855 restricted the genus *Actinocrinus* to the Subcarboniferous, and included in it only such species which at the arm regions are provided "mit rundlichen Falten," and in which the vault is elevated and extended into a proboscis. He refers all Silurian and Devonian species previously described under *Actinocrinus*, to distinct families.

interradial in other series, contrary to *Batocrinus* and all other groups of the Actinocrinidæ, which in that series have three plates, or, as we express it, also a special anal plate in the second series. In *Batocrinus* the second primary radials are linear and quadrangular, in *Actinocrinus* hexagonal and of a similar form as the first radials. The secondary radials in the former contain two or even three pieces, while in the latter the same order of radials, and all others above the first, have but a single series of plates.

In *Batocrinus* the arms, from the first joint up, are composed of a double series of small pieces, while these plates in *Actinocrinus* are preceded by two, three or more large cuneate single joints. In both genera the species show a great variability in the number of their arms, but while in *Actinocrinus* the whole number of arms is equally divided among the rays, in *Batocrinus* the rays adjoining the posterior side frequently have the greater number. In the former, all divisions of the ray are given off alternately from opposite sides, the branches remaining simple; in *Batocrinus*, the divisions are equal, and each branch bifurcates again; there are, however, rarely more than two divisions from each ray, except toward the posterior side, where the inner division of the rays have sometimes two additional bifurcations.

Closer than with *Batocrinus* are the relations with *Gennæocrinus*, which, as has been stated, occupies an intermediate position between *Actinocrinus* and *Batocrinus*, and which, preceding them in geological times, represents a link between the two genera.

We place McCoy's *Phillipsocrinus* provisionally under *Actinocrinus*, which it resembles very closely in its general habitus. It has the same peculiar ornamentation, is lobed, has a strong subcentral anal tube, nodose vault-pieces, but it has, according to description, four basals and only 2 × 5 radials. The latter was evidently a mistake, most probably the third radials were strongly bent outward and not preserved. McCoy had only a single specimen for description, and that this was an abnormal one is sufficiently proved by the presence of seven plates in the second range. It is very possible that the malformation made the additional plate in the basal ring necessary, for there is no other specimen with four basals known from the Subcarboniferous. Pictét refers *Phillipsocrinus* to *Melocrinus*, which we cannot indorse.

Generic Diagnosis.—Body turbinate, more or less lobed at the arm-regions; calyx beautifully ornamented with radiating striæ, which concentrate at the middle of the plate, where they form into a more or less prominent node; vault extended into a large subcentral anal tube.

Basals three, equal, rather large, and forming a shallow cup, the lower side slightly excavated for the column. Primary radials 3×5, the first larger than the rest, alternately hexagonal and heptagonal, generally higher than wide; the second hexagonal, smaller than the first, its height almost as great as its width; the third pentagonal and smaller, frequently bent outward, sometimes abruptly, and forming the base of a lateral extension, which gives to the radial portions a lobed, and to the general body a stellate form. Secondary radials 1×10, axillary. Succeeding orders of radials composed of a single series of plates to each division of the ray, the one axillary, the other simple. The simple plate is succeeded by a number of brachials connected with the body, which jointly form a fixed branch in a lateral direction.

The axillary plate supports always toward the opposite side of the preceding order the next series of radials, and so on alternately until the full number of arms of the species is produced. Arms numerous, not bifurcating in their free state, or rarely so; their number very variable, ranging among the different species from not less than twenty to fifty or more; and these equally divided among the rays. The arms are long, rather heavy, their upper ends round or somewhat flattened, the tips infolded. They are composed of a double series of narrow plates, separated by a zigzag suture. The pinnules are long, given off, like in the case of all double-jointed arms, from every joint and from both rows, they are laterally compressed, with the abutting sides flat. The joints of which the pinnules are composed are long, and they are provided at their outer side, near the middle, with a tooth-like spine, sometimes of considerable length, which is curved upward in form of a hook. The inner side of the joints is deeply grooved, and covered with two rows of small alternate plates. The pinnules are laterally attached, and resemble a fine network; those of the same arm rest tightly against those of the opposite row, thus closing the ventral furrows both of arm and pinnules, in case the arms are folded.

The interradials generally consist of three large plates, almost of equal size. There is one in the first, and two in the succeeding series, the third series consisting either of one large or of two comparatively small pieces, a fourth series is but rarely observed. The posterior side has a special anal plate in line with the first primary radials, and is of equal size with them. There are two plates in the second, smaller than the first interradial at the other sides, and one, two or three plates in the succeeding series. Interaxillary plates may be present or absent, their number never exceeds three.

The vault is composed of rather conspicuous plates, all proximal and radial dome plates nodose or tuberculous, the others merely convex, with the exception of the centre plate, which is prominent, larger than the rest, and which toward the anterior side forms the base of the anal tube. The tube is almost central, strong, composed of heavy pieces, and sometimes extends beyond the limits of the arms.

Inner floor of the vault, along the interpalmar spaces, strengthened by braces, which increase in thickness outward, leaving open galleries which diverge to the arm bases. There is a respiratory (?) pore apparently at the side of each arm opening; they however, are but rarely observed, owing to imperfect preservation of the arm bases.

Column long, moderately heavy, its joints frequently sharply edged; central canal round or pentalobate, and of medium size.

Geological Position, etc.—The genus is strictly Subcarboniferous, and has been found only in the lower and middle portions of that formation. In America it does not extend vertically beyond the Keokuk limestone; geographical distribution wide.

We recognize the following species:—

1853. **Actinocrinus armatus** De Koninck and Lehon. Rech. Crin. Belg., p. 138, Pl. 4, figs. 4, a, b, c; Meek and Worthen, Geol. Rep. Ill., ii, p. 149. Mount. limest. Tournay, Belgium.

1869. **Actinocr. asperrimus** Meek and Worthen. (**Strotocr.** (?) **asperrimus**). Proc. Acad. Nat. Sci. Phila., p. 160; also Geol. Rep. Ill., v, p. 349, Pl. 8, fig. 3. Lower Burlington limestone (not Upper, as stated by Meek and Worthen).

This is a regular transition form between **Actinocrinus** and **Teleiocrinus**, but as the rim is interrupted not only at the interradial, but also over the interaxillary spaces, we arrange it with **Actinocrinus**.

1860. **Actinocr. brontes** Hall (Sect. A). Supp. Geol. Rep. Iowa, p. 47; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Keokuk limest. Keokuk, Iowa.

1861. **Actinocr. clarus** Hall (Sect. B). Desc. New Sp. Crin., p. 2; also Bost. Journ. Nat. Hist., p. 277, Photgr. Pl. 2, figs. 24, 25; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Lower Burlington limest. Burlington, Iowa.

1858. **Actinocr. cœlatus** Hall (Sect. B). Geol. Rep. Iowa, i, pt. ii, p. 585, Pl. 10, figs. 14, a, b; Meek and Worthen, Geol. Rep. Illinois, v, p. 341. Lower Burlington limest. Burlington, Iowa.

1844. **Actinocr. constrictus** McCoy (Sect. A). Synop. Carb. Foss. Ireland, p. 181, Pl. 27, fig. 3. Mount. limest. Ireland.

1844. **Actinocr. costus** McCoy. Synop. Carb. Foss. Ireland, p. 181, Pl. 26, fig. 2; de Kon. and Lehon, 1853, Recher. Crin. Belg., p. 129, Pl. 3, figs. 2, a, b and Pl. 4, figs. a-d. Mount. limest. Ireland, and Tournay, Belg.

It seems very probable that **A. costus**, **A. lævis** and **A. tennuis** are synonyms.

1864. **Actinocr. Daphne** Hall (Sect. B). 17th Rep. N. York St. Cab. Nat. Hist., p. 52; also 1873, Geol. Rep. Ohio Paleont., ii, p. 162, Pl. 11, fig. 11. Waverly sandstone. Richfield, Ohio.

1843. **Actinocr. decadactylus** Portlock (not Goldf. = **Melocr. decadactylus**). Geol. Rep. Londonderry, p. 349. Mount. limest. Ireland.

1853. **Actinocr. deornatus** de Kon. and Lehon. Recher. Crin. Belg., p. 142, Pl. 3, figs. 5, a, b. Mount. limest. Tournay, Belg., and Wexford, Engl.

Probably **A. deornatus**, **A. stellatus**, **A. dorsatus**, and perhaps **A. icosidactylus** are synonyms.

1853. **Actinocr. dorsatus** de Kon. and Lehon. Recher. Crin. Belg., p. 139, Pl. 4, figs. 5 a, b: Meek and Worthen (Sect. A), Geol. Rep. Ill., ii, p. 149. Mount. limest. Tournay, Belgium.

*1869. **Actinocr. ectypus** Meek and Worthen. (**Strotocr. ectypus**). Proc. Acad. Nat. Sci. Phila., p. 159; also 1873, Geol. Rep. Ill., v, p. 253, Pl. 7, fig. 5. Lower Burlington limest. Burlington, Iowa.

This is a good **Actinocrinus**, the type specimen was depressed, and thereby had obtained an unnatural expression somewhat like **Strotocrinus**.

1861. **Actinocr. excerptus** Hall (Sect. B). Desc. New Sp. Crin., p. 3; also, Bost. Jour. Nat. Hist., p. 276; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Lower Burlington limest. Burlington, Iowa.

A very doubtful species, probably *Syn.* of **A. proboscidialis**.

1860. **Actinocr. Fosteri** McChesney (Sect. B). Desc. New Pal. Foss., p. 19; also, 1867, Chicago Acad. Sci., p. 14, Pl. 5, fig. 2; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Lower Burlington limest. Burlington, Iowa.

1860. **Actinocr. glans** Hall. Supp. Geol. Rep. Iowa, p. 16. Upper Burlington limest. Burlington, Iowa.

Syn. **Actinocr. tholus** Hall, 1860. Supp. Geol. Rep. Iowa, p. 35.

Syn. **Actinocr. eryx** Hall, 1861. Desc. New Pal. Crin., p. 12.

This is a very variable species. The plates of the body in the lower layers at Burlington are scarcely convex, higher up, almost tuberculous, specimens of the former kind being described as **A. glans**, those of the latter as **A. tholus**. As **A. eryx** Hall redescribed a species of **A. glans** in which arms and anal tube were preserved, and in his photographic plates, which were distributed several years later, Hall unfortunately confounded his **A. eryx** (we examined the type specimen now in the Museum of Comparative Zoology at Cambridge), with **Megistocr. Whitei**, which has branching in place of simple arms, and no anal tube.

The species deviates somewhat in its general habitus from **Actinocrinus**, and we therefore place it here with some doubt.

1860. **Actinocr. Hurdianus** McChesney (Sect. B). Desc. New Pal. Foss., p. 24; also 1867, Chicago Acad. Sci., p. 17, Pl. 5, figs. 24; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Lower Burlington limest. Burlington, Iowa.

1843. **Actinocr. icosidactylus** Portlock. Rep. on the County of Londonderry, p. 348, Pl. 15, fig. 7; de Kon. and Lehon, 1853, Recher. Crin. Belg., p. 141, Pl. 2, fig. 4 and Pl. 4, fig. 6. Mount. limest. Engl. and Belg.

1861. **Actinocr. infrequens** Hall (Sect. B). Desc. New Sp. Crin., p. 14; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Lower Burlington limest. Burlington, Iowa.

1860. **Actinocr. jugosus** Hall (Sect. A). Supp. Geol. Rep. Iowa, p. 49. Lower portion of the Keokuk limest. Keokuk, Iowa, and Warsaw and Hamilton, Ill.

1821. **Actinocr. lævis** Miller (not Goldfuss nor Kloeden). Hist. of Crinoidea, p. 105, and plates; Agassiz, 1835, Mem. Soc. Neuchat., i, p. 196; Milne-Edwards, Anim. s. vert. de Lamk. (2me ed.), vol. ii, p. 670; de Koninck, 1842, Anim. Foss. du Terr. Carb., p. 52, Pl. G, figs. 4 a, b, c; McCoy, 1844 (with doubt), Syn. Carb. Foss. Ireland, p. 182; de Kon. and Lehon, 1853, Recher. Crin. Belg., p. 152, Pl. 3, fig. 6. Mount. limest. Tournay, Belg.

Syn. **Encrinus dubius** Schlottheim. Nachtr. Petref., ii, p. 100, Pl. 28, figs. 2 a, b.

1861. **Actinocr. limabrachiatus** Hall (Sect. B). Desc. New Sp. Crin., p. 2; also, Bost. Jour. Nat. Hist., p. 268; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Lower Burlington limest. Burlington, Iowa.

1860. **Actinocr. lobatus** Hall (Sect. A). Supp. Geol. Rep. Iowa, p. 51; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Keokuk limest. Warsaw, Ill.

1869. **Actinocr. longus** Meek and Worthen (Sect. B). Proc. Acad. Nat. Sci. Phila., p. 156; also, Geol. Rep. Ill., v, p. 345, Pl. 8, fig. 1. Lower Burlington limest. Burlington, Iowa.

1858. **Actinocr. Lowei** Hall (Sect. A). Geol. Rep. Iowa, i. pt. ii, p. 611, Pl. 15, figs. 5 a, b; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Keokuk limest. Iowa and Illinois.

1861. **Actinocr. lucina** Hall (Sect. B). Desc. New Sp. Crin., p. 11. Lower Burlington limest. Burlington, Iowa.

1858. **Actinocr. multibrachiatus** Hall (Sect. B). Geol. Rep. Iowa, i, pt. ii, p. 580, Pl. 10, fig. 10; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Lower Burlington limest. Burlington, Iowa.

Syn. **A. multibrachiatus** var. **echinatus** Hall, 1861. Desc. New Pal. Crin., p. 10.

1857. **Actinocr. multiradiatus** Shumard (Sect. A). Trans. Acad. Sci. St. Louis, i, p. 7, Pl. 1, fig. 5; Hall, 1858, Geol. Rep. Iowa, i, pt. ii, p. 579, Pl. 10, fig. 9; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Upper Burlington limest. Burlington, Iowa.

1861. **Actinocr. opusculus** Hall (Sect. B). Bost. Journ. Nat. Hist., p. 261; Meek and Worthen, 1873, Geol. Rep. Ill., v, p. 341. Lower Burlington limest. Burlington, Iowa.

1849. **Actinocr. olla** McCoy (Sect. A). Ann. and Mag., p. 247. Mount. limest. Derbyshire, Eng.

1861. **Actinocr. ovatus** Hall (Sect. B). Desc. New Pal. Crin., p. 14; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Lower Burlington limest. Burlington, Iowa.

1869. **Actinocr. penicillus** Meek and Worthen (Sect. A). Proc. Acad. Nat. Sci. Phila., p. 155; also, 1873, Geol. Rep. Ill., v, p. 342, Pl. 8, fig 2. Lower Burlington limest. Burlington, Iowa.

1858. **Actinocr. pernodosus** Hall (Sect. A). Geol. Rep. Iowa, i, pt. ii, p. 608, Pl. 15, figs. 3, a, b; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Keokuk limest. Iowa and Illinois.

1821. **Actinocr. polydactylus** Miller (not Bonney = *Mariacr. pachydactylus* Hall, = *Melocr. pachydactylus* Wachsm. and Spr.). Hist. Crinoidea, p. 103; Agassiz, Mem. Soc. de Neuchat., i, p. 197; Milne-Edwards, 1836, Anim. s. vert. de Lamk. (ed. ii), vol. ii, p. 670; Bronn, 1836, Lethæa Geogn., i, p. 61, Pl. 4, fig. 4, and p. 670; Phillips, 1836, Geol. Yorkshire, ii, p. 206, Pl. 4, figs. 17, 18; de Koninck, Anim. Foss. Terr. Carb. Belg., p. 51, Pl. G, figs. 3, a, b; McCoy, 1844, Synop. Carb. Foss. Ireland, p. 183, and British Pal. Foss. Mus. Cambr., ii, p. 121; de Kon. and Lehon, 1853, Recher. Crin. Belg., p. 154, Pl. 4, fig. 2; Roemer, 1855, Lethaea Geogn. (Ausg. 3), p. 248. Mount. limest. Mendip Hills, Caldy, Ireland, and Tournay, Belg.

1858. **Actinocr. proboscidialis** Hall (Sect. B). Geol. Rep. Iowa, i, pt. ii, p. 584, Pl. 10, fig. 13; Meek and Worthen, 1873, Geol. Rep. Ill., v, p. 341. Lower Burlington limest. Burlington, Iowa.

Syn. **A. lagina** Hall, 1861. Desc. New Pal. Crin., p. 13.

Syn. **A. quaternarius** Hall, 1860. Supp. Geol. Rep. Iowa, p. 22.

Syn. **A. quaternarius** var. **spiniferus** Hall, 1861. Desc. New Pal. Crin., p. 11.

Syn. **A. themis** Hall, 1861. Ibid., p. 11.

1844. (?) **Actinocr. pusillus** McCoy. Synop. Carb. Foss. Ireland, p. 182, Pl. 26, fig. 4. Mount. limest. Ireland.

There is some doubt whether this species belongs to **Actinocrinus**; the rays are lobed but more like in species of **Dorycrinus**. Figure and description are too indistinct to ascertain therefrom the form of the anus.

1861. **Actinocr. reticulatus** Hall (Sect. B). Desc. New Spec. Crin., p. 2; also Bost. Journ. Nat. Hist., p. 269; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Lower Burlington limest. Burlington, Iowa.

Syn. **A. locellus** Hall, 1861. Desc. New Pal. Crin., p. 15.

Syn. **A. thoas** Hall, 1861. Ibid., p. 11.

1860. **Actinocr. scitulus** Meek and Worthen (Sect. A). Proc. Acad. Nat. Sci. Phila., p. 386; also Geol. Rep. Ill., ii, p. 202, Ibid., v, p. 341. Upper Burlington limest. Burlington, Iowa.

Syn. **A. rusticus** Hall, 1861. Desc. New Sp. Crin. p. 2; also Bost. Journ. Nat. Hist., p. 267.

Syn. **A. Sillimani** Meek and Worthen, 1861. Proc. Acad. Nat. Sci. Phila., p. 134.

Syn. **A. Wachsmuthi** White, 1861 (not 1879). Proc. Bost. Acad. Nat. Hist., vol. ix, p. 17.

1860. **Actinocr. sexarmatus** Hall (Sect. B). Supp. Geol. Rep. Iowa, p. 21; Meek and Worthen, Geol. Rep. Ill., v, p. 341, Photogr. Pl. 3, fig. 26. Lower Burlington limest. Burlington, Iowa.

Syn. **A. securus** Hall, 1861. Desc. New Pal. Crin., p. 14.

Syn **A. thetis** Hall, 1861. Ibid., p. 11.

1853. **Actinocr. stellaris** de Kon. and Lehon. Recher. Crin. Belg., p. 456, Pl. 3, figs. 3, a, b, and figs. 4, a-g; also Pl. 4, fig. 3; Pictét, Traité de Paléont., iv, p. 323, Pl. 101, fig. 5. Mount. limest. Tournay, Belg.

Syn. **A. Gilbertsoni** de Koninck (not Miller nor Phillips). Anim. Foss. du Terr. Carb. de Belg., p. 50, Pl. G, figs. 2, a, b, c.

1853. **Actinocr. tennuis** de Kon. and Lehon. Recher. Crin. Belg., p. 128, Pl. 2 figs. 3, a, b. Mount. limest. Tournay, Belg.

1860. **Actinocr. tennuisculptus** McChesney (Sect. B). Desc. New Pal. Foss., p. 15; also Chicago Acad. Sci., 1867, vol. i, Pl. 5, fig. 11. Lower Burlington limest. Burlington, Iowa.

Syn. **A. chloris** Hall. Desc. New Sp. Pal. Crin., p. 3; also Bost. Journ. Nat. Hist., p. 275.

This species and **A. daphne** Hall, were placed by Meek and Worthen under Sect. A; but they belong more properly to Sect. B.

1836. **Actinocr. tessellatus** Phill. (Sect. B). Geol. Yorkshire, p. 206, Pl. 4, fig. 21. Mount. limest. Sommerset, Engl.

1861. **Actinocr. thalia** Hall (Sect. B). Desc. New Sp. Crin., p. 13; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Lower Burlington limest. Burlington, Iowa.

1821. **Actinocr. triacontadactylus** Miller. Type of the genus. Hist. of the Crinoidea, p. 95, with five plates; Agassiz, 1835, Mém. Soc. de Neuchat., i, p. 196; Phillips, 1836, Geol. Yorkshire, p. 206, Pl. 4, figs. 12, 13; 1843, Portlock, Geol. Rep. Londonderry, p. 348; McCoy, 1844, Carb. Foss. Ireland, p. 182; Brit. Pal. Foss. Mus. Cambr., p. 121; De Kon. and Lehon, 1853, Recher. Crin. Carb. Belg., p. 131, Pl. 3, fig. 1; Roemer, 1855, Lethaea Geogn. (Ausg. 3), p. 248. Mount. limest. Yorkshire, Mendip Hills, near Bristol, Engl., and Tournay, Belg.

1853. **Actinocr. tricuspidatus** de Kon. and Lehon. Recher. Crin. Carb. Belg., p. 143, Pl. 2, figs. 5, a, b; Pictét, 1857, Traité de Paléont., iv, p. 323, Pl. 101, fig. 4. Mount. limest. Visé, Belg.

1860. **Actinocr. unicarinatus** Hall (Sect. A). Supp. Geol. Rep. Iowa, p. 48. Burlington and Keokuk. Transition bed (not Keokuk bed proper as given by Hall).

1858. **Actinocr. verrucosus** Hall (Sect. A). Geol. Rep. Iowa, i, pt. ii, p. 578, Pl. 10, figs. 7 a, b; Meek and Worthen, Geol. Rep. Ill., v, p. 341. Upper Burlington limest. Burlington, Iowa.

Syn. **A. asterias** McChesney, 1860. New Pal. Foss., p. 9; also, 1867, Chicago Acad. Sci., vol. i, p. 9, Pl. 5, fig. 6.

1875. **Actinocr. viaticus** White (Sect. B). U. S. Surv. West of the 100th Meridian, under Wheeler, iv, Paleont., p. 82, Pl. v, fig. 1. (Preliminary Rep., 1874) Subcarbon. Nevada.

16. **TELEIOCRINUS** nov. gen.

(τέλειος, perfect; κρῖνον, a lily.)

Syn. *Actinocrinus* Hall (in part), 1858. Geol. Rep. Iowa, i, pt. ii, p. 590, and Ibid. Suppl., 1860.

Syn. *Calathocrinus* Hall, 1861 (not von Meyer, 1848). Subgenus of *Actinocrinus*. Desc. New Pal. Crin., p. 12.

Syn. *Strotocrinus* (Sect. B) Meek and Worthen. Geol. Rep. Ill., ii, p. 188.

The above name is proposed for a series of species, which were arranged by Meek and Worthen in a section under *Strotocrinus*, but which differ from the typical form of that genus in being provided with a long anal tube, instead of having a simple opening through the vault, as in their Sect. A. The form of the anus alone would warrant only a subgeneric division of the two groups, but there are other characters which have induced us to separate them generically.

In our general remarks upon the family, we have shown that Meek and Worthen's *Strotocrinus B*, for which we propose the genus *Teleiocrinus*, in all probability, sprung off from *Actinocrinus, Sect. B;* while Meek and Worthen's *Strotocrinus A*—their typical form—is similarly related to *Physetocrinus*, which we separate generically from *Actinocrinus*. The lateral rim, therefore, which produces the remarkable resemblance, according to our interpretation, in the form of *Strotocrinus* and *Teleiocrinus*, results from modifications in the one and the same direction, but which take place in different groups. We propose the following:—

Generic Diagnosis.—Body large; calyx urn-shaped, subconical below; the upper part, including the higher orders of radials, spread out horizontally, and formed into an extended, continuous rim around the body; vault moderately convex, with a strong subcentral anal tube; surface ornamentation similar to *Actinocrinus*, but, as a rule, very much coarser, the nodes more prominent than the striations, and sometimes almost entirely obscuring them.

Basals three, large, massive, projecting beyond the point of attachment for the column, and frequently extended into a bipartite node; sutures deep.

Primary radials 3×5; the first large, as high as wide; the second generally hexagonal, of the same proportions as the first but smaller; the third like the second, but angular above instead of truncate.

Secondary radials 1×10, axillary, supporting the two main divisions of the ray. The radials of all succeeding orders are composed respectively of a single series of pieces, of which only one plate, of each main division, in each order, bifurcates again, and this alternately on opposite sides, the other—opposite—plate which is never axillary, being succeeded in a direct line by a row of a variable number of fixed arm plates, which form branches within the body, alternately given off from the main trunks. All plates of the lateral branches and main divisions are closely joined with each other, and with those of the adjoining rays, and these together form the peculiar rim which surrounds the body. The plates of the rim are nearly of equal size, convex, and formed longitudinally into ridges, which give to the alternate branches the aspect of fixed arms, which they evidently are. Arm openings large and lateral, with a separate respiratory (?) pore to each opening.

Interradial, anal and interaxillary plates arranged as in *Actinocrinus*, and scarcely more numerous, they decrease in size upward, the upper ones are very minute.

Dome convex, in form of a ten-rayed star, indistinctly grooved between the arm bases. Vault constructed of larger and smaller pieces, which all decrease outward. The larger ones, which include the apical and all radial plates, are nodose or in part spiniferous; the smaller ones, including interradial and other accessory pieces are scarcely convex. The inner floor of the vault is strengthened by braces, which increase in thickness as they recede from the centre, and which, on approaching the rim, extend to the calyx, and from tunneled passages, one to each arm opening.

Column comparatively slender, composed of short, round joints, a part of which, at regular intervals, project out beyond the others, and send up and down, all around, at equal distances, five thickened processes or ribs, apparently as a natural provision to give it strength without destroying its flexibility. These processes give to the column a highly sculptured and somewhat pentagonal aspect, especially in its upper portions, where they are prominent and almost continuous vertically. But as these processes are only attached to the older and larger joints of the column, they gradually grow farther apart as they recede from the body, by the interpolation of the later developed joints, which increase in number downward. Some species, in place of five, have ten or more rows of processes along the column.

Perforation of medium size; pentalobate.

Geological Position, etc.—*Teleiocrinus* is limited to the Upper Burlington limestone, and is found only in America.

We place here the following species :—

*1859. **Teleiocrinus aegilops** Hall. (**Actinocr. aegilops**) Supp. Geol. Rep. Iowa, p. 5; Meek and Worthen, **Strotocr.** (B) **aegilops,** Geol. Rep. Ill., v, p. 349. Upper Burlington limest. Burlington, Iowa.

This is probably a younger stage of **Teleiocr. umbrosus.**

*1861. **Teleiocr. althea** Hall. (**Actinocr.—Calathocr.—althea**) Desc. New Sp. Crin., p. 13, Photogr. Pl. 4, fig. 13. Upper Burlington limest. Burlington, Iowa.

*1861. **Teleiocr. clivosus** Hall. (**Actinocr. clivosus**) Bost. Journ. Nat. Hist., p. 274. Upper Burlington limest. Burlington, Iowa.

*1861. **Teleiocr. erodus** Hall. (**Actinocr.—Calathocr.—erodus**) Desc. New Sp. Crin., p. 12; Meek and Worthen, **Strotocr.** (B), Geol. Rep. Ill., ii, p. 190. Upper Burlington limest. Burlington, Iowa.

*1861. **Teleiocr. insculptus** Hall. (**Actinocr.—Calathocr.—insculptus**) Desc. New Sp. Crin., p. 12; Meek and Worthen, **Strotocr.** (B), Geol. Rep. Ill., v, p. 348. Upper Burlington limest. Burlington, Iowa.

*1861. **Teleiocr. liratus** Hall. (**Actinocr. liratus**) Supp. Geol. Rep. Iowa, Pl. 4, fig. 3; Meek and Worthen, **Strotocr.** (B) **liratus**, Geol. Rep. Ill., ii, p. 190; Ibid., v, p. 355, fig. 2. Upper Burlington limest. Burlington, Iowa.

Syn. **Actinocr. subumbrosus** Hall. Suppl. Geol. Rep. Iowa, p. 3.

*1860. **Teleiocr. rudis** Hall. (**Actinocr. rudis**) Supp. Geol. Rep. Iowa, p. 33. Upper Burlington limest. Burlington, Iowa.

*1861. **Teleiocr. tenuiradiatus** Hall. (**Actinocr. tenuiradiatus**, not 1847 = *Palæocystites tenuiradiatus.*) Desc. New Sp. Crin., p. 12; Meek and Worthen, **Strotocr.** (B) **tenuiradiatus**, Geol. Rep. Ill., v, p. 349. Upper Burlington limest. Burlington, Iowa.

*1858. **Teleiocr. umbrosus** Hall. (**Actinocr. umbrosus**) Type of the genus. Geol. Rep. Iowa, i, pt. ii, p. 590, Pl. 11, figs. 3 a, b; Meek and Worthen, **Strotocr.** (B) **umbrosus**, Geol. Rep. Ill., ii, p. 190; Ibid., v, p. 360, Pl. 8, fig. 5. Upper Burlington limest. Burlington, Iowa.

Syn. **Actinocr. delicatus** Meek and Worthen, 1869. Proc. Acad. Nat. Sci. Phila., p. 156; also Geol. Rep. Ill., v, p. 343, Pl. 8, fig. 2.

This is described from a very young specimen of this genus, and exhibits most remarkably all the characteristics of **Actinocrinus**.

17. STEGANOCRINUS Meek and Worthen.

(Pl. 18, figs. 3, 4, 5.)

1866. Meek and Worthen. Geol. Rep. Ill., ii, p. 195.
1868. Meek and Worthen. Ibid., iii, p. 475.
1878. Wachsm. and Spr. Proc. Acad. Nat. Sci. Phila., p. 243.
1878. Zittel. (Subgenus of *Actinocrinus.*) Handb. der Palaeont., p. 370.

Syn. *Actinocrinus* (in part) Shumard, 1855, Geol. Rep. Missouri by Swallow, pt. ii, p. 189; Hall, 1858, Geol. Rep. Iowa, i, pt. ii, pp. 577, 582; Meek and Worthen, 1860, Proc. Acad. Nat. Sci. Phila., p. 387.

The relations of this genus with *Actinocrinus* and *Teleiocrinus* have been fully discussed in our general remarks upon the family.

Generic Diagnosis.—General form of the body like *Actinocrinus.* The rays extended into long tubular appendages, which bear the arms on both sides; dome with subcentral anal tube; surface ornamented by radiating ridges passing from plate to plate, and meeting in a small tubercle at the middle of each.

Basals three, forming a low cup. Primary radials 3 × 5. large; the first much larger than the others, hexagonal and heptagonal;

the second hexagonal, almost as high as wide; the third axillary, but smaller by half or more than the second, sometimes forming a part of the arm-like appendages, which in other species begin with the secondary radials. The secondary radials consist of $1 \times 2 \times 5$ plates in each ray; sometimes both are axillary, and as such divide the ray into two equal sections, of which each one forms a separate tube, and gives off lateral arms from either side; in other cases only one is a bifurcating plate, which is the larger of the two, resting upon the wider side of the primary radials, while the other, which is smaller and obliquely given off, is truncate above, and supports an arm.

In the same manner other series of radials are given off from all succeeding radial plates, on one side a bifurcating plate bearing a higher order of radials, on the other a lateral arm, and this alternately from opposite sides (Pl. 18, fig. 3). The number of radials is to some extent indefinite, they extend to almost the height of the arms, which are long, and the ray itself terminates finally in a short arm. All the radials are of the same form, and nearly the same size, decreasing very gradually in an upward direction. They are wider than high, cuneate and alternately arranged, with the shorter side abutting against the side of the preceding arm, while the next arm is given off from the upper oblique side.

Arms long, of moderate thickness, constructed like those of *Actinocrinus*, beginning with one or two cuneate pieces, which soon turn into two series of alternate plates. Arm grooves deep; pinnules unknown.

Interradials three or more, those of the calyx forming a connection with the interradial plates in the dome. The posterior side, like that of all other *Actinocrinites*, consisting of a single special anal plate, which is in line with—and has the size of—the first radials; it supports two plates in the second, and generally three in the third series.

Vault highly elevated to moderately convex, composed of a variable number of pieces; centre and proximal dome plates not distinctly defined. The first radial dome plates, from which the brachial appendages begin, are spiniferous, and so alternately is one-half of the succeeding plates which cover the free rays. The covering of these appendages consists of two rows of plates, side by side, a larger and a smaller one, which are so arranged that at each side of the ray the larger plates alternate with the smaller ones, and the former abut laterally against an arm opening. The appendages are very heavy, composed of strong nodose plates; their cross-section, as that of their inner passage, oval, higher than wide (Pl. 18, fig. 5). At each side of the base of each arm, there is a respiratory (?) pore; that of one side is located at some distance from the arm openings, the other and smaller one lies close to it. The pores are so arranged that the larger ones stand at one side of the appendages in front, at the other behind the arm with which they are connected. Similar pores are placed beside the proximal arms, but these pass directly through the main body. Anal tube long, subcentral, composed of nodose pieces. Column round, of moderate size; central canal of medium width, pentalobate.

Geological Position, etc.—*Steganocrinus*, so far as known, is restricted to the age of the Burlington limestone, and has been found only in America.

We recognize the following species:—

1860. **Steganocrinus araneolus** Meek and Worth. (**Actinocr. araneolus**) Proc. Acad. Nat. Sci. Phila., p. 387; **Steganocr. araneolus**, 1866, Geol. Rep. Ill., ii, p. 198, Pl. 15, figs. 1 a, b. Lower Burlington limest. Burlington, Iowa.

*1855. **Steganocr. concinnus** Shumard. (**Actinocr. concinnus**) Swallow's Geol. Rep. Missouri, pt. ii, p. 189, Pl. A, fig. 5; Meek and Worth., 1866, **Actinocr. concinnus**, Geol. Rep. Ill., p. 200, Pl. 15, figs. 9 a, b. Upper Burlington limest. Burlington, Iowa.

Syn. **Actinocr. validus** Meek and Worthen, 1860, Proc. Acad. Nat Sci. Phila. p. 384.

1858. **Steganocr. pentagonus** Hall. Type of the genus. (**Actinocr. pentagonus**) Geol. Rep. Iowa, i, pt. ii, p. 577, Pl. 10, figs. 6 a, b; Meek and Worthen, 1866, **Steganocr. pentagonus**, Geol. Rep. Ill., ii, p. 198; Ibid., 1868, iii, p. 474, Pl. 16, fig. 8. Lower Burlington limest. Burlington, Iowa.

1858. **Steganocr. sculptus** Hall. (**Actinocr. sculptus**—not Miller) Geol. Rep. Iowa, i, pt. ii, p. 582, Pl. 10, figs. 11 a, b; Meek and Worthen, 1866, **Steganocr. sculptus**, Geol. Rep. Ill., ii, p. 198. Lower Burlington limest. Burlington, Iowa.

18. AMPHORACRINUS Austin.

1848. Austin. Quart. Journ. Geol. Soc. London, iv, p. 292.
1873. Meek and Worthen. Geol. Rep. Ill., v, p. 386.

Not Roemer, 1855. Lethæa Geogn. (Ausg. 3), p. 250 = *Agaricocrinus*.

Not Hall, 1861. Bost. Journ. Nat. Hist., p. 561 = *Agaricocrinus*.

Not Meek and Worthen. Geol. Rep. Ill., ii, p. 209 = *Dorycrinus*.

Syn. *Amphora*. Cumberland, 1826. Reliqu. Conserv., p. 26.

Syn. *Actinocrinus* Phillips (in part), 1836. Geol. Yorkshire, p. 206.

Syn. *Actinocrinus* Hall (in part), 1860. Supp. Geol. Rep. Iowa.

Cumberland proposed in 1826 the name *Amphora* for two very distinct species, which were distinguished by him by numbers. His species No. 1, represents a lobed species of *Actinocrinus* Miller, while his No. 2 is *Amphoracr. Gilbertsoni* Austin. Cumberland's descriptions of the genus (?) *Amphora*, were evidently taken from his first species, for he describes it as resembling in outer form "a wine *Amphora* with five handles for suspension and a central neck to pour from," which applies well only to Pl. C, fig. 5. This species must therefore be considered the type of *Amphora* if taken in a generic sense, but being a species of *Actinocrinus*, the name became a synonym, and Austin was perfectly at liberty to remodel it into *Amphoracrinus*, or even propose an entirely new name. Austin's *Amphoracr. crassus* and *A. granulosus*, which were mentioned in connection with the genus, have never been defined. Goldfuss, in 1848, used the name in a specific sense, not being aware that Phillips had already, in 1836, adopted for Cumberland's "*Amphora* No. 2" Miller's MS. name "*Gilbertsoni*."

Roemer and Hall have both confounded *Amphoracrinus* with *Agaricocrinus*, with which the form of the body has a slight resemblance, but from which it differs materially in the arrangement of plates; in having the radials laterally extended; in the subcentral anal tube, and also in the arm structure.

Meek and Worthen at first brought *Amphoracrinus* into connection with *Dorycrinus* Roemer, from which it differs as much as from *Agaricocrinus*. *Dorycrinus* has delicate arms, arranged in pairs, a comparatively deep calyx, and a lateral anal opening.

Amphoracrinus is a somewhat aberrant form, but its closest affinities are evidently with the *Actinocrinites*, with which it agrees in the lobed form of the body, in the general structure of the vault, in the arrangement of the anal plates, and in the position of the anal tube; while in the depressed form of the calyx it resembles the *Agaricocrinites*, and in the arms it is somewhat like the *Periechocrinites*.

Generic Diagnosis.—Body higher than wide, decidedly lobed; symmetry bilateral. Calyx short, composed of comparatively few plates, lower portions, up to arm bases, from saucer-shaped to slightly convex, but never concave. Dome highly elevated, and somewhat inflated, especially toward the posterior side, which is extended into a subcentral or excentric anal tube. Surface of body plates, including dome, covered with peculiar granules or indistinct wrinkles.

Basals three, moderately large, forming together a shallow hexagonal basin, the upper side without re-entering angles; a low rim borders the columnar facet. Primary radials 3 × 5; the first wider than high, much narrower at their junction with the basals, superior lateral sides short; second radials generally shorter than the first, but wider; third radials wide, as high as the second; the second are arranged horizontally to the vertical axis of the body, while the third sometimes take even a downward direction. In the European species only the secondary radials assume that position; in American species the convexity of the calix does not extend beyond the first radials. The upper radials bend so abruptly outward, that only their lower corners come in contact with the interradials, the plates themselves form the base of a lobed lateral extension; contrary to *Agaricocrinus*, in which they are flattened out, and form a disk in connection with the adjoining pieces.

Secondary radials 1 × 10, either all bifurcating, or one side of each ray only. In the former case, each plate supports on each of its sloping sides a tertiary radial, which in turn supports the primary arms; in the other, one arm is given off from a secondary radial. The rays, to the base of the arms, are spread out horizontally, and the arms curve upward very gradually; this gives to the specimen, with the arms attached, an unusually broad appearance, its width and length being almost equal. Arms cylindrical, strong, of nearly equal size to their full length, divergent, simple or ramifying, composed of two series of very narrow pieces, alternately arranged, rounded at the back, with zigzag suture lines. In *A. spinobrachiatus* Hall, in which the arms on becoming free remain simple, some of the joints at each side of the arm are extended into long lateral spines, which stand out conspicuously from both sides of the arm bases. The lower ones are short, but they increase in length upward until they attain a length of one and one-half the width of the arm. The spines are placed farther apart as they increase in size, the distance being lengthened each time by one additional joint. In species in which the arms divide, the joints are smooth, and the bifurcation takes place from the double-jointed arms, as in the case of *Periechocrinus*, not from single plates as in *Platycrinus*, etc.

Interradials three, of moderate size, the two upper ones situated within the sinus formed by the extended rays. Anals three to four large ones, succeeded by additional smaller ones; the first in line with the first radials; the second series two, rarely three. In the construction of the anal side, *Amphoracrinus* forms a link between the *Actinocrinites* and *Agaricocrinites*. In this respect it is interesting to observe that the second series of plates, within the limits of the same species, has sometimes two, and sometimes three plates, but wherever the third plate is present, it is narrower and smaller, and touches the first anal but slightly; while when absent, the plate above them falls in deeply between the two plates.

Dome high, inflated, the interradial spaces depressed, the radial portions formed into broad ridges, which increase in prominence toward the arm bases. Central dome, and the four large proximal pieces placed in contact with each other, large, and strongly spiniferous (the spines in *A. divergens* Hall sometimes attain a length of an inch and a-half, and are bi- or tri-digitate), the two smaller proximal plates are separated by a wide, somewhat inflated area, which supports an anal tube. The tube is located in the rear of the central plate and is almost central, while the central plate is pushed somewhat to the anterior side. The tube is constructed of plates similar to those of the vault; it is rather stout throughout, but very short, its upper extremity rounded, with a small subcentral anal opening, which is surrounded by plates and spines, similar to those which surmount the vault at the base of the tube, but on a smaller scale. The other plates of the dome are of nearly equal size, their surface beautifully granulated. Inner floor of the vault as in *Actinocrinus*, deeply grooved along the radial portions, and formed into closed galleries toward the arm bases.

Column round, constructed alternately of larger and smaller joints, whose lateral margins are sharply edged; central canal small.

Geological Position, etc.—*Amphorocrinus* occurs only in the lower strata of the Subcarboniferous—not beyond the age of the *Lower* Burlington limestone—both in America and Europe.

We recognize the following species:—

*1849 (?). **Amphoracrinus atlas** McCoy. (**Actinocr atlas**) Ann. and Mag. Nat. Hist. (ser. ii), vol. iii, p. 246; Roemer, 1855, **Amphoracr. atlas**, Lethæa Geogn. (Ausg. 3), p. 250. Mount. limest. Bolland, Engl.

Perhaps *Syn.* of **Amphoracr. Gilbertsoni** Austin.

1860. **Amphoracr. divergens** Hall. (**Actinocr. divergens**) Supp. Geol. Rep., Iowa, p. 36; Meek and Worthen, 1873, Geol. Rep. Ill., v, p. 388, Pl. 6, fig. 6. Lower Burlington limest. Burlington, Iowa.

Syn. **Amphoracr. divergens** var. **multiramosus** Meek and Worth., 1873. Geol. Rep. Ill., v, p. 389, Pl. 6, fig. 6.

Syn. **Amphoracr. planobasilis** Hall, 1860. Supp. Geol. Rep. Iowa, p. 19, Pl. 4, figs. 10, 11; **Amphoracr. planobasilis** Meek and Worth., 1873, Geol. Rep. Ill., v. p. 388.

Syn. **Actinocr. quadrispinus** White. Proc. Bost. Soc. Nat. Hist., ix, p. 15; **Amphoracr. quadrispinus** Meek and Worthen. Geol. Rep. Ill., v, p. 388.

1821. **Amphoracr. Gilbertsoni** Miller (not de Koninck). Type of the genus.. **Actinocr. Gilbertsoni** (Philips, 1836, Geol. of Yorkshire, p. 206, Pl. 4, fig. 19; Austin, 1842, Ann. and Mag. Nat. Hist., x, p. 109; **Amphoracr. Gilbertsoni.** Quart. Journ. Geol. Soc. London, iv, p. 292; Bronn, 1860, Klassen d. Thierreichs, ii, Pl. 28, fig. 2; Quenstedt, 1862, Handb. d. Petref., p. 619, Pl. 54, figs. 24 a, b. Subcarboniferous. Florence Court, Ireland.

Syn. **Amphora No. 2.** Cumberland, 1826, Reliquiæ Conservata, p. 36.

Syn. **Melocr. amphora** Goldfuss, 1838. Nova Acta Ac. Leop., xix, p. 341.

Syn. **Actinocr. amphora** Portlock, 1843. Rep. Geol. Londonderry, Pl. 20, figs. 4 a, and 5 a, b; McCoy, 1844, Synops. Pal. Foss. Ireland, p. 181.

1860. **Amphoracr. spinobrachiatus** Hall. (**Actinocr. spinobrachiatus**) Supp. Geol. Rep. Iowa, p. 6; Meek and Worthen, 1873. **Amphoracr. spinobrachiatus**, Geol. Rep. Ill., v, p. 388, Pl. 6, fig. 5. Lower Burlington limest. Burlington, Iowa.

Syn. **Actinocr. inflatus** Hall, 1860. Supp. Geol. Rep. Iowa, p. 20, (not **Actinocr.** (**Amphoracr.**) **inflatus** Hall, 1861 = **Agaricocr. inflatus**); Meek and Worthen, 1873, **Amphoracr.** (?) **inflatus**, Geol. Rep. Ill., v, p. 388. Lower Burlington limest. Burlington, Iowa

*1864. **Amphoracr. viminalis** Hall (**Actinocr. viminalis**). 17th Rep. N. York St. Cab. Nat. Hist., p. 54; Geol. Rep. Ohio, Paleont., ii, p. 165, Pl. 11, figs. 12–14. Waverly gr. Richfield, Ohio.

19. PHYSETOCRINUS Meek and Worthen.

(Pl. 19, fig. 5).

1869. Meek and Worthen (subgenus of *Strotocriuus*). Proc. Acad. Nat. Sci. Phila., p. 158.

1873. Meek and Worthen. Geol. Rep. Ill., V, p. 349.
(Described by Hall under *Actinocrinus*.)

Physetocrinus was proposed by Meek and Worthen as a subgenus of *Strotocrinus*, on account of its close affinities with their *Strotocrinus* Sect. A, both having a simple anal opening through the vault. They thus separate *Physetocrinus* generically from *Actinocrinus*, but they place *Strotocrinus* and our *Teleiocrinus*, although these differ in the same characters, as mere sections under the same generic form. Meek and Worthen evidently made the rim the criterion for the generic division. This we acknowledge to be a good character, but it must not be used to unite two groups, otherwise distinct, in which the rim has been independently developed, by modifications under similar conditions.

Physetocrinus differs from *Actinocrinus* in the form and construction of the vault, in having no anal tube; in having pores along the radial portions of the dome, and in possessing no hook-like projections along the pinnules.

Generic Diagnosis.—Body large, wider than high; calyx semi-ovate, much higher than the dome, which is depressed, convex, or almost straight; plates ornamented with beautiful striæ and with a deep indentation at each corner of the plates.

Basals three, large, truncate below, projecting out from the body, and forming together a low cup. Primary radials 3×5, of nearly equal size, the upper supporting $1 \times 2 \times 5$ comparatively large secondary radials, which all bifurcate and support the two main divisions of the ray. These extend out from the body, and throw off on both sides lateral branches from each plate as in *Actinocrinus*, which on becoming free turn into arms. The five main rays, their divisions, and every branch, are separated by small pieces, which toward the arm bases form deep sinuses, extending deeply into the vault, and giving to the surface that corrugated aspect which is so characteristic of this genus.

Interradial plates more numerous than in *Actinocrinus;* they consist of one in the first, and two in each succeeding series, gradually decreasing in size. The upper plates, which are minute, join with the plates of the vault, to form the depressions between the main rays. There are three, five, or more interaxillary pieces, which, connecting with the vault, form the sinuses between the main division of the ray, while one or more interbrachial plates, in a similar manner, separate the lateral branches.

Anal area somewhat wider, and the sinus between the adjoining rays a little deeper than in the other four interradial fields; it is composed of one large special plate in line with the first radials, two smaller plates in the second, and generally three plates in the succeeding series.

Vault composed of rather delicate, extremely small tuberculous pieces, which are disposed apparently without order or regularity; only the proximal dome plates being distinguishable. There are small braces on the inner side of the floor, and the entire vault is bent so as to form, in connection with the braces, in the interradial and interbrachial spaces, natural ridges, which at the inner side constitute grooves or open galleries for the reception of the ambulacral tubes. It is a remarkable feature of this genus, that the inner floor within the grooves is lined with indentations, which evidently formed passages through the vault, perhaps in connection with the hydrospires, and either communicated with the surrounding element or with soft appendages. These indentations have been observed only in *Physetocrinus* and *Strotocrinus* (not *Teleiocrinus*), but in several species, and hence may be considered a good generic distinction. They are located between the sutures along the middle series of plates, and are best observed in natural casts (Pl. 19, fig. 5), in which they form little tubercles, which extend to the arm bases.

Anus in form of a circular opening through the vault, surrounded by very minute plates, which were somewhat flexible, for they bulge out frequently into a small protuberance.

Arms long, the sides somewhat angular; constructed of two series of pieces; pinnules composed of slender joints (without hooks), closely arranged.

Column like that of *Actinocrinus*.

Geological Position, etc.—*Physetocrinus* has been discovered only in America, and in rocks of the age of the Burlington limestone.

We recognize the following species:—

1869. **Physetocrinus asper** Meek and Worthen. (**Strotocr.—Physetocr.—asper**) Proc. Acad. Nat. Sci. Phila., p. 161; also Geol. Rep. Ill., v, p. 351, Pl. 7, fig. 1. Upper Burlington limest. Burlington, Iowa.

1869. **Physetocr. dilatatus** Meek. (**Strotocr.—Physetocr.—dilatatus**) Proc Acad. Nat. Sci. Phila., p. 162; also Geol. Rep. Ill., v, p. 363, Pl. 10, fig. 6. Upper Burlington limest. Burlington, Iowa.

1858. **Physetocr. ornatus** Hall. (**Actinocr. ornatus**) Geol. Rep. Iowa, i, pt. ii, p. 583, Pl. 10, fig. 12; Meek and Worthen, 1873, Geol. Rep. Ill., v, p. 349. Lower Burlington limest. Burlington, Iowa.

Syn. **Actinocr. senarius** Hall, 1860. Supp. Geol. Rep. Iowa, p. 25.

1858. **Physetocr. ventricosus** Hall. Type of the genus. (**Actinocr. ventricosus**) Geol. Rep. Iowa, i, pt. ii, p. 595, Pl. 11, figs. 6 a, b; Meek and Worthen, Geol. Rep. Ill., v, p. 349. Upper Burlington limest. Burlington, Iowa.

Syn. **Actinocr. ventricosus** var. **internodius** Hall, 1861. Desc. New Sp. Crin., p. 3; also Bost. Journ. Nat. Hist., p. 278.

Syn. **Actinocr.** var. **reticulatus** 1861. Desc. New Sp. Crin., p. 3.

Syn. **Actinocr.** var. **cancellatus**. Bost. Journ. Nat. Hist., p. 279.

Syn. **Actinocr. subventricosus** McChesney, 1860. New Pal. Foss., p. 21; also 1869, Chicago Acad. Sci., i, pt. i, p. 16, Pl. 4, fig. 6; Meek and Worthen, Geol. Rep. Ill., v, p. 349.

20. STROTOCRINUS Meek and Worthen.

(Pl. 18, figs. 1, 2.)

1866. Meek and Worthen (in part, Sect. A). Geol. Rep. Ill., ii, p. 188.
1866. Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 253.
1869. Meek and Worthen. Ibid., p. 158.
1873. Meek and Worthen. Geol. Rep. Ill., v, p. 347.
1878. Zittel. (Subgenus of *Actinocr.*) Handb. d. Palæont., p. 370.

Syn. *Actinocrinus* (in part) Hall, 1860 and 61; Meek and Worthen, 1861.

Syn. *Calathocrinus* Hall. (Subgenus of *Actinocrinus.*) 1861, Desc. New Sp. Crin., p. 12 (not von Meyer, 1848).

The relations of this genus with *Teleiocrinus*—Meek and Worthen's *Strotocrinus* B—have been sufficiently discussed, also with *Physetocrinus*, and so we offer without remarks our

Revised Generic Diagnosis.—Body extremely large, the lower portions conical, the upper spread horizontally, forming a continuous rim surmounting the cone; dome flat or slightly convex, without anal tube; surface of plates beautifully striated.

Basals three, large, of equal size, forming a cup which is truncate below. Primary radials 3 × 5; the first larger, higher than wide; second and third of nearly equal size. The third radials give off 1 × 2 × 5 secondary radials, all bifurcating plates, which form the bases of the two main divisions of the ray. These and all succeeding plates are spread out horizontally, and form a part of the rim.

The succeeding orders of radials are composed of 1 × 2 plates to each main division of the ray, one of them always axillary, the other truncate above. The former gives off the next number of radials, while the latter is succeeded by a number of fixed arm plates which form lateral branches and give off finally the free arms. The radials are so arranged that in each succeeding order, and these are numerous, the bifurcating plate is placed always to the opposite side, so that the branches are given off alternately from opposite sides like pinnules. The two main trunks of each ray extend in length beyond the branches, and as both, the main trunks and branches, are marked along the median line by a conspicuous ridge or elevation, passing from plate to plate, the branching of the rays in the rim is most beautifully indicated. In the formation of the rim, the interradial and interaxillary plates also contribute, and these extend frequently to near the free arm bases.

The lateral branches either abut against each other or are partly separated by small pieces, which, as we suggested, are rudiments of early pinnules.

Interradials, anals, and interaxillary plates arranged as in the preceding genus, but they are more numerous, and, contrary to *Teleiocrinus*, extend far into the rim.

Vault depressed, convex or more frequently flat, and only near the arm bases somewhat rounded, the spaces along the ten main divisions somewhat elevated above the general plane. The disk is paved by many hundreds of small polygonal pieces, which decrease in size toward the arms, and which at the outer points of the rays become almost microscopic. The apical plates are larger, and are separated from each other, but not otherwise distinguished from the other plates, and hence are not easily identified.

Anus in form of a simple opening through the vault. The inner floor of the vault is constructed similar to that of *Physetocrinus*, and has similar indentations (pores?) along the grooves; but the divisions of the ray, within the rim, are separated as in *Teleiocrinus* by partitions, and thus are formed into regular ducts, which diverge until there is a separate passage to each ray. Arm openings laterally arranged around the rim, each one with a respiratory(?) pore aside of it. Arms long, comparatively thin, not bifurcating in their free state; pinnules long, composed of slender joints.

Column round, not large in proportion to the size of the specimen, without external rips or thickened processes; central canal of medium size, pentagonal.

Geological Position, etc.—*Strotocrinus* seems to be limited to the Subcarboniferous of the Mississippi valley, and is here found only in a small belt at the middle portion of the Upper Burlington limestone, where it seems to have flourished in great profusion, but none reached up to the Keokuk Transition bed.[1] The two or three species of this genus belong to the largest and most beautiful forms of the Palæocrinoidea, the body without arms attains sometimes a height of five inches by six inches width along the

[1] The species which S. A. Miller describes from Bloomfield, Mo., under *Strotocr. Bloomfieldensis* is from cherty layers of the Upper Burlington, and not from the Keokuk limestone; we take it to be a synonym of *Strotocr. regalis* until specimens showing the test prove the contrary, a diagnosis based upon the internal cast only, has in our opinion very little value.

rim, the latter spread out an inch and more all around, while the main branches reach a length of two inches and a-half.

We place here the following species:—

1859. **Strotocrinus glyptus** Hall. (**Actinocr. glyptus**) Supp. Geol. Rep. Iowa. p. 2; Meek and Worthen, **Strotocr. glyptus** (Sect. A), Geol. Rep. Ill., ii, p. 190. Upper Burlington limestone. Burlington, Iowa. This is not a *Syn.* of **Actinocr. erodus** Hall as supposed by Meek and Worthen.

1859. **Strotocr. perumbrosus** Hall. (**Actinocr. perumbrosus**). Supp. Geol. Rep. Iowa, p. 7; Meek and Worthen, **Strotocr. perumbrosus** (Sect. A), Geol. Rep. Ill., ii, p. 190; also Ibid., v, p. 357, Pl. 8, fig. 4. Upper Burlington limest. Burlington, Iowa. This is probably a *Syn.* of **Strotocr. regalis.**

1859. **Strotocr. regalis** Hall. (**Actinocr. regalis**) Supp. Geol. Rep. Iowa, p. 8; Meek and Worthen, 1866, **Strotocr. regalis,** Geol Rep. Ill. ii, p. 192. Upper Burlington limest. Burlington, Iowa.

Syn. **Actinocr. speciosus** Meek and Worthen, 1860, Proc. Acad. Nat. Sci. Phila., p. 386. (Meek acknowledged it to be a *Syn.* of **Strotocrinus regalis** in 1866).

Syn. **Strotocr. Bloomfieldensis** S. A. Miller, 1879, Jour. Cincin. Soc. Nat. Hist., vol. ii, Pl. 15, fig. 6.

21. GENNÆOCRINUS. Nov. Gen.

(*γενναῖος*, of noble origin, *κρῖνον*, a lily).

We propose the above name for a little group of Crinoids from the Upper Devonian, which cannot be satisfactorily referred to any established genus. In their general construction they closely resemble *Actinocrinus* and *Physetocrinus*, but differ from both, and in fact from all Actinocrinites, in the arrangement of the anal plates. The anal area has in the second series, like all other Actinocrinidæ, previous to the Subcarboniferous, three plates in place of two, agreeing therein with the Batocrinites, from which they differ, however, in the much greater number both of anal and interradial plates, the different arrangement of these plates, which form an unbroken line with the interradial vault pieces, the presence of interaxillaries, the strongly lobed form of the body, the mode of bifurcation, and in other characters. It is possible when the construction of the vault and arms are better known, that *Gennæocrinus* should be placed subgenerically either under *Actinocrinus* or *Physetocrinus*.

Generic Diagnosis.—General form of body wider than high, lobed at the arm regions; calyx beautifully striated, the higher radials formed into ridges and resembling fixed arms; vault low hemispherical, composed of small, spiniferous or nodose plates.

Basals three, short, with a tripartite rim formed by the projection of the lower margin of the plates. Primary radials 3 × 5, of nearly similar form but decreasing in size upward. The third radial gives off 1 × 10 secondary radials, and these form the two main trunks, of which each one gives off, alternately throughout all the bifurcations, and from every first joint, an axillary, and to the opposite side a fixed arm plate, the one supporting the next order of radials, the other being succeeded by additional arm plates, which on becoming free, pass into a simple arm.

Interradials numerous, from five to seven or more, the second resting between the second and third primary radials, the upper ones being in contact with the interradial plates. The space between the rays is wide, deeply depressed, especially at the posterior side, and this depression extends to the vault. Anal area very wide, the first plate in line with the first radials, and of their size. There are two plates in the second range, three or four in the third, with a large number of small pieces above, which imperceptibly connect with the plates of the vault.

Interaxillary plates one to three. Vault depressed its radial portions formed into ridges or lobes, which rapidly increase in prominence toward the arm regions. It is composed of moderately small, apparently irregularly arranged pieces, which are more or less spiniferous.

Anus excentric, probably in form of a simple opening through the vault. Arms unknown.

Geological Position, etc.—*Gennæocrinus* is restricted to the Hamilton group of America.

We place here the following species :—

*1862. **Gennæocrinus calypso** Hall. (**Actinocr. calypso**) 15th Rep. N. York. St. Cab. Nat. Hist., p. 133. Hamilton gr. Western N. Y.

*1861. **Gennæocr Cassedayi** Lyon. (**Actinocr. Cassedayi**) Proc. Acad. Nat. Sci., Phila., p. 410, Pl. 4, figs. 3, 3a. Encrinal limest. Near Lousville, Ky.

*1862. **Gennæocr. cauliculus** Hall. (**Actinocr. cauliculus**) 15th Rep. N. York. St. Cab. Nat. Hist., p. 132. Hamilton gr. Western N. York.

*1862. **Gennæocr. eucharis** Hall. (**Actinocr. eucharis**) 15th Rep. N. York, St. Cab. Nat. Hist., p. 130. Hamilton gr. Western N. York.

*1860. **Gennæocr. Kentuckiensis** Shumard. Type of the genus. (**Actinocr Kentuckiensis**) Am. Journ. Sci. and Arts. (ser. 2), vol. 28, Septbr. 1859, p. 238, Cat. Pal. Foss., p. 345. Lower part of Hamilton gr. Beargrass Quarries, near Louisville, Ky.

Syn. **Actinocr. cornigerus** Lyon & Cass., 1859.(not Hall, 1858).

*1862. **Gennæocr. nyssa** Hall. (**Actinocr. nyssa**). 15th Rep. N. York. St. Cab. Nat. Hist., p. 129. Hamilton gr. Western N. York.

*1862 (?) **Gennæocr. pocillum** Hall. (**Actinocr. pocillum**). 15th Rep. N. York. St. Cab. Nat. Hist., p. 134. Hamilton gr. Western N. York. (This species probably belongs to some other group.)

f. Batocrinites.

22. BATOCRINUS Casseday.

(Pl. 18, fig. 8 and Pl. 19, fig. 2).

1854. Casseday. Deutsche Zeitschr. d. Geol. Gesellsch., vi, p. 237.
1857. Pictét. Traité de Paléont., iv, p. 324.
1865. Meek and Worthen (Subgen. *Actinocr*). Proc. Acad. Nat. Sci., Phila., p. 153.
1866. Meek and Worthen (Subgenus of *Actinocr.*). Geol. Rep., Ill., ii, p. 150.
1869. Meek and Worthen. Proc. Acad. Nat. Sci., Phila., p. 350.
1873. Meek and Worthen. Geol. Rep., Ill., v, p. 364.
1878. Wachsm and Spr. Proc. Acad. Nat. Sci., Phila., p. 329.
1879. Zittel (Subgenus of *Actinocr*). Handb. Palæont., p. 370.

Syn. *Actinocrinus* (in part), Shumard, Hall, White, McChesney, Meek and Worthen (prior to 1865).

Syn. *Uperocrinus*. Meek and Worthen, 1865 (Subgenus of *Batocrinus*. Proc. Acad. Nat. Sci., Phila., p. 153.

The generic distinctions between *Batocrinus* and *Actinocrinus* have been fully discussed in our remarks upon *Actinocrinus*, but it remains yet to note the somewhat different mode in which the arms increase in the two groups. We describe below two new species of *Batocrinus* and three of *Eretmocrinus*, from which it appears that in these genera, and in the *Batocrinites* generally, the increase of arms, from one species to another, is not gradually, by the addition of a single arm to each ray, as in the case of *Actinocrinus*, but by duplicating the entire number of arms throughout the species.

Meek and Worthen in 1866, in adopting *Batocrinus* as a genus, separated it into subgenera, and again subdivided the typical form into two sections: "A, species in which the arm openings are directed outward; B, in which they are directed upwards, and arranged, more or less, into groups." The position of these openings had evidently no important bearing upon the general structure of the crinoid, only that in the former the ambulacral passages entered horizontally, in the others obliquely, and this difference is caused by the greater or less degree of prominence developed in the uppermost ring of radials.

The name *Uperocrinus*, in a subgeneric sense, was proposed by Meek and Worthen for species with a narrow calyx, drawn out so as to form a kind of handle for the upper portions, but was given up afterwards.

Generic Diagnosis.—General form of body biturbinate, wheel-shaped, or globose; calyx and vault of a similar form, the former composed of smooth, slightly convex to strongly nodose plates, scarcely ever striated; the dome consisting of convex or tuberculous pieces, with a strong, almost central anal tube. Symmetry of calyx bilateral.

Basals three, equal, not very high, forming an extended rim with a concavity for the reception of the column. Primary radials 3×5; the first hexagonal or heptagonal, larger than the second and third combined; the second quadrangular, linear, always narrower than the first, but yet twice or three times wider than high, sometimes altogether anchylosed with the third; the third pentangular, short, the lower lateral sides abruptly spreading and giving a greater width to the median portions, the upper sides supporting the higher radials. Secondary radials 2×10, very wide, as large as the primary ones; those of the second series bifurcating. The anterior ray has sometimes but two or three arms, this is frequently accidental, but in some species the rule. Tertiary radials $2 \times 2 \times 10$, narrower than the secondary, supporting the arms.

In some species the posterior rays support additional plates in the body, but only in the division next to the anal area, this side sometimes having one, two or three additional arms, while the opposite division retains the usual number of four. The upper row of plates is at the outer face truncated for the reception of the arms, their upper sides being notched along the median portions for the arm passages. This notch is joined by a similar notch in the corresponding plates of the dome, which, combined with the other, forms an arm opening (Pl. 19, fig. 2, and Pl. 18, fig. 8); the opening is oval in form, longer than wide, resting within the centre of a small concavity. The part which extends into the vault, follows the lateral edges of a tertiary radial dome plate. The opposite side of the radial is likewise excavated to receive a respiratory (?) pore, which is enclosed on the other side by an adjoining interradial or interbrachial piece. Hence the two openings are separated by the tertiary radial dome plates, whose width varies in different species, and according to the position which the arm occupies within the ray (Pl. 18, fig. 8). Whenever the respiratory (?) pore is in connection with the arms of the inner part of the ray, it is placed closer to the arm opening than pores which are placed toward the outer side. The respiratory (?) pores in the *Batocrinites* are exceptionally large, sometimes attaining a width equal to one-third that of the arm opening. Their connection with the inner cavity has been explained elsewhere.

The interradials of the calyx are not numerous, varying from one to four or five, but rarely exceeding three. The first very large, polygonal, nearly as large as the primary radials; it rests between the upper edges of the first radials, between the second, and against the lower sloping edges of the third, and is followed by two or three very much smaller pieces. The anal area has one plate in line with the first radials, of about their size; there are three plates in the second series, and a few more small pieces above. None of the plates of the interradial or anal series connect with the dome, from which the interradial area of the calyx is separated by the tertiary radials, which meet all around laterally. There are no interaxillary plates, except in the case of *B. planodiscus* and occasionally in *B. trochiscus*, in which the arm regions are spread out in width to three times the height of the body. This species has also a greater number of interradials.

Vault elevated, composed of comparatively large and heavy pieces, of nearly equal size, even the apical plates, with the exception of the central plate, being but little larger than the rest. The centre piece and the proximal dome plates are much crowded toward the anterior side, owing to the nearly central anal tube, of which, on that side, the large central plate forms the base. The tube is constructed of similar plates as the vault, and very long, sometimes extending more than twice the length of the arms beyond their tips, it is very straight in all cases, and tapers gradually almost to a point, with a narrow passage at the upper end.

Arms from eighteen to twenty-six, or thirty-six to forty, either in pairs or single from each arm opening, round, very short, of medium size and equal width throughout their length. From the body up, they are composed of two series of alternate pieces, and in species which have the double arm structure, the first of these joints, without increasing in height, gives off, in place of the first pinnule in the other species, a second arm, which passes into the same arm opening as its companion. Pinnules composed of slender joints, closely attached laterally, their sides flattened, their depth greater than their width, with a deep ventral furrow covered by small plates.

Column round, composed of rather large joints with more or less angular edges; perforation of moderate size, pentangular.

Geological Position, etc.—*Batocrinus* is strictly a Subcarboniferous form. It is exclusively an American genus, and embraces the last survivors of the Actinocrinidæ.

We place here the following species:—

*1860. **Batocrinus æquibrachiatus** McChesney. (**Actinocr. æquibrachiatus**) New Pal. Foss., p. 25; also Chicago Acad. Sci., 1867, p. 18; Meek and Worthen, 1873, **Batocr. æquibrachiatus**, Geol. Rep. Ill., v, p. 368. Upper Burlington limest. Burlington, Iowa.

Syn. **Actinocr. asteriscus** Meek and Worthen, 1860. Proc. Acad. Nat. Sci. Phila., p. 385; also 1866, Geol. Rep. Ill., ii, p. 207, Pl. 15, figs. 8 a, b, c; also 1873, **Batocr. asteriscus**, Ibid., v, p. 368.

Syn. **Actinocr. æquibrachiatus** var. **alatus** Hall. Desc. New Spec. Crin., 1861; also Bost. Journ. Nat. Hist., p. 263, Photogr. Pl. 3, figs. 21–23.

1858. **Batocr. æqualis** Hall. (**Actinocr. æqualis**) Geol. Rep. Iowa, i, pt. ii, p. 592, Pl. 11, figs. 4 a, b; Meek and Worthen, 1873, **Batocr. æqualis**, Geol. Rep. Ill., v, p. 367. Lower Burlington limest. Burlington, Iowa.

Syn. **Actinocr. doris** Hall, 1861. Desc. New Sp. Crin., p. 15; Meek and Worthen, 1873, **Batocr. doris**, Geol. Rep. Ill., v, p. 367.

*1860. **Batocr. andrewsianus** McChesney. (**Actinocr. andrewsianus**) New Pal. Foss., p. 27; also 1867, Chicago Acad. Nat. Sci., p. 20, Pl. 5, fig. 5. Upper Burlington limest. Burlington, Iowa.

1858. **Batocr. biturbinatus** Hall. (**Actinocr. biturbinatus**) Geol. Rep. Iowa, i, pt. ii, p. 616, Pl. 16, figs. 5, 6, a, b, c; Meek and Worthen, Geol. Rep. Ill., v, p. 367. Keokuk limest. Illinois and Iowa.

1860. **Batocr. calyculus** Hall. (**Actinocr. calyculus**) Supp. Geol. Rep. Iowa, p. 55, Pl. 1, figs. 12 a, b, c; Meek and Worth., 1873, **Batocr. calyculus**, Geol. Rep. Ill., v, p. 367. Warsaw limest. Spurgeon Hills, Ind.

Syn. **Batocr. calyculus** var. **hardinensis** Meek and Worth., 1866. Proc. Acad. Nat. Sci. Phila., p. 253.

We doubt that the type specimen came from the St. Louis limest., it would be the only example of an Actinocrinoid being found beyond the Warsaw limest.

*1860. **Batocr. Caroli** Hall. (**Actinocr. Caroli**) Supp. Geol. Rep. Iowa, p. 54, Pl. 1, fig. 11. Warsaw limest. Warsaw, Ill.

1869. **Batocr. Cassedayanus** Meek and Worth. Proc. Acad. Nat. Sci. Phila., p. 353; Geol. Rep. Ill., v, p. 370, Pl. 5, fig. 1. Lower Burlington limest. Burlington, Iowa.

1855. **Batocr. Christyi** Shum. (not Hall, 1863 = *Periechocr. Christyi.*) Figured in Christy's letters on Geol., Pl. 1, figs. 1, 2; Shumard, **Actinocr. Christyi,** Geol. Rep. Missouri by Swallow, pt. ii, p. 191, Pl. A, fig. 3; Meek and Worth., 1873, **Batocr. Christyi,** Geol. Rep. Ill., v, p. 367, Pl. v, figs. 4 a, b; Wachsm. and Spr., 1878, Proc. Acad. Nat. Sci. Phila., p. 231. Upper Burlington limest. Burlington, Iowa.

1860. **Batocr. clypeatus** Hall. (**Actinocr. clypeatus**) Supp. Geol. Rep. Iowa, p. 12, Pl. 3, fig. 12; Meek and Worth., 1867, **Batocr. clypeatus,** Geol. Rep. Ill., ii, p. 150. Lower Burlington limest. Burlington, Iowa

Syn. **Actinocr. inornatus** Hall, 1860. Supp. Geol. Rep. Iowa, p. 24; Meek and Worth., **Batocr. inornatus,** Geol. Rep. Ill., v, p. 367.

Syn **Actinocr. papillatus** Hall, 1860. Supp. Geol. Rep. Iowa, p. 29, Pl. 3, figs. 10, 11; Meek and Worth., **Batocr. papillatus,** Geol. Rep. Ill., v, p. 367.

1858. **Batocr. discoideus** Hall. (**Actinocr. discoideus**) Geol. Rep. Iowa, i, pt. ii, p. 594; Meek and Worth., 1867, **Actinocr. (Batocr.) discoideus,** Geol. Rep. Ill., ii, p. 150, and 1873, **Batocr. discoideus,** Ibid., v, p. 367. Lower Burlington limest. Burlington, Iowa.

Syn. **Actinocr. formosus** Hall, 1860. Supp. Geol. Rep. Iowa, p. 30; Meek and Worth., 1873, **Batocr. formosus,** Geol. Rep. Ill., v, p. 367.

Syn. **Actinocr. subæqualis** McChesney, 1860. Desc. Pal. Foss., p. 17; also 1867, Chicago Acad. Nat. Sci., p. 13, Pl. 5, fig. 7; Meek and Worth., **Batocr. subæqualis,** Geol. Rep. Ill., v, p. 367.

1861. **Batocr. dodecadactylus** Meek and Worth. (**Actinocr. dodecadactylus**) Proc. Acad. Nat. Sci. Phila., p. 131, and 1866, **Batocr. dodecadactylus,** Geol. Rep. Ill., ii, p. 205, Pl. 15, figs. 3 a, b, c, and Ibid., v, p. 368. Upper Burlington limest. Burlington, Iowa.

This species forms an exception to the rule in having apparently only twelve arms. It may possibly be a young **B. rotundus,** and that some of the arms branch off in the free state.

*1860. **Batocr. euconus** Meek and Worth. (**Actinocr.—Alloprosallocr.—euconus**) Proc. Acad. Nat. Sci. Phila., p. 164, changed in 1873 to **Batocrinus (Alloprosallocrinus euconus),** Geol. Rep. Ill., v, p. 368. Warsaw limest. Spurgeon Hills, Ind.

1860. **Batocr. Hageri** McChesney. (**Actinocr. Hageri**) New Pal. Foss., p. 28; also 1867, Chicago Acad. Nat. Sci., p. 21, Pl. 4, fig. 1; Meek and Worth., 1873, **Batocr. Hageri,** Geol. Rep. Ill., v, p. 367. Upper Burlington limest. Burlington, Iowa.

1854. **Batocr. icosidactylus** Casseday. (Type of the genus.) Deutsche Geol. Gesellschaft, vi, p. 238; Meek and Worth., 1867, **Actinocr. (Batocr.) icosidactylus,** Geol. Rep. Ill., v, 367. Warsaw limest. Spurgeon Hills, Ind.

*1859. **Batocr. Indianænsis** Lyon and Cass. (**Actinocr. Indianænsis**) Am. Journ. Sci. and Arts, vol. 29, p. 75; Meek and Worth., 1873, **Actinocr. Indianænsis,** Geol. Rep. Ill., v, p. 341. Keokuk limest. Crawfordsville, Ind.

1854. **Batocr. irregularis** Casseday. Deutsche Geol. Gesellschaft, vi, p. 238; Meek and Worthen, 1867, Geol. Rep. Ill., ii, p. 150; also 1873. Ibid., v, p. 367. Warsaw limest. Spurgeon Hills, Ind.

1860. **Batocr. lagunculus** Hall. (**Actinocr. lagunculus**) Supp. Geol. Rep. Iowa, p. 41; Meek and Worth., **Batocr. lagunculus,** Geol. Rep. Ill., v, 367. Keokuk limest. Iowa and Illinois.

*1861. **Batocr. laura** Hall (**Actinocr. laura**). Descr. New Sp. Crin., p. 15. Upper Burlington limest. Burlington, Iowa.

1860. **Batocr. lepidus** Hall (**Actinocr. lepidus**). Supp. Geol. Rep. Iowa, p. 32; Meek and Worth. **Batocr. lepidus**, Geol. Rep. Ill., v, p. 367. Lower Burlington limest. Burlington, Iowa.

1858. (?). **Batocr. longirostris** Hall. (**Actinocr. longirostris**) Geol. Rep. Iowa, i, pt. ii, p. 589, Pl, 11, figs. 2, 4 c, d; Meek and Worth., **Batocr. longirostris**, Geol. Rep. Ill., v, p. 367. Lower Burl. limest. Burlington, Iowa. This species shows a marked departure from the characters of the genus and its reference is not without doubt.

1860. **Batocr. mundulus** Hall. (**Actinocr mundulus**) Supp. Geol. Rep. Iowa, p. 39; Meek and Worth., **Batocr. mundulus**, Geol. Rep. Ill., v, p. 367. Keokuk limest. Keokuk, Iowa.

1850. **Batocr. Nashvillæ** Troost. (**Actinocr. Nashvillæ**) Cat. Crin. Tenn. (Proc. Am. Assoc. for Advanc. of Sci., p. 60); Hall, 1858, Geol. Rep. Iowa, i, pt. ii, p. 609, Pl. 15, fig. 4, and Pl. 16, figs. 4 a, b; Wachsm. and Spr. 1878, Proc. Acad. Nat. Sci. Phila., p. 234; Meek and Worth., **Batocr. Nashvillæ**, Geol. Rep. Ill., v, p. 368. Keokuk limest. Iowa, Illinois, Missouri, Tennessee and Kentucky.

Var. **subtractus** White. (**Actinocr. Nashvillæ** var. **subtractus**), Proc. Bost. Soc. Nat. Hist., ix, p. 16. Upper Burlington limest. and Keokuk Transition beds.

1865. **Batocr. pistilliformis** Meek and Worth. (**Batocr.—Uperocr.—pistilliformis**), Proc. Acad. Nat. Sci. Phila., p. 153; also 1866, **Actinocr.** (**Batocr. C. Uperocr**) **pistilliformis**, Geol. Rep. Ill., ii, p. 151, Pl. 14, fig. 8; Ibid., 1873, v, p. 367. The original is said to be obtained from the Kinderhook gr. of Marion Co., Ill., but more probably from the Burlington limest., and that it is a *Syn.* of **B. pyriformis**.

Syn. **Actinocr. pyriformis** var. **rudis** Meek and Worth. Proc. Acad. Nat. Sci. Phila. (not **A. rudis** Hall, 1860).

1865. **Batocr. pistillus** Meek and Worth. (**Actinocr.—Uperocr.—pistillus**) Proc. Acad. Nat. Sci. Phila., p. 152; also 1868, **Actinocr.—Batocr.—pistillus**. Geol. Rep. Ill., iii, p. 472, Pl. 16, figs. 4 a, b; 1873, **Batocr. pistillus**. Ibid., v, p. 367. Upper Burl. limest. Burlington, Iowa.

1860. **Batocr. planodiscus** Hall. (**Actinocr. planodiscus**) Supp. Geol. Rep. Iowa, p. 45; Meek and Worth., 1873, **Batocr. planodiscus**, Geol. Rep. Ill., v, p. 367; Wachsm. and Spr., 1878, Proc. Acad. Nat. Sci. Phila., p. 233. Keokuk and Burlington Transition bed and Lower Keokuk limest. Nauvoo, Ill., and Keokuk rapids.

1855. **Batocr. pyriformis** Shumard (**Actinocr. pyriformis**, not Ad. Roemer, 1856). Geol. Rep. Missouri by Swallow, pt. ii, p. 192, Pl A, figs. 6 a, b; Meek and Worth., 1865, **Actinocr.—Uperocr.—pyriformis**. Proc. Acad. Nat. Sci. Phila., p. 153; also 1873 (**Batocr. pyriformis**). Geol. Rep. Ill., v, p. 375, Pl. 5, fig. 5, and Ibid., ii, p. 150; Wachsm. and Spr., 1878, Proc. Acad. Nat. Sci. Phila., p. 233. Upper Burlington limest. Burlington, Iowa, and Illinois and Missouri.

1869. **Batocr. quasillus** Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 352; also Geol. Rep. Ill., v, p. 369 Pl. 5, fig. 2. Lower Burlington limest. Burlington, Iowa.

1855. **Batocr. rotundus** Yandell and Shum. (Figured in Christy's letters on Geology, 1848, as *Actinocrinites*). Yand. and Shum., Geol. Rep. Missouri by Swallow, pt. ii, p. 191, Pl. A, figs. 2 a, b; Meek and Worth., 1873, **Batocr. rotundus.** Geol. Rep. Ill., v, p. 367. The leading fossil of the Upper Burlington limest. Boone and Marion Cos., Mo., Quincy and Oquaka, Ill., Burlington, Iowa. This is a somewhat variable species; it sometimes has a good sized anal tube, while in other cases this seems to be modified into a simple vault opening; the number of arms varies from eighteen to twenty-two.

Syn. **Actinocr. oblatus** Hall. Supp. Geol. Rep. Iowa, p. 38. (This species differs only in having twenty-two arms).

1860. **Batocr. similis** Hall. (**Actinocr. similis**) Supp. Geol. Rep. Iowa, p. 40; Meek and Worth., 1873, **Batocr. similis,** Geol. Rep. Ill., v, p. 367. Keokuk limest. Iowa and Illinois.

Syn. **Actinocr. clavigerus** Hall, 1860. Supp. Geol. Rep. Iowa, p. 44; Meek and Worth., 1867, **Batocr. clavigerus,** Geol. Rep. Ill., v, p. 367.

1860. **Batocr. sinuosus** Hall. (**Actinocr. sinuosus**) Supp. Geol. Rep. Iowa, p. 27, Photogr. Pl. 3, figs. 8, 9; Meek and Worth., 1873, **Batocr. sinuosus.** Geol. Rep. Ill., v, p. 368. Upper Burlington limest. Burlington, Iowa.

*1860. **Batocr. steropes** Hall. (**Actinocr. steropes**) Supp. Geol. Rep. Iowa, p. 43. Keokuk limest. Keokuk, Iowa.

1869. **Batocr. trochiscus** Meek and Worth. Proc. Acad. Nat. Sci. Philad., p. 354; Geol. Rep. Ill., v, p. 372, Pl. 5, fig. 6. Burlington and Keokuk Transition Bed. Iowa and Ill. (A more mature stage of **B. Christyi**).

1858. **Batocr turbinatus** Hall. (**Actinocr. turbinatus**) Geol. Rep. Iowa, i, pt. ii, p. 587, Pl. 11, fig. 1; Meek and Worth., 1873, **Batocr. turbinatus,** Geol. Rep. Ill., v, p. 367. Lower Burlington limest. Burlington, Iowa. *Syn.* **Batocr. turbinatus,** var. **elegans** Hall. Geol. Rep. Iowa, i, pt. ii, p. 588, Pl. 11, fig. 5.

*1857. **Batocr. Yandelli** Shumard. (**Actinocr. Yandelli**) Trans. St. Louis, Acad. i, p. 9, Pl. 1, figs. 4 a, b; Meek and Worth. (**Actinocr.** Sect. A.), Geol. Rep. Ill., v, p. 341. Keokuk limest. Bottom mould Knob, Jefferson Co., Ky.

*1880. **Batocr. Wachsmuthi** White. (**Actinocr. Wachsmuthi,** not **A. Wachsmuthi,** 1862 = **Actinocr. scitulus**). Author's Edit. from the 12th Annual Rep. of U. S. Geol. Surv. by Hayden, p. 162, Pl. 40, figs. 1 a, b; Geol. Rep. Ind. for 1879–80, p. 142, Pl. 7, fig. 6. Keokuk limest. Crawfordsville, Ind.

We add the following new species:—

Batocrinus Lovei, Wachsm. and Spr.

Form of body wheel-shaped, as wide as high, running nearly to a point at each pole. Plates of the calyx smooth, without ornamentation, those of the dome convex. Basals forming a conical cup, slightly truncate below. Radials 3 × 5; the first larger than both the others combined; second twice as wide as high; the third with obtuse upper angles. There are two rows of two plates in the two succeeding orders, those of the third order larger than those of the second, and the outer plates wider than the inner ones. Each ray has four arm openings—except the anterior which has but two—the outer ones of the ray, and those between the main divisions are placed a little farther apart, but are not separated by any sinus. Each opening gives off a single arm, which is short, and from the base up composed of two series of plates. Near each arm opening, there is a conspicuous respiratory (?) pore, which like the arm opening is directed laterally.

Interradials two to three, the first large; anals one, three and three. Vault lower by one-third to one-half than the calyx; apical dome plates somewhat prominent; interradial spaces a little depressed. Ventral tube perfectly central, extending far beyond the tips of the arms. Column comparatively slender.

This species agrees in every particular with *B. Christyi*, except it generally is smaller, and it has a single arm in place of two from each arm opening. It also differs in the more depressed form of the vault, and in being found only at the base of the Upper Burlington limestone; while *B. Christyi* struggles through to the Burlington and Keokuk Transition beds.

Locality and Position.—Base of Upper Burlington limest. Subcarb. Burlington, Iowa.

This species is named in honor of Mr. James Love of Burlington, an excellent collector, and an ardent lover of Crinoids.

*__Batocrinus Whitei__ Wachsm. and Spr., n. sp.

Body small, globose, a little wider than high, height of calyx and dome equal, both with convex sides; the arm bases slightly projecting. Surface of plates ornamented, the median line of all radials up to the arm bases marked by a ridge; other less distinct elevations diverge from the centre of the first interradial plates, which continue to the radials, but without uniting with the radial ridges.

Base short, truncate, forming an elevated ring around the column. First primary radial almost as large as second and third together and considerably wider, the upper sloping sides comparatively long; the second fully as high as the third and nearly as wide.

Secondary radials 2×10, the upper largest, with two shorter pieces in the next order, making four arm openings in four of the rays, the anterior ray has no tertiary radials and only two openings in all. Each arm opening supports a single arm, which, from the second plate up, is constructed of two series of pieces alternately arranged. Arms nearly round, of medium thickness and length, gradually tapering to their tips. Pinnules very long, composed of joints three times longer than wide, and perfectly smooth. Interradials two to three, the first much larger than all others combined, and fully as large as the first radials. Anal area composed of one, three and two pieces, with a depression between the arm bases. Vault constructed of tuberculous pieces of nearly equal size. Anal tube long, extended beyond the arms, constructed of convex plates, which are interspersed all the way up to the top, with strongly nodose or slightly spiniferous pieces. Column slender, composed of alternately larger and smaller joints, the larger ones with rounded edges.

This species is interesting for its close affinities with *B. Indianænsis* from Crawfordsville, with which it agrees in all points except that *B. Whitei* is smaller by one-half, and has a single arm proceeding from each arm opening; while *B. Indianænsis* has always two as in the case of *B. Lovei* and *B. Christyi.*

We take pleasure in naming this species in honor of Dr. C. A. White of the National Museum, to whom we are indebted for many favors.

Geological Position, etc.—This species occurs in considerable quantities at Bono, Ind., but is rare at Canton and Edwardsville, Ind.; it is found in shaly layers, probably equivalent to the lower part of the Keokuk group.

23. **ERETMOCRINUS** Lyon and Casseday.

1859. Lyon and Cass. Am. Journ. Sci. and Arts (ser. 2), vol. 28, p. 241.
1866. Shumard. (Subgen. (?) of *Actinocr.*) Cat. Pal. Foss., pt. i, p. 369.
1869. Meek and Worthen. (Subgen. of *Batocr.*) Proc. Acad. Nat. Sci. Phila., p. 350.
1873. Meek and Worth. (Subgen. of *Batocr.*) Geol. Rep. Ill., v, p. 368.
1878. Wachsm. and Spr. Proc. Acad. Nat. Sci. Phila., p. 235.
1879. Zittel. (Subgen. of *Actinocr.*) Handb. d. Palæont., p. 370.
Syn. *Actinocrinus* (in part), Hall, 1861. Bost. Journ. Nat. Hist.

Lyon and Casseday's description of this genus was not very satisfactory and partly incorrect, and that is evidently the reason why it has never been recognized as it should be. Hall ignored it altogether, Shumard could not distinguish it from *Actinocrinus*, and Meek and Worthen, who adopted the name, placed it subgenerically at first under *Actinocrinus*, and later under *Batocrinus*. It differs from the former in almost the same characters as *Batocrinus*, but as distinctly from the latter, in the number and arrangement of the arms, in their greater length, depressed spatulate form; also in the form of the calyx, the extended basal ring, the preponderance of the dome portions over the calyx, the excentric position of the anal tube, its inflated character, and its disposition to bend sideways. We consider these characters sufficient for a full generic division, and propose the following:—

Revised Generic Diagnosis.—Body small, biturbinate or subglobose; calyx truncate at the base, composed of smooth, convex or nodose plates with rarely striations. Vault more or less inflated, and exceeding the calyx in its dimensions.

Basals three, equal, formed into a wide rim, which extends far beyond the periphery of the column. Primary radials 3×5; the first large, equal in size to the second and third together, and wider than either of them; the second quadrangular; the third regularly pentagonal, sometimes smaller than the second. Secondary radials composed of two series of plates each, and so are the tertiary radials when present. The plates of the marginal row, those supporting the arms, form a projecting circlet around the body, and are laterally extended; they are large, their outer sides excavated for the reception of the arm plates, the upper side notched for the ambulacral passages. At the side of the arm openings, which are generally directed obliquely toward the vault and close to the arm, there is located a respiratory (?) pore, which is arranged like in *Batocrinus*, and generally as large. The arm openings are arranged in groups of two, three, four, or five each, with great variability in the different rays. There are from twelve to twenty-two arm openings in all, and each one supports either a simple or a compound arm. The openings of adjacent rays are placed farther apart than those of the same ray, and are separated by a small depression, which at the posterior side of the body is considerably deeper and wider.

Arms fully twice as long as in *Batocrinus*, the upper portions flattened, much wider, and folded inward. They are composed of a double series of joints, which at the bottom rest upon one or two small cuneate pieces. The succeeding arm plates are generally short, but they become gradually longer as they increase in width. The lower portions of the arms are round or nearly so, the increase in width beginning at one-fourth to one-third their height, when they are gradually flattened, spread out laterally, and become broad and spatulate, remaining thick and heavy along the middle line, growing thin toward the edges. In some species the arms become fully an inch wide, while in others the increase in width is comparatively insignificant. In some species, every arm joint from both sides is extended, in others only every second, third or fourth joint, while the intermediate ones remain narrow. In these arms the wider joints appear in the form of lateral spines, which begin short, but gradually increase to a considerable length. Ambulacral furrows deep; pinnules similar to those of *Batocrinus.*

Interradial plates one to three, the first large, extended to the middle portions of the third primary radials, the upper ones very small. Anals, one in the first, three in the second series, with a few additional plates above. Interaxillaries none.

Dome elevated, inflated, generally larger than the calyx, composed of nodose or spiniferous plates; the apical plates more prominent and larger; the large centre piece occupying the very centre of the vault; posterior side with a shallow depression filled by small anal pieces.

Anal tube strong, more or less excentric, extending beyond the infolding arms, and frequently bent abruptly to one side; the middle portions more or less inflated, top and base of almost equal width, the upper end provided with a small opening.

Column round, composed of very wide pieces alternating with much smaller ones, the former frequently with sharp edges; central canal small.

Geological Position, etc.—*Eretmocrinus* occurs at the age of the Burlington and Keokuk groups, in America only.

We recognize the following species:—

1861. **Eretmocrinus attenuatus** Hall. (**Actinocr. matuta** var. **attenuata**) Desc. New. Sp. Crin. p, 14. Upper Burlington limest. Burlington, Iowa.

1860. **Eretmocr. calyculoides** Hall. (**Actinocr. calyculoides**) Supp. Geol. Iowa, p. 17, Photogr. Pl. 3, figs. 2–5; Meek and Worth., 1873, **Batocr.** (**Eretmocr.**) **calyculoides** Geol. Rep. Ill., v, p. 368. Upper Burl. limest. Burlington, Iowa.

1861. **Eretmocr. carica** Hall. (**Actinocr. carica**) Desc. New. Sp. Crin. p. 10; Meek and Worth, 1873, **Batocr.** (**Eretmocr.**) **carica,** Geol. Rep. Ill., v, p. 368. Lower Burlington limest. Burlington, Iowa.

1861. **Eretmocr. clio** Hall. (**Actinocr. clio**) Desc. New. Sp. Crin. p. 1; also Bost. Journ. Nat. Hist., p. 262, Photogr. Pl. 3, fig. 7; Meek and Worth., 1873, **Batocr.** (**Eretmocr.**) **clio,** Geol. Rep. Ill., v, p. 368. Lower Burlington limest. Burlington, Iowa.

1861. **Eretmocr. clœlia** Hall. (**Actinocr. clœlia**) Desc. New. Sp. Crin., p. 1: also Bost. Journ. Nat. Hist., p. 266; Meek and Worth., 1873, **Eretmocr. (Batocr.) clœlia,** Geol. Rep. Ill., v, p. 368. Upper Burlington limest. Burlington, Iowa.

1861. **Eretmocr. corbulis.** (**Actinocr. corbulis**) Desc. New. Sp. Pal. Crin. p. 1: also Bost. Journ. Nat. Hist., p. 265; Meek and Worth., **Batocr.—Eretmocr.(?) —corbulis,** Geol. Rep. Ill., v, p. 368. Lower Burlington limest. Burlington, Iowa.

*1860 **Eretmocr. coronatus** Hall. (**Actinocr. coronatus**) Supp. Geol. Rep. Iowa, p. 28, Photogr. Pl. 3, figs. 1–2. Lower Burlington limest. Burlington, Iowa.

1860. **Eretmocr. gemmiformis** Hall. (**Actinocr. gemmiformis**) Supp. Geol Rep. Iowa, p. 23, Photogr. Pl. 3, fig. 6; Meek and Worth., **Batocr.—Eretmocr.(?) —gemmiformis,** Geol. Rep. Ill., v, p. 368. Lower Burlington limest. Burlington, Iowa.

*1855. **Eretmocr. Konincki** Shumard. (**Actinocr. Konincki**) Geol. Rep. Missouri; by Swallow, pt. ii, p. 194, Pl. A, figs. 8 a, b, c; Meek and Worth., **Batocr. Konincki,** Geol. Rep. Ill., v, p. 367. Upper Burlington limest. Burlington, Iowa.

Syn. **Actinocr. urnæformis** McChesney, 1860. New. Pal. Foss. p. 23; Meek and Worth., **Batocr.—Eretmocr.(?)—urnæformis,** Geol. Rep. Ill., v, p. 368.

*1861. **Eretmocr. leucosia** Hall. (**Actinocr. leucosia**) Desc. New. Pal. Crin., p. 1: also Bost. Journ. Nat. Hist., p. 261. Lower Burlington limest. Burlington, Iowa.

1859. **Eretmocr. magnificus** Lyon and Cass. Type of the genus. Am. Journ. Arts and Sci. (ser. 2), vol. 28, Septbr., p. 241; Meek and Worth., **Batocr.—Eretmocr.—magnificus,** Geol. Rep. Ill., v, p. 368. Keokuk limest. Hardin Co., Ky.

1861. **Eretmocr. matuta** Hall. (**Actinocr. matuta**) Desc. New. Sp. Crin., p. 14; Meek and Worth., Geol. Rep. Ill., v, p. 368. Upper Burlington limest. Burlington, Iowa.

1869. **Eretmocr. neglectus** Meek and Worth. (**Batocr.—Eretmocr.—neglectus**) Proc. Acad. Nat. Sci., Phila., p. 355; Geol. Rep. Ill., v, p. 377, Pl. 5, fig. 3. Lower Burlington limest. Burlington, Iowa.

1858. **Eretmocr. ramulosus** Hall. (**Actinocr. ramulosus**) Geol. Rep. Iowa, i, pt. ii, p. 615, Pl. 15, fig. 7; Wachsm. and Spr., 1878. Proc. Acad. Nat. Sci., Phila., p. 237. Burlington and Keokuk Transition bed, and Lower Keokuk limest. Burlington and Augusta, Iowa, and Nauvoo, Ill.

It is more than probable that this species is a *Syn.* of **E. magnificus.**

1861. **Eretmocr. remibrachiatus** Hall. (**Actinocr. remibrachiatus**) Desc. New. Sp. Crin., p. 11, Photogr. Pl. 3, figs. 8–9; Meek and Worth., Geol. Rep. Ill., v, p. 368. Upper Burlington limest. Burlington, Iowa.

1855. **Eretmocr. Verneuilianus** Shumard. (**Actinocr. Verneuilianus**) Geol. Rep. Missouri, by Swallow, Pt. ii, p. 193, Pl. A, figs. 1a, b; Meek and Worth. **Batocr.—Eretmocr.—Verneuilianus** Geol. Rep. Ill., v, p. 368, Pl. 4, figs. 3 and 4. Upper Burlington limest. Burlington, Iowa, Illinois and Missouri.

Next to **Batocr. rotundus** this is the most characteristic species of the Burlington group. It does not represent a typical form of this genus, the arms like those of **E. Konincki** being but little flattened, but its structure other wise leaves no doubt that it belongs to **Eretmocrinus.**

We further place here the following new species, which are interesting as all three are of a similar type, and either descendants from each other, or closely related to each other:—

Eretmocrinus originarius n. sp.

Body small, calyx and dome of equal height, the former subturbinate with nearly straight sides, the vault somewhat inflated, with convex sides. Radial plates covered with an obscure ridge, passing longitudinally from plate to plate, all other plates of the calyx nearly or quite smooth.

Basal cup low, truncate at the bottom, extending into a ring which projects beyond the rather large column. First radial as large as second and third combined; the second much shorter, quadrangular, twice as wide as high; the third as large as the second, and but little wider, the lateral sides almost straight. Secondary radials consisting of two series of plates, which are of a similar form as the two upper primary radials but smaller. They are followed in the anterior ray by the arms, in the four other rays by tertiary radials. In the lateral rays both upper and secondary radials are axillary, and give off 2×2 tertiary radials with four arm openings, the two postero-lateral rays have three, of which one side only is bifurcating, while the other remains simple. Arms simple throughout, of medium length, the tips slightly spatulate and folded inward; composed of rather high, somewhat convex joints, with comparatively strong pinnules.

Interradials three, the first very large, with a faint node in the centre; anals one, three and two. Dome composed of convex plates; annal tube unknown, but evidently not very large.

Geological Position, etc.—From the age of the earlier Keokuk limest., near Bono, Lawrence Co., Ind., where the species occurs in great quantities. Collection of Chas. Wachsmuth.

Eretmocrinus intermedius n. sp.

In form, size, and ornamentation resembling *E. originarius*, perhaps a little more truncate at the basal portions, and the arm bases more spreading, differing, however, in the arm structure. It has normally six arms from each posterior, and four from the rest of the rays, twenty-four arms to the individual. The radial portions of the calyx, in the lateral rays, are unchanged, while the anterior ray has in addition 2×2 tertiary radials, and consequently twice the number of arms. In the posterior rays, both second tertiary radials are bifurcating, and give to the inner side of the ray a simple arm, to the outer 2×2 quaternary radials, of which each series supports an arm. The plates of the upper order of radials, all around the body, and frequently the last axillary plate of the posterior rays, are not enclosed within the body or only partly so, thus remaining in a somewhat undeveloped state, while they are in form and size regular radials. Compared with *B. originarius*, the arms are more crowded, the upper portions more spatulate. Arm joints transversely angular, the outer sides straight or very little convex. Vault unknown.

Geological Position, etc.—From the same layer as the preceding species, and almost as common. Collection of Chas. Wachsmuth.

Eretmocrinus adultus n. sp.

Plates apparently without ornamentation. Calyx low basin-shaped, with a projecting rim along the basals. First radials a little shorter than second and third together, but wider than either of them; the third wider than the second. The higher orders of radials comparatively large, composed of two plates each, which increase in size upward, those forming the arm bases very much wider, as large or larger than the first primary radials. Articulating scar or facet for the attachment of the arms occupying but little more than one-half to two-thirds the width of the plates, somewhat projecting, thereby producing a shallow depression between the arm bases, outer face truncate or concave. The concavity is filled by three arm pieces, a central one which is angular above, and a shorter piece on each side of it, the latter of the height of the regular arm joints but narrower. They are followed by a similar piece on each side, and two other pieces resting against the sloping sides of the little axillary plate, alternating with the former, and constituting the base of two arms, which from the second or third joint become free. The species has fourteen pairs of arms, two in the anterior ray, and three in each of the others. Arms long gradually flattening at midway, upper portions strongly spatulate and folded inward.

Interradials consisting of one large plate, succeeded either by one or two smaller ones, or by a single large, elongate piece, wedged in between the plates of the higher order of radials. Anals one, three, and three plates. Vault unknown; anal tube long, extending considerably beyond the arms, of rather large size, composed of smooth plates. *E. adultus* agrees in its double arm structure with *Batocr. Indianænsis* and *B. Christyi*, but has spatulate arms and a very different arm formula. It is of the type of *Eretmocr. originarius* with which it is more closely allied than would appear at first sight. *E. adultus* is larger and especially broader, but this is evidently due to the double arm structure which required those modifications, the differences are similar to those between *Batocr. Lovei* and *B. trochiscus.*

Geological Position, etc.—Keokuk limest. Canton, and Edwardsville, Ind. Collection of Chas. Wachsmuth.

24. DORYCRINUS Roemer.

1854. F. Roemer. Archiv f. Naturgesch., Jahrg., xix, Band i, p. 207.
1855. F. Roemer. Lethæa Geogn. (Ausg. 3), p. 249.
1869. Meek and Worth. Proc. Acad. Nat. Sci., Phila., p. 165.
1873. Meek and Worth. Geol. Rep. Ill., v, p. 379.
1879. Zittel. (Subgenus of *Amphoracrinus*). Handb. d. Palæont., i, p. 370.

Syn. *Amphoracrinus* Meek and Worth. (not Austin), 1866, Geol. Rep. Ill., ii, p. 209.

Syn. *Actinocrinus* (*Amphoracr.*) Meek and Worth., 1861, Proc. Acad. Nat. Sci., Phila., p. 132.

Syn. *Sphærocrinus* Meek and Worth., 1865 (not Roemer, 1851). Ibid., p. 154.

Syn. *Cœlocrinus* Meek and Worth., 1865 (not *Cœliocrinus* White, 1863). Ibid., p. 273; and 1868, Geol. Rep. Ill., ii, p. 215.

Roemer's typical species of *Dorycrinus* is provided with six large spines at the vault, and upon this peculiarity, principally, the genus was founded. In regard to this point the genus must be amended, as there are other species, evidently belonging to the same group, which have only a central spine, others have three, and still others in place of the spines a large convex or nodose plate. There are, however, other excellent distinctions which make *Dorycrinus* a good genus.

Neither Hall, Shumard, de Koninck and Lehon, Pictét, nor Schultze, have recognized *Dorycrinus*, all referring the species to *Actinocrinus*, with which it agrees only in the general family characters, and in having the rays extended into lobes. *Dorycrinus* inclines far more toward *Batocrinus* and *Eretmocrinus*, with which it agrees in the general form of its plates, and in the peculiar double arm structure, which became here a constant character. It differs, however, very essentially in the lobed form of the body, its strongly expressed bilateral symmetry, in the lateral position of the anus, and in its opening out directly through the body, as also the shortness and delicacy of the arms. It differs from *Agaricocrinus* and *Amphoracrinus* in the form and proportions of the body, in the arrangement of the plates, and in the altogether different arm structure.

We place Meek and Worthen's subgenus *Cœlocrinus*, which had been previously described, successively, under *Actinocrinus*, *Amphoracrinus* and *Sphærocrinus*, as a synonym under *Dorycrinus*, the only known species being a somewhat aberrant form, but not sufficiently distinct even to make it a subdivision.

Generic Diagnosis.—Calyx broadly turbinate or subglobose, truncate at the base, and deeply sinuate at the interradial spaces, the sinus at the posterior side much deeper and wider, and extending up to the vault, thereby giving to the body a decidedly pentalobate aspect, with a strongly expressed bilateral symmetry. Dome from one-fourth to one-half the height of the body, strongly convex, composed of comparatively few and large plates, frequently armed with one to six spines. Plates sometimes corrugated, but not striated, and all more or less convex or nodose.

Basals three, equal, short, in the typical forms of the genus abruptly spreading, the lower exterior margins extending almost at right angles to the axis of the fossil; deeply sinuate at the sutures, but sometimes forming a continuous ring. Primary radials 3×5; the first as large or larger than the second and third together; the second much narrower than the first, but wider than high, quadrangular in outline, although sometimes (in the same specimen) pentagonal or hexagonal, owing to the position of the second series of interradials, upper and lower sides parallel; the third more or less pentagonal, wider than high, wider in rays with three or four arm bases than with two. The third radial, in rays with only two arm openings, with 2×2 secondary radials, which support the arms, but in rays with three or four openings, and consequently with tertiary radials, the secondary radials consist of a single series of plates, of which one or both are axillary. In the latter case, the plate gives off 1×2 arm-bearing plates, in the former another row of secondary radials, which support the arms. The arm bearing plates, all around the body, are projecting, rounded toward their sides, and separated by a deep lateral depression or sinus, which is deeper and wider between the main divisions of the ray, and which at the space between the rays forms a wide and deep gap. *Dorycrinus* has variously from twelve to twenty arm openings to the species, and twice that number of arms, two to each opening, given off in a similar manner as in some species of *Batocrinus* and *Eretmocrinus*. The arm openings are unequally divided among the rays, only species with twenty openings having four to each ray. In species with a less number, the posterior rays are stronger, and have always four openings, except when there are only twelve openings in all. The anterior ray is generally stronger, or has at least as many arms as the antero-lateral rays, which, as a rule, are the least developed, and in most species have but two pairs of arms. Slight variations in the arm formula of the same species occur frequently in this genus. Respiratory (?) pores close to the arm openings.

Interradials two or three, rarely more, in two series; the first very large, frequently but not always extending to the third primary radials; the plates of the upper series small, placed within the sinus between the rays, and hence are connecting with the interradial dome plates. Anal area constructed very differently from the interradial, composed of a large plate in line with the first radials, but higher than those, with the upper sloping sides longer. There are three plates in the second series, the middle one larger with truncate upper side, succeeded by a row of two to four similar plates, which form a longitudinal line, often elevated into a ridge up to the anal aperture. The opening is surrounded by one or two rows of plates, which at the upper side lean against the central dome piece. It is a simple aperture penetrating a somewhat thickened protuberance, and nearly always situated and directed laterally. No interaxillary plates.

Dome elevated, inflated, occasionally a little depressed toward the middle. Plates large, centre plate and the first five radial pieces larger than the proximal dome pieces, and frequently extended into spines, which in some extreme cases attain a length of three to four inches. There are other species with only a central spine, and still others in which the respective plates are only larger or more convex. The proximal plates connect with the centre piece, they are very regularly arranged and readily recognized, but otherwise not distinct from the rest of the vault pieces.

Column round, not strong, and composed alternately of much larger and smaller segments; central canal small.

Geological Position, etc.—*Dorycrinus* is in America a strictly

Lower Subcarboniferous genus; the only species so far recognized in Europe has been found in the Devonian of the Eifel.

The following is a list of the known species:—

1869. **Dorycrinus canaliculatus** Meek and Worth. Proc. Acad. Nat. Sci. Phila., p. 166; Geol. Rep. Ill., v, p. 381, Pl. 6, fig. 4. Lower Burlington limest. Burlington, Iowa.

*1861. **Dorycr. concavus** Meek and Worth. (**Actinocr. concavus**) Proc. Acad. Nat. Sci. Phila., p. 131; **Sphærocr. concavus** Meek and Worth., 1865, Ibid., p. 154; **Cœlocr. concavus** Meek and Worth., 1865 (Dec.), Ibid., p. 273; also Geol. Rep. Ill., ii, p. 215, Pl. 15, figs. 10 a, b, c. Lower Burlington limest. Burlington, Iowa.

1858. **Dorycr. cornigerus** Hall. (**Actinocr. cornigerus**, not **A. cornigerus** Lyon and Casseday) Geol. Rep. Iowa, i, pt. ii, p. 576, Pl. 9, figs. 12 a, b, c; also Ibid., Supp., Pl. 3, fig. 4; Meek and Worth., **Dorycr. cornigerus**, Geol. Rep. Ill., p. 380. Upper Burlington limest. Burlington, Iowa.

Syn. **Actinocr. divaricatus** Hall, 1860. Supp. Geol. Rep. Iowa, p. 11.

Syn. **Actinocr. quinquelobus** Hall, 1860. Supp. Geol. Rep. Iowa, p. 15; Meek and Worth. **Dorycr. quinquelobus** 1873. Geol. Rep. Ill., v, p. 380.

*1860. **Dorycr. decornis** Hall. (**Actinocr. decornis**) Supp. Geol. Rep. Iowa., p. 13. Burlington limest. Burlington, Iowa.

(This is a very doubtful species.)

1858. **Dorycr. Gouldi** Hall. (**Actinocr. Gouldi**) Geol. Rep. Iowa., i, pt. ii, p. 613, Pl. 15, figs. 6 a, b; Meek and Worth. *Dorycr. Gouldi*, Geol. Rep. Ill., v, p. 380. Lower part of the Keokuk limest. Keokuk, Iowa.

1875. **Dorycr. Kelloggi** Worthen, Geol. Rep. Ill., vi, p. 513, Pl. 29, fig. 8. Keokuk limest. Keokuk, Iowa.

1853. **Dorycr. mississippiensis** Roemer. Type of the genus. Archiv f. Naturgesch., Jahrg. xix, Band i, Pl. 10, figs. 1, 2, 3; Meek and Worth., 1873, Geol. Rep. Ill., v, p. 380. Keokuk limest. Iowa, Illinois, Tennessee, Kentucky and Missouri.

Syn. **Actinocr. (Dorycr). mississippiensis** var. **spiniger** Hall, 1860. Supp. Geol. Rep. Iowa., p. 54. (This is merely a young form.)

1858. **Dorycr. missouriensis** Shumard. (**Actinocr. missouriensis**) Geol. Rep. Missouri, by Swallow, pt. ii. p. 190, Pl. A, figs. 4 a, b, c; Meek and Worth. **Dorycr. missouriensis**, 1873. Geol. Rep. Ill., v, p. 380. Upper Burl. limest. Palmyra, Mo. and Burlington, Iowa. (This species is very variable in the number of arms.)

Syn. **Actinocr. desideratus** Hall. Desc. New Sp. Crin. p, 2; Bost. Journ. Nat. Hist., p. 273; Meek and Worth. **Dorycr desideratus**, Geol. Rep. Ill., v, p. 380.

*1855. **Dorycr. parvus** Shumard. (**Actinocr. parvus**) Geol. Rep. Mo., by Swallow, ii, p. 193, Pl. A, fig. 9; Upper Burlington limest. (not St. Louis limest. as quoted by Shumard), Palmyra, Mo. and Burlington, Iowa.

Syn. **Actinocr. trinodus** Hall, 1858. Geol. Rep. Iowa, i, pt. ii, p. 575.

Syn. **Actinocr. symmetricus** Hall, 1858. Geol. Rep., Iowa, i, pt. ii, p. 574, Pl, 9, figs. 8 a, b; Meek and Worth., **Dorycr. symmetricus** 1873, Geol. Rep. Ill., v, p. 380.

Syn. **Actincor. (Amphoracr.) subturbinatus** Meek and Worth., 1860, Proc. Acad. Nat. Sci. Phila., p. 388; Geol. Rep. Ill., ii, p. 212, Pl. 15, figs. 4 a, b. **Dorycr. subturbinatus**, 1873, Ibid., v, p. 380.

*1862 (?) **Dorycr. præcursor** Hall. (**Actinocr. præcursor**) 15th Rep. N. Y., St. Cab. Nat. Hist., p. 131. Hamilton gr. Western New York.

We refer this species with doubt to the genus; it is imperfectly known.

*1855. **Dorycr. prumiensis** Müller. (**Actinocr prumiensis**) Verhand. Naturhist. Verein. f. Rheinlande, xii, p. 81, Pl. 9, figs. 1, 5; also 1857. **Pyxidocr. prumiensis** Neue Echin. Eifl. Kalk, p. 253, Schultze, 1867, Mon. Echin. Eifl. Kalk, p. 60, Pl. 6, fig. 6. Devon. Eifel, Germ.

1868. **Dorycr. quinquelobus** (var.) **intermedius** Meek and Worth. Proc. Acad. Nat. Sci. Phila., p. 346; Geol. Rep. Ill., v, p. 385, Pl. 10, fig. 4. Transition bed between Burl. and Keok. limest. Pleasant Grove, Iowa. This is more properly a variety of **D. mississippiensis**, from which it differs only in having fewer arms and in its smaller size.

1868. **Dorycr. Roemeri** Meek and Worth. Proc. Acad. Nat. Sci. Phila., p. 346; also Geol. Rep. Ill., v, p. 383, Pl. 10, fig. 3. Uppermost part of Upper Burl. limest. Burlington, Iowa.

*1860. **Dorycr. spinosulus** Hall. (**Actinocr. spinosulus**) Supp. Geol. Rep. Iowa., p. 52, Keokuk limest. Nauvoo, Ill. (Probably a young **D. mississippiensis.**

*1858. **Dorycr. subaculeatus** Hall. (**Actinocr. subaculeatus**) Geol. Rep. Iowa, i, pt. ii, p. 570, Pl. 10. figs. 2 a-b; Meek and Worth., **Dorycr. subaculeatus**, Geol. Rep. Ill., v, p. 380. Lower Burlington limest. Burlington, Iowa.

1850. **Dorycr. unicornis** Owen and Shumard. (**Actinocr. unicornis**) Journ. Acad. Nat. Sci. Phila., ii. (ser. ii), p. 67; also U. S. Geol. Rep. Iowa, Wis. and Minn., p. 573, Pl. 5 a, figs. 12 a, b; Hall, 1858, Geol. Rep. Iowa, i, pt. ii, p. 568, Pl. 10, figs, 5 a, b, c; Meek and Worth., 1873, **Dorycr. unicornis**, Geol. Rep Ill. v, p. 380, Pl. 6, fig. 2. Lower Burlington limest. Burlington, Iowa.

Syn. **Actinocr. tricornis** Hall, 1858, Geol. Rep. Iowa, i, pt. ii, p. 569.

Syn. **Actinocr. pendens** Hall, 1860. Ibid., Supp., p. 31.

*1861. **Dorycr. unispinus** Hall. (**Actinocr. unispinus**) Desc. New Sp. Crin. p. 2; also Bost. Journ. Nat. Hist., p. 270. Lower Burlington limest. Burlington, Iowa.

C. RHODOCRINIDÆ Roemer.

(Amend. Zittel, amend. Wachsm. and Spr.)

The genera which we include among the *Rhodocrinidæ* were arranged by the earlier writers, either in connection with such genera as *Cyathocrinus*, *Poteriocrinus*, or in various ways with *Actinocrinus*, *Melocrinus*, *Dimerocrinus*, *Periechocrinus*, *Carpocrinus* and others.

Austin [1] placed *Rhodocrinus* and *Sagenocrinus* under the Actinocrinoidea, *Dimerocrinus* under the Merocrinoidea.

D'Orbigny [2] placed *Gilbertsocrinus* and *Dimerocrinus* under the Melocrinidæ, *Glyptocrinus* and *Rhodocrinus* under the Cyathocrinidæ.

[1] Ann. and Mag. Nat. Hist., 1842–3.

[2] Course elém. de Paléont., 1852, vol. 2.

Pictét[1] arranged *Rhodocrinus*, *Acanthocrinus*, *Dimerocrinus*, and *Thysanocrinus* under the Cyathocriniens, *Lyriocrinus* and *Scyphocrinus* Hall (not Zenker), under the Carpocriniens, and all under the Cyathocrinidæ.

Roemer,[2] who was the first to propose the name Rhodocrinidæ, referred to it only the genus *Rhodocrinus*, placing *Sagenocrinus* with the Sagenocrinidæ, *Thysanocrinus* with the Poteriocrinidæ, and *Dimerocrinus* which we take to be identical with *Thysanocrinus* he referred to the Cyathocrinidæ.

The great dissimilarity which manifests itself in these classifications, must be partly attributed to the imperfect knowledge which prevailed with regard to some of those genera at that time. It was evidently the intention of the writers to group the Crinoids according to the presence or absence of underbasals, the number of basals and the arm structure, but these parts had been often incorrectly represented, or were as yet entirely unknown.

A very marked improvement is visible in the classification of Zittel[3] who placed among the Rhodocrinidæ, *Ollacrinus*, *Rhodocrinus*, *Acanthocrinus*, *Ripidocrinus*, and *Thysanocrinus*, and proposed the name Glyptocrinidæ for *Glyptocrinus*, *Glyptaster*, *Thylacocrinus*, *Lampterocrinus*, *Eucrinus*, and *Sagenocrinus*, these genera, without exception, have underbasals, and Zittel discriminated distinctly between genera in which the calyx is constructed exclusively of three rings of plates, and those in which the radials are separated by interradials—our Sphæroidocrinidæ—and he distinguished these from our Ichthyocrinidæ. He, however, placed *Dimerocrinus* with some of our Actinocrinidæ, as that genus was thought to possess no underbasals, and he for a similar reason admitted *Lyriocrinus* among the Calyptocrinidæ.

The Glyptocrinidæ and Rhodocrinidæ of Zittel, according to his own diagnosis, differ only in the form of the body and the position of the interradial (not anal) plates. He describes the form of the Glyptocrinidæ as high (turbinate), that of the other bowl-shaped (more or less depressed), the first interradials of the former as being placed between the second and third radials, those of the latter as forming together with the first radials a ring of ten alternating plates. We doubt very much whether these dif-

[1] Traité de Paléont., 1857, vol. iv.

[2] Lethæa Geogn., 1855 (Ausg. 3).

[3] Handbuch der Palæontologie, i.

ferences, even if they were persistent, can be deemed sufficient for a family distinction. *Thysanocrinus* of the Rhodocrinidæ has generally at four sides the first interradial disposed between the first and second radials; while in *Thylacocrinus*, according to Oehlert's figure, all five first interradials rest directly upon the basals, or to use Zittel's language, "form a ring of ten plates with the first radials as in his *Rhodocrinidæ*."

In our classification, we place under the Rhodocrinidæ all genera of the Sphæroidocrinidæ which have well-defined underbasals, and we admit also *Glyptocrinus* in which these plates are exceedingly rudimentary, or perhaps in some species altogether undeveloped. The Rhodocrinidæ have five—exceptionally three—basals; from 2 to 3×5 primary radials, 2 to 6×10 secondary and sometimes several tertiary radials. The plates of the higher orders, if such are present, being formed into extended free rays with lateral arms. Arms rather delicate, branching or simple, the latter being rather the exception. Interradials numerous, arranged with two or three plates in each series, except in the first which has but one plate. In most of the genera, the first interradial rests directly upon the truncate upper side of the basals, thereby separating the first radials all around. In others, however, only the first plate of the posterior or anal side is supported by a basal, that of the other four sides being placed against the upper corners of the first and between the second radials, the former producing an almost perfect pentrahedral, the latter a more or less bilateral symmetry.

In *Glyptocrinus*, the first interradial rests between the first and second radials at every side; interaxillaries generally present; vault flat or low hemispherical, composed of small and more or less irregular pieces; apical dome-plates not well defined; interradial regions depressed; anus in form of a simple opening through the vault, rarely proboscis-like. Column round or pentagonal.

For greater convenience of study we subdivide the Rhodocrinidæ into three groups.

a. Glyptocrinites.—Calyx turbinate, symmetry almost perfectly pentahedral, radial plates with rounded, strongly elevated ridges which gently pass into the arms. Interradial areas depressed, the first plate resting either directly upon the basals, or between the second and third radials, without special anal plate beneath their line. Restricted to the Lower Silurian.

b. Glyptasterites.—Calyx turbinate, symmetry bilateral, radials less carinated than in the preceding group. A special anal plate supported upon the basals, with another within the second series, resting between the two interradials, and in line with the first interradial plate of the four lateral areæ. Upper Silurian.

c. Rhodocrinites —Calyx subglobose, somewhat depressed; symmetry nearly perfectly pentahedral. Radials without elevated ridges. Interradial plates extending down to the basals, posterior area but little distinct from the others, sometimes a little wider, with one or two irregular additional plates. Found from the Upper Silurian to the Subcarboniferous.

These groups, as those of the Actinocrinidæ, are based upon the general form of the body and the arrangement of anal plates. In their form, the *Glyptocrinites* resemble the *Glyptasterites*, but in the arrangement and position of interradial and radial plates the former agree with the *Rhodocrinites*. It might have been not out of the way if we had placed the genus *Glyptocrinus* in a group by itself, as it differs from *Archæocrinus* and *Reteocrinus*, with which it has been associated, and from all other Rhodocrinidæ, in having the first plate at each interradial side placed between the second radials, a combination which is found not unfrequently in the earlier Actinocrinidæ. This becomes more important since some species of that genus apparently have no underbasals, and it is a question whether that genus, at least partly, should not be arranged with the other group altogether. The unmistakable evidence of minute underbasals in some species, and the close affinities which the genus has with *Reteocrinus*, with which it is connected by most remarkable transition forms, has induced us to place it with the Rhodocrinidæ. *Glyptocrinus* evidently forms a link between those two great divisions, and leans as much to the one as to the other, but whether it is the prototype of the Actinocrinidæ or of the Rhodocrinidæ we are unable to assert, there being arguments in favor of both theories. It seems to us more probable that the Rhodocrinidæ were introduced first, but this must remain a supposition so long as we know comparatively nothing of the crinoidal forms which preceded *Glyptocrinus*.

The arms of the Rhodocrinidæ in the Lower Silurian, are single- or double-jointed; the Upper Silurian forms, almost without exception, have two rows of interlocking plates. Respiratory pores, such as noticed in the Actinocrinidæ, have never been observed in this family; *Ollacrinus* has lateral appendages, two to each interradial area, with a central canal passing through each, communicating with the inner body. The entrances of these canals into the body occupy the same relative position to the ambulacral or arm openings, as the respiratory pores to the arm openings in *Batocrinus*, and these like those are connected with the radial grooves beneath the vault. The appendages seem to be in some way connected with the interradial depressions which are so frequently found upon the vault of this genus and in *Rhodocrinus* (Pl. 19, fig. 1). The depressions are in some specimens deeper than in others, and as the plates of which they are composed are smaller and thinner, it is very probable that the test in these parts was flexible, liable to contraction and expansion.

Geological Position, etc.—Nine of the thirteen genera which we place among the Rhodocrinidæ are restricted to the Silurian, two are strictly Devonian, and the remainder which first appear in the Devonian, become extinct in the lower part of the Subcarboniferous. None of the genera seem to have had a great variety of species or to have existed in great numbers, except some few species of the Lower Silurian.

We arrange the three sections as follows:—

a. GLYPTOCRINITES.

1. *Glyptocrinus* Hall.
2. *Archæocrinus* Wachs. & Spr.
3. *Reteocrinus* Billings.

b. GLYPTASTERITES.

4. *Glyptaster* Hall.
   Subgen. *Eucrinus* Angelin.
5. *Dimerocrinus* Phillips.
6. *Lampterocrinus* Roemer.
7. *Sagenocrinus* Austin.

c. RHODOCRINITES.

8. *Lyriocrinus* Hall.
9. *Ripidocrinus* Beyrich.
10. *Thylacocrinus* Oehlert.
11. *Anthemocrinus* Wachs. & Spr.
12. *Rhodocrinus* Miller.
13. *Ollacrinus* Cumberland.

P. S.—At the moment this goes to press, we received from S. A. Miller a very interesting paper containing descriptions of several new Crinoids from the Hudson River group, published in the April number of the Journ. Cincin. Soc. Nat. Hist. Miller proposes the name *Xenocrinus* for a form, which in external appearance resembles closely *Reteocrinus* Billings, but from which it differs, according to description, by having a quadrangular column, four basals and no underbasals, thus bringing it in close proximity to *Mariacrinus* and *Melocrinus*, and among the Actinocrinidæ. There is something in the habitus of the genus that leads us to think it should be associated with the Rhodocrinidæ, and that it had underbasals which were not disclosed.

No Actinocrinoid has ever been discovered in which the interradial field, except at the "azygous" side, extends to the basal disk; such, however, seems to be clearly the case in *Xenocrinus penicillus.* We leave the discussion of this genus to our future appendix, as we hope to have an opportunity to examine some of the specimens.

Another of Miller's new species is described with four basals and a quadrangular stem; but, contrary to the former, here only the interradial area at the posterior or anal side descends to the basals. Miller refers the species to *Glyptocrinus* with which it has no doubt close affinities, but it appears to us, that if *Xenocrinus* is a good generic form, the other also should be made a new genus. *Gl. Harrisi* is distinguished from *Glyptocrinus* almost by the same characters as *Xenocrinus* from *Reteocrinus.* We further refer *Glyptocrinus cognatus* Miller, to *Reteocrinus.*

a. Glyptocrinites.

1. GLYPTOCRINUS Hall.

1847. Hall. Paleont. New York, i, p. 281.
1857. Billings. Geol. Surv. Canada, of 1853 to 1856, p. 256.
1859. Billings. Ibid., Decade iv, p. 55.
1863. Hall. Trans. Albany Inst., iv, p. 202.
1873. Meek. Geol. Surv. Ohio Paleont., i, p. 30.
1879. Zittel. Handb. d. Paleont., i, p. 374 (not *Glyptocrinus* d'Orb., 1850, Prodr. i, p. 45, nor p. 103).
Syn. *Apiocrinite* Anthony, 1838 (not Miller, 1821).
Syn. *Icosidactylocrinus* Owen, 1843, Cat. Spec. Ohio Valley.

We are compelled to exclude from the genus *Glyptocrinus* several species which were referred to it by Hall and Billings, and have arranged them with other genera. We place *Glyptocr. Carleyi* Hall—which has four basals and not five—under *Mariacrinus* as reconstructed and amended by us. The generic differences between *Glyptocrinus* and *Glyptaster* have never been satisfactorily pointed out, and Hall's explanatory remarks (Trans.

Albany Inst., iv, p. 202) have by no means cleared up the difficulties attending their separation.

According to Hall, the principal distinction should be found in the rudimentary or imperfect condition of the underbasals in *Glyptocrinus*, as opposed to the moderately large size of the same pieces in *Glyptaster*, and in that the rays of the former were twice subdivided in the body, with simple undivided arms, while the latter had but a single division in the body. A comparison of all the species that have been referred to *Glyptocrinus*, shows conclusively that these supposed distinctions are not borne out by the facts. Hall's so-called *Glyptocr. O'Nealli* has well defined underbasals, and the second branching of the ray takes place in the free arms, while the rays in *Glyptocr. nobilis* divide at least three times in the body, and on the other hand in *G. Dyeri* Meek, the second bifurcation takes place in the arms. We have placed *G. O'Nealli* Hall, *G. Richardsoni* and *G. gracilis* Wetherby, *G. Baeri* Meek, and *G. cognatus* Miller, under *Reteocrinus* Billings, and should have proposed *G. nobilis* the type of a new genus, if we had before us good specimens instead of figures of casts in which neither basal nor anal plates are shown. The high dome, the anal tube, the large number of arms, and its occurrence in a different geological horizon suggests very strongly to our mind its generic distinctness.

Glyptocrinus is one of the oldest forms of the Rhodocrinidæ, and is the forerunner and type of a little group of Silurian Crinoids, which are readily recognized by their obconical form; the prominent rounded ridges that follow the radial series of the calyx, looking like recumbent arms; the beautifully striated surface, and the character of the arm structure. The arms in all of them rise from the edge of the vault, forming uninterrupted prolongations of the elevated ridges of the calyx, and the radial plates pass into arm plates so gradually, that it becomes almost impossible to discern where the calyx terminates and the arms begin. Zittel has arranged these genera into a distinct family and we should follow his example if we had not discovered that the same characters exist among the Actinocrinidæ, and indeed—what is more significant—among genera with five, four and three basals, but only in Silurian types, thus indicating that the characters above noted represent probably a younger stage of family development.

Glyptocrinus differs from *Glyptaster* in having rudimentary instead of moderately developed underbasals, in not having the first anal plate on a level with the first radials, and in the arms, which in *Glyptocrinus* are composed of single joints, instead of two rows of interlocking pieces as in *Glyptaster*. *Reteocrinus* differs in the size of its underbasals, the deeply depressed inter radial spaces, the irregular arrangement, and exceedingly large number of interradial and interaxillary plates, and that the rays are not connected laterally, but, all the way up from the basals, separated by small interradial pieces.

We propose for *Glyptocrinus* the following:

Revised Generic Diagnosis.—Calyx obconical to subglobose, its symmetry almost perfectly pentahedral. Surface ornamented with radiating striæ in form of elevated ridges, which divide into numerous triangular impressed areæ. The ridges passing along the radial portions are rounded, nearly as wide as the arm joints, and appear like arms that are soldered into the body. The arms rise vertically from the edge of the vault, forming undisturbed continuations of the ridges of the calyx, and the higher radial plates pass imperceptibly into arm plates.

Underbasals five, rudimentary—perhaps sometimes obsolete—entirely hidden from view by the column, and filling only a small portion of the basal concavity. Basals five, of uniform size, small, scarcely extending to the sides of the body, slightly concave for the attachment of the column. Primary radials 3×5, the lower series somewhat larger, nearly similar in form; the second hexagonal; the third pentagonal in outline, and supporting on its upper sloping sides the secondary radials. The number of secondary radials varies with the species, but, as a general rule, it might be asserted, that in species with a third order of radials or a second division within the body, there are only two secondary radials, while in species in which the second bifurcation takes place in the free arms, their number is much greater. Species of the latter kind sometimes have six, eight or more, and these are succeeded to the last bifurcation by three, four or more free plates. The tertiary radials, where they exist, are as variable in number as those of the secondary order. There may be within the same species one, three or more of these plates soldered into the body, or they all may be free plates, depending on the age of the individual.

Arms twenty, rising upright, almost vertically from the last radial, long, slender, simple from the second division, rounded on the outer side, and composed of a single series of short, somewhat wedge-shaped pieces, of which each one supports at its larger end a pinnule. Pinnules very slender, alternately and very closely arranged, the proximal ones fixed in the body walls, the first generally given off from the second secondary radials.

Interradial areæ occupied by a large number of pieces, arranged in four or more series, with one plate in the first, two in the second, and generally three in each succeeding series. The posterior or anal area differs from the others in being a trifle wider, and having three plates instead of two in the second and all succeeding series. The median row generally consists of larger plates, and these elevated above the level of the others. The first anal, like the first interradial plate, rests upon the upper sloping side of the first and between the second radials. Interaxillary plates from one to ten, with a less number in species in which the last bifurcation takes place in the body.

Vault scarcely elevated above the horizon of the arm bases; the interradial regions somewhat depressed; composed of numerous very small, convex plates. The apical dome plates not well defined; anal aperture directly through the vault, excentric.

Column round, of medium size; central canal small, distinctly pentagonal.

Geological Position, etc.—*Glyptocrinus*, as amended by us, occurs exclusively in the Lower Silurian at the age of the Trenton and Hudson River groups, and apparently only in America.

We recognize the following species:—

1879. **Glyptocrinus angularis** Miller and Dyer. Jour. Cincin. Soc. Nat. Hist., p. 5, Pl. 1, fig. 10. Hudson River gr. Cincinnati, Ohio.

1847. **Glyptocr. decadactylus** Hall. Type of the genus. Paleont. N. York, i, p. 281, Pl. 77, figs. 1 a–f, and Pl. 78, figs. 1 a–u; also Geol. Rep. Ohio, Paleont., i, p. 30, Pl. 2, figs. 5 a, b; Zittel, Handb. der Palaeont., i, p. 375, figs. 262. Hudson River gr. Cincinnati, Ohio.

1872. **Glyptocr. Dyeri** Meek. Proc. Acad. Nat. Sci. Phila., p. 314; also Geol. Rep. Ohio, Paleont., i, p. 32, Pl. 2, figs. 2 a, b (not 2 c). Hudson River gr. Cincinnati, O.

1855 (?) **Glyptocr. fimbriatus** Shumard. Geol. Rep. Missouri, by Swallow, pt. ii, p. 194, Pl. A, figs. 10 a, b. Trenton gr. Cape Girardeau, Mo.

This species evidently does not belong to **Glyptocrinus**, description and figure are too imperfect to place it correctly.

1874. **Glyptocr. Fornshelli** S. A. Miller. Cincin. Quart. Journ. Sci. Hudson River gr. Cincinnati, Ohio.

1861 (?) **Glyptocr. nobilis** Hall. Rep. of Progress, Geol. Rep. Wis., p. 21; also 20th Rep. N. York St. Cab. Nat. Hist., 1867, p. 21, Pl. 10, figs. 9, 10. Niagara gr. Racine, Wis.

(See our remarks under **Glyptocrinus** and **Lampterocrinus.**)

1857. **Glyptocr. ornatus** Billings. Geol. Rep. Canada (Rep. of Progress), p. 260: Ibid., 1859, Decade iv, p. 60, Pl. 9, figs. 2 a, b. Trenton limest. Ottawa, Canada.

1872. **Glyptocr. parvus** Hall. Desc. New Crin., etc., pt. i, fig. 17, (without description); 24th Rep. N. York St. Cab. Nat. Hist., p. 207, Pl. 6, fig. 17; Meek, 1873, Geol. Rep. Ohio, Paleont., i, p. 36, Pl. 2, figs. 4 a, b. Hudson River gr. Cincinnati, Ohio. (Perhaps a young **G. decadactylus.**)

1857. **Glyptocr. priscus** Billings. Geol. Rep. Canada (Rep. of Progress). p. 257: also, 1859, Ibid., Decade iv, p. 56, Pl. 7, figs. 1 a–f. Trenton limest. Ottawa, Canada.

1857. **Glyptocr. ramulosus** Billings. Geol. Rep. Canada (Rep. of Progress), p. 258: 1859, Ibid., Decade iv, p. 57, Pl. 7, figs. a–f and Pl. 8, figs. 1 a–e. Trenton limest. Ottawa, Canada.

1875. **Glyptocr. Shafferi** S. A. Miller. Cincin. Quart. Journ. Sci., vol. ii, p. 277; Journ. Cincin. Soc. Nat. Hist., 1880, Oct., p. 3, Pl. 7, fig. 3. Hudson River gr. Cincinnati, Ohio.

If this is a **Glyptocrinus**, it evidently is a very young specimen.

Syn **Glyptocr. Shafferi** var. **Germanus** Miller. Journn. Cincin. Soc. Nat. Hist., 1880, Oct., p. 3, Pl. 7, fig. 2.

*1872. **Glyptocr. subglobosus** Meek. (**Glyptocr. Dyeri** var. **subglobosus**) Proc. Acad. Nat. Sci. Phila., p. 314; also Geol. Surv. Ohio, Paleont., i, p. 34, Pl. 2, fig. 2 c. Hudson River gr. Cincinnati, Ohio.

We take this to be an independent species, and not a variety of **G. Dyeri**, it may possibly prove to be a **Reteocrinus.**

2. ARCHÆOCRINUS Nov. gen.

(*αρχαῖος* ancient, *κρῖνον* a lily.)

Among the species described in the Canada Report by Billings as *Rhodocrinus* and *Glyptocrinus*, there are several which cannot be brought under either of these, or any other known genus. They differ from *Glyptocrinus* in their larger size, their surface ornamentation, in having the first radial plates separated by interradials, in their shorter and branching arms, and in having them constructed of a double series of wedge-form pieces. They differ from *Reteocrinus* in having smaller underbasals, in having the interradial plates systematically arranged, of a less number, and larger size, and also in the arm structure; from *Rhodocrinus* in the general form of the body, in the large number of secondary radials, and the elevated ridges passing gradually and vertically into arms, which do not spring off laterally from the body as in the latter genus.

We propose for this little group, which is one of the oldest of the known Crinoids, the name "*Archæocrinus*" and make Billings' *Glyptocrinus lacunosus* the type of the genus.

Generic Diagnosis.—Calyx large, pear-shaped, sometimes obconical; plates smooth or granulated; the radial plates with keel-like elevations along their median line, but less prominently than in *Glyptocrinus*, and the carinæ narrower.

Underbasals five, pentagonal, rather small and rarely extending beyond the column. Basals five, hexagonal, with a truncate upper side, supporting the first radial plates. Primary radials 3×5, of medium size, gradually decreasing upward, width and height about equal. They support two rows of secondary radials of three to four plates in each row, which are followed in the same line by the arm plates, all further divisions of the rays taking place in the arms. The rays are widely separated by large interradial areæ. Arms short, slender, the branches divergent; composed of two rows of cuneiform pieces, alternately arranged and interlocking. Interradial areæ large; resting directly upon the upper truncate side of the basals, and passing gradually into vault pieces. The plates of the two proximal series are generally of equal size, all succeeding ones are much smaller. There are two plates in the second series in all five areæ, those at the posterior side are probably a little wider. Interaxillaries represented by one or more plates.

Vault and anus unknown. Column round.

Geological Position, etc.—*Archæocrinus* is only known from the Lower Silurian of America.

We place here the following species:—

*1857. **Archæocrinus lacunosus** Billings. Type of the genus. (**Glyptocr. lacunosus**) Geol. Rep. Canada (Rep of Progress), p. 261; Ibid., 1859, Decade iv, p. 61, Pl. 8, figs. 3 a–e. Trenton limest. Ottawa, Canada.

*1857. **Archæocr. marginatus** Billings. (**Glyptocr. marginatus**) Geol. Rep. Canada. (Rep. of Progress), p. 260; Ib., 1858, Decade iv, p. 59, Pl. 9, figs. 1, 1 a. Trenton limest. Ottawa, Canada.

*1857. **Archæocr. microbasilis** Billings. (**Thysanocr.—Rhodocr.—microbasilis**) Geol. Rep. Canada (Rep. of Progress), p. 264; Ibid., 1859, Decade iv, p. 63, Pl. 6, fig. 2. Trenton limest. Ottawa, Canada.

*1857. **Archæocr. pyriformis** Billings. (**Thysanocr.—Rhodocr.—pyriformis**) Geol. Rep. Canada (Rep. of Progress), p. 262; Ibid., 1859, Decade iv, p. 61, Pl. 6, figs. 1 a–d. Trenton limest. Montreal, Canada.

3. RETEOCRINUS Billings.

1859. Billings. Geol. Rep. Canada, Decade iv, p. 63.
Syn. *Glyptocrinus* (in part), Hall 1866 and 1872; Meek 1873.

Among the species described by Hall under *Glyptocrinus*, there is one—*Gl. O'Nealli*—which in several important characters differs from his typical form. It has well-developed underbasals, very large basals, a pentagonal stem, and exceedingly depressed interradial and anal regions, peculiar radial plates, etc., in all of which characters it agrees with the genus *Reteocrinus* Billings, which was described from imperfect material, and altogether misunderstood by its founder. According to Billings, the calyx consists of a reticulated skeleton, composed of incomplete or rudimentary plates, each consisting of a central nucleus with three to five stout processes radiating from it. Of such plates he describes three rings of five each, corresponding in their position with the underbasals, basals and first radials of other crinoids, and he compares the genus with *Cyathocrinus*, *Dendrocrinus* and similar forms.

This description at first glance does not agree with *Gl. O'Nealli*, but a closer comparison with *Reteocr. stellaris* Billings shows at once a remarkable similarity in the form and arrangement of these rudimentary plates with the principal plates of the former species, and leads to the conclusion that the interradial plates, which are said to be wanting in *Reteocrinus*, really exist there, but are so deeply imbedded within the depression as to be hidden from view by the matrix. Even in *Glyptocr.* (?) *O'Nealli*, the construction of the interradial spaces is but rarely observed. Looking at the specimens in the condition in which they are generally found, they agree remarkably well with Billings' description. The second and third primary radials appear to be free plates, and the calyx seems to be composed of only three rings of plates like in the Cyathocrinidæ.

The resemblance of *Gl. O'Nealli* with the genus *Reteocrinus*, was pointed out already by Meek (Paleont. of Ohio, i, p. 34), but he left the species under *Glyptocrinus;* also Wetherby noticed this similarity in the description of his *Glyptocr. Richardsoni*, and he agrees with us, that both his species and *Gl. O'Nealli* should be arranged under *Reteocrinus*.

A reconstruction of the genus with *Gl. O'Nealli* = *Reteocr. O'Nealli*, as type, will, we believe, clear up a number of difficulties, and we accordingly propose the following:—

Revised Generic Diagnosis.—Calyx obconical, its symmetry somewhat bilateral; interradial and interaxillary spaces profoundly depressed; radial plates highly elevated into strong rounded ridges, which in outer appearance resemble arms; they bifurcate and follow the secondary radials, whence they pass gradually into free arm joints.

Underbasals five, well developed, extending beyond the column. Basals five, large, protuberant, hexagonal, the upper side slightly truncate and supporting the first series of interradial plates; the upper portions inflected, and involved in the interradial depressions.

Radials 3 × 5, those of different rays separated by interradials; the first and third pentagonal, the second quadrangular, as long as the two former ones but narrower. The radials are highly elevated, forming a broad rounded ridge, which from the third radial branches upward, following the secondary radials, and downward from the first primary radials toward the basals. This branching gives to the first and third radials a similar form, only the direction of the branches reversed, the truncation taking place from reversed sides of the plates. Secondary radials four to five in the adult, a less number in young specimens; decreasing in height upwards, quadrangular, shaped like arm joints, and like them giving off pinnules, which in the adult are incorporated [1] within the body.

Arms ten, long, slender, rounded, bifurcating, composed of a single series of rectangular or slightly wedge-formed pieces, which give off on alternate sides rather stout, closely arranged pinnules. Interradial series resting directly upon the basals, consisting of a very large number of minute pieces, of irregular form, and without definite arrangement; the posterior area wider, with a conspicuous row of decidedly larger and more prominent special anal pieces along the median part. Interaxillary plates almost as numerous as the interradials, and of a similar character. The peculiar depressed state of the interradial and interaxillary areæ, the irregularity with which their plates are arranged, suggests the possibility that they were adapted to expansion by the animal.

Vault composed of numerous, very small and convex pieces, with an elevation running to each arm base; the plates in the

[1] See our remarks upon fixed pinnules in our general notes upon the Sphæroidocrinidæ.

median part, which probably include the apical plates, somewhat larger. Anal aperture directly through the vault, small, subcentral.

Column subpentagonal, its lateral faces but little depressed; central canal rather large.

Geological Position, etc.—*Reteocrinus* belongs to the age of the Trenton and Hudson River groups, and is only found in America.

We place here the following species:—

*1872. **Reteocrinus Baeri** Meek. (**Glyptocr. Baeri**) Amer. Journ. Sci. and Arts, iii (Ser. 3), p. 260; also 1873, Geol. Rep. Ohio, Palæont., p. 37, Pl. 2, fig. 1 a, b. Upper part of Hudson Riv. gr. Richmond, Ind.

*1881. **Reteocrinus cognatus** S. A. Miller. (**Glyptocr. cognatus**) Journ. Cincin. Soc. Nat. Hist. (April No.), p. 7, Pl. 1, fig. 5. Hudson River gr. Middletown, Ohio.

*1859. **Reteocr. fimbriatus** Billings. Geol. Rep. Canada, Decade iv, p. 65, Pl. 9, figs. 3 a, b, c. Hudson River gr. Island of Anticosti.

*1881. **Reteocr. gracilis** Wetherby. (**Glyptocr. gracilis**) Now in press. Cincin. Journ. Nat. Hist., Pl. ii, figs. 2, 2 a. Hudson River gr.

*1866. **Reteocr. O'Nealli** Hall. Proposed type of the genus. (**Glyptocr. O'Nealli**) Desc. New Sp. Crin., p. 2; also 24th Rep. N. Y. St. Cab. Nat. Hist., p. 206, Pl. 5, figs. 18, 19; Meek, 1873, Geol. Rep. Ohio, Paleont., i, p. 34, Pl. 2, figs. 3 a, b, c. Upper part of the Hudson River gr. Lebanon, O.

*1880. **Reteocr. Richardsoni** Wetherby. (**Glptocr. Richardsoni**) Journn. Cincin. Soc. Nat. Hist; Desc. New Crin. Cincin. gr.,, Pl. 16, figs. 1 a-e. Hudson River gr. Clinton Co., Ohio.

*1859. **Reteocr. stellaris** Billings. Geol. Rep. Canada Dec., iv, p. 64, Pl. 9, figs. 4 a-e. Trenton limestone. Ottawa, Can.

b. Glyptasterites.

4. GLYPTASTER Hall.

1852. Hall. Paleont. N. York, ii, p. 187.
1863. Hall. Trans. Albany Inst., iv, p. 202.
1879. Hall. 28th Rep. N. Y. St. Cab. Nat. Hist. (ed. ii), p. 133.
1879. Zittel. Handb. der Palæont., i, p. 375.

The genus *Glyptaster* is involved in some confusion. It was founded upon a specimen from the Niagara group of New York, which Hall named *Glyptaster brachiatus.* In the type specimen, the plates of the calyx are altogether obscure except possibly the basals, which were stated to be five in number. The specimen further showed five highly elevated ridges along the radial portions of the calyx, and ten long, slender arms, which are composed of a double series of interlocking joints, and spread out horizontally at right angles to the walls of the body, without bifurcations, and, according to figure, without pinnules.

Judging from this description, the double-jointed arms are the only characters which distinguish the genus from *Glyptocrinus.* The next two species referred to *Glyptaster* were *G. occidentalis* and *G. inornatus*, both described by Hall from the Niagara gr. of Waldron, Ind. In these specimens, which are found rather abundantly, only the calyx was preserved, while the vault and arms remained unknown, thus leaving it somewhat doubtful whether the two Waldron species may not be generically distinct from the New York form.

Glyptaster is closely allied to *Eucrinus* Angelin, indeed so closely, that we have some doubt whether the two should not be altogether united instead of being separated subgenerically, as now pursued by us. So far as known, the latter form differs only in having tertiary radials and additional arms. It is possible that *Glyptaster pentangularis* Hall and *Glyptocr. armosus* McChesney belong to the subdivision, the two species are only known from internal casts, which are unreliable for purposes of identification, unless accompanied by a cast of the external mould.

In a very interesting specimen of *Glyptaster inornatus*, kindly loaned us by Mr. Wm. F. Gurley, of Danville, Ill., and the only specimen known to us in which the vault and anal aperture have been found preserved, we notice in two of the rays on the side toward the interradial spaces, and enclosed by them, a highly elevated fixed pinnule. The specimen is of comparatively large size, and as the interradials in this species have no conspicuous surface markings, these pinnules are readily recognized. Both are given off from a first secondary radial, which thereby takes the form and aspect of a bifurcating plate. The first joint of the pinnule is rather large, and the ridge or elevation upon the plate is about one-half the width of that upon the radials. Two more joints follow, likewise enclosed within the body walls, and having a ridge equally conspicuous, though narrower. From the first joint of the pinnule is given off another or secondary pinnule, fixed like the other but more slender, and composed of at least two joints. The first plate of the primary pinnule has altogether the appearance of a tertiary radial, and is given off in a like manner, but the succeeding plates, though somewhat larger than common, resemble more those of ordinary pinnules, or may be described as intermediate between fixed pinnule plates and radials. This is but an abnormal case, but it gives some idea how in the course of time, among species, bifurcating radials became developed from pinnule-bearing plates, and additional arms from the proximal pinnules.

Generic Diagnosis.—Form of calyx subturbinate or obconical; strongly depressed between the arm bases; plates delicate, beautifully ornamented with granules and striæ, the radial portions with strong ridges or costæ; anal area very wide, and hence symmetry distinctly bilateral.

Underbasals five, small but not rudimentary, and generally extending beyond the column. Basals five, four of them equal with the upper side angular, the fifth larger with a truncate upper side for the support of the first anal plate. Primary radials 3×5, width and height nearly equal, decreasing in size upward. The third radials support two rows of secondary radials, which are separated by one to three interaxillary plates, the latter being perhaps absent in young specimens. The number of secondary radials, like in the *Glyptocrinites*, is variable, differing among species, and increasing with age in the individual; their exact number is rarely ascertained, as they pass gradually into brachials and regular arm plates.

Arms ten, simple? and composed of two rows of interlocking pieces with pinnules.

Interradial areæ large, and, compared with the preceding genera, composed of fewer and larger plates. There is one plate in the first series, which rests between the two upper sides of two first and between two second radials; two in the second series, on a level with the third radials, with much smaller plates above, which connect with the interradial portions of the dome.

Anal area distinctly wider. The first anal plate resting upon the truncate posterior basal, and between two adjoining first radials; there are three plates in the second, and four or five in each succeeding series. Above the level of the third primary radials the plates are bent somewhat inward, the anal area is in the middle elevated into a low ridge, at the sides depressed.

The vault which is only known in *Glyptaster inornatus* is decidedly pentalobate, and resembles *Dorycrinus* in the anal region. Anal opening excentric, protruding and reaching somewhat beyond the limits of the vault, not extended into a tube.

Apical dome plates well defined but somewhat displaced, owing to the great number of plates which surround the anus. Radial regions of the dome prominent, in form of five high ridges which bifurcate, sending a branch to each arm. They are composed of two rows of rather large convex and elongate plates, transversely arranged, which in branching separate, and pass on as two single rows of plates.

Interradial dome regions depressed, and composed of small irregular pieces.

Column round; central canal of medium size.

Geological Position, etc.—*Glyptaster* is known only from the Niagara group, Upper Silurian, of America.

We recognize the following species:—

*1861 (?). **Glyptaster armosus** McChesney. (**Eucalyptocr armosus**) Desc. New Pal. Crin., p. 95; also 1867, **Glyptocr.** (?) **armosus**, Chicago Acad. Sci., p. 23, Pl. 7, fig. 6; Hall, 20th Rep. N. Y. St. Cab. Nat. Hist., Pl. 10, fig. 11. Niagara limest. Racine, Wis.

Syn. **Glytocr. siphonatus** Hall. (Nov.) 1861, Geol. Rep. Wis., p. 22; 20th Rep. N. Y. St. Cab. Nat. Hist., p. 328, Pl. 10, fig. 11.

Gl armosus was described from internal casts, and there is some doubt as to its specific and even generic character.

1852. **Glyptaster brachiatus** Hall. Type of the genus. Paleont. N. Y., ii, p. 187, Pl. 41, fig. 4. Niagara gr. Lockport, N. Y.

1863. **Glyptaster inornatus** Hall. Trans. Alb. Inst., iv, p. 205; also 28th Rep. N.Y. St. Cab. Nat. Hist., 1879 (ed. ii), p. 134, Pl. 14, figs. 1–6. Niagara gr. Waldron, Ind.

1863. **Glyptaster occidentalis** Hall. Trans. Alb. Inst., iv, p. 204; also 20th Rep. N. Y. St. Cab. Nat. Hist., p. 305, and 28th Rep. 1879 (ed. ii), Pl. 13, figs. 7, 11. Niagara gr. Waldron, Ind., and Racine, Wis.

1864. (?) **Glyptaster pentangularis** Hall. 20th Rep. N. Y. St. Cab. Nat. Hist., p. 326, Pl. 10, fig. 3 (advance sheets 1864). Niagara gr. Racine, Wis.

The species was described from casts, but probably belongs to this genus.

Subgenus **EUCRINUS** Angelin.

1878. Angelin. Iconogr. Crin. Suec., p. 24.

1879. Zittel. Handb. der Palæont., i, p. 375.

Syn. *Rhodocrinus* Schultze 1866 (in part). Echin. Eifl. Kalk, p. 57.

Syn. *Dimerocrinus* (in part) Phillips, 1839; d'Orbigny, 1850 and 1852; Pictet, 1857.

Eucrinus agrees with *Glyptaster* in the form of the calyx, the style of ornamentation, and size and form of underbasals. It also has 3 × 5 primary radials, and an elevated ridge all along the radial regions, but differs in having tertiary radials—from one to two or more—and four arms to each ray. There is no departure in the arrangement of the interradial plates, the first anal stands in line with the first radials, and is succeeded by three plates in the second series, and other plates above.

In all known species, the median row of anal plates is arranged longitudinally, somewhat curved toward the margins, and slightly elevated in form of a ridge above the general level of the other plates, as in the case of *Glyptaster inornatus* and several other species.

We place here Schultze's *Rhodocr. quinquelobus*, it being the only species of this group in which the construction of the vault is known. The dome is composed of small plates, central dome plate crowned with a short spine, anus excentric, almost lateral, and not prolonged into a proboscis.

Arms are rather strong, composed of two series of interlocking pieces.

Column round; central canal of medium size.

Geological Position, etc.—*Eucrinus* has been found in Sweden in rocks of the Upper Silurian, in Germany in the Stringocephalen-kalk of the Eifel. Two of Angelin's species have been referred to our new genus *Anthemocrinus*. We recognize only the following species:—

*1839. **Eucrinus icosidactylus** Phillips. (**Dimerocr. icosidactylus**) Murchison's Silur. Syst., p. 673, Pl. 17, fig. 5; D'Orbigny, 1850, Prodr. de Paléont., i, p. 46; Pictét, Traité de Paléont., iv, p. 142. Upper Silurian. Dudley, Eng.

1878. **Eucr. interradialis** Angelin. Iconogr. Crin. Suec., p. 25, Pl. 6, fig. 6, and Pl. 19, figs. 1, 7, 8. Upper Silurian. Gothland, Sweden.

1878. **Eucr. lævis** Angelin. Type of the genus. Iconogr. Crin. Suec., p. 25, Pl. 6, figs. 8, 8 a. Upper Silurian. Gothland, Sweden.

1878. **Eucr. quinquangularis** Angelin. Iconogr. Crin. Suec., p. 25, Pl. 10, figs. 5, 14. Upper Silurian. Gothland, Sweden.

*1867. **Eucr. quinquelobus** Schultze. (**Rhodocr. quinquelobus**) Echin. Eifl. Kalk, p. 57, Pl. 7, fig. 6. Devonian. Eifel, Germ.

1878. **Eucr. ornatus** Angelin. Iconogr. Crin. Suec., p. 25, Pl. 6, figs. 7 a, b. Upper Silurian. Gothland, Sweden.

1878. **Eucr. speciosus** Angelin. Iconogr. Crin. Suec., p. 25, Pl. 19, figs. 2, 2 a, and Pl. 23; figs. 7 a, b, and Pl. 26; figs. 26, 26 a, and Pl. 27; fig. 2. Upper Silurian. Gothland, Sweden.

5. DIMEROCRINUS Phillips.

1839. Phillips. Murchison's Silur. Syst., p. 674 (in part).
1841. Müller. Monatsber. Berl. Akad., i, p. 208 (in part).
1850. D'Orbigny. Prodr. de Paléont., i, p. 46 (in part).
1852. D'Orbigny. Cours. élém. de Paléont., ii, p. 142 (in part).
1857. Pictét. Traité de Paléont., iv, p. 318 (in part).

1879. Zittel. Handb. der Palæont., i, p. 368 (in part).
(Not Pacht, 1853. Verh. Kaiserl. Russ. Gesellsch., p. 262.)
Syn. *Thysanocrinus* Hall, 1852. Paleont. N. York, ii, p. 188.
(Not *Thysanocrinus* (*Rhodocr.*) Billings. Geol. Surv. Canada for 1853 to 1856, p. 262.)

The name *Dimerocrinus* was given by Phillips to two species from Dudley, England, which are known as *D. decadactylus* and *D. icosidactylus*, and which were figured without specific or generic definition. The genus has been generally accepted, but is since described as having only one ring of plates beneath the radials, and this variously by different writers as composed of either three or five plates.

We have carefully examined the two species, and find that they both have underbasals. Those of *D. decadactylus* are placed within a rather deep concavity, formed between the basals and hidden by the column, exactly as some species described and figured by Hall under his genus *Thysanocrinus*, which we take to be a synonym of *Dimerocrinus*. Phillips' *D. icosidactylus* is generically distinct, and has been referred by us to *Eucrinus*. Very closely allied is *Patelliocrinus* Angelin, which Zittel unites with *Dimerocrinus;* the two genera resemble each other most remarkably, but the former can readily be separated by its three basals and the absence of underbasals.

Generic Diagnosis.—Body small, calyx short, subglobose or conical; plates not numerous, surface less ornamented than in the preceding genera, smooth or indistinctly granulose; symmetry bilateral.

Underbasals five, small, arranged within a concavity, which is nearly or entirely filled by the column. Basals five, four of them equal, angular above; the fifth truncate and supporting the first anal plate. Primary radials 3×5; the first almost as large as the second and third together and considerably wider, the two lower sides making an angle, which rests deeply between the basals; lateral sides short, the first interradial is almost touching the angle of the basal plates; second radials more or less quadrangular, wider than high; the third radials giving off two or three secondary radials, of the form of arm plates, of which each one supports an arm. Pinnules strong, less closely arranged than usually in this family, their joints rounded, two or three times as long as wide.

Interradial areæ composed of but few plates, the first one large, placed between the second radials, and leaning partly against the third, with two small plates above. Posterior or anal area wider, the first plate in line with the first radials and of the same size; it is followed by three plates in the second series and several smaller ones above, the upper ones connecting with the vault. Vault, and form of the anus unknown.

Geological Position, etc.—The only three known species are Upper Silurian, from the age of the Niagara group.

1839. **Dimerocrinus decadactylus** Phillips. Type of the genus. Murchison's Silur. Syst., p. 674, Pl. 17, fig. 4; d'Orbigny, 1850, Prodr. de Paleont., i, p. 46; Pictét, Traité de Paleont., i, p. 368. Upper Silurian. Dudley, Eng.

*1852. **Dimerocr. liliiformis** Hall. (**Thysanocr. liliiformis**) Paleont. N. Y., ii, p. 188, Pl. 42, figs. 1 a-f. Niagara gr. Lockport, New York.

*1852. **Dimerocr. immaturus** Hall. (**Thysanocr. immaturus**) Paleont. N. Y., ii, p. 191, Pl. 42, figs. 4 a-f. Niagara gr. Lockport, N. Y.

6. LAMPTEROCRINUS Roemer.

1860. Roemer. Silur. Fauna West. Tenn., p. 37.
1863. Hall. Trans. Albany Inst., iv, p. 202.
1868. Hall. 20th Rep., N. Y. St. Cab. Nat. Hist., p. 328.
Syn. *Balanocrinus* Troost, 1850 (not Agassiz, 1846), Cat. Foss. Tenn.

Hall, in comparing the genera *Glyptocrinus*, *Glyptaster*, *Balanocrinus* and *Lampterocrinus* (Trans. Albany Inst., iv, p. 202), considered the last two identical, and that they differ from the former in having larger underbasals. He then discriminated in favor of Troost's Catalogue name, but afterwards in the 20th Rep. N. Y. St. Cab., p. 320, he very properly, recognized the priority of Roemer's name *Lampterocrinus*. A difference as above stated would scarcely be sufficient to warrant a generic separation, but we think this genus is separable from the other two by other and more important characters than those noted by Hall. *Lampterocrinus* differs from *Glyptocrinus* in the arrangement of its anal plates, and in having an anal tube; from *Glyptaster* in the anal and arm structure, and from both of them in the size of the basals and underbasals, in the form and construction of the vault, and in the pentagonal column.

Roemer describes *Lampterocrinus* as having four primary radials, the fourth bifurcating and excavated for the reception of an arm. This is not quite in accordance with our views, we think the so-called fourth radial is an arm-bearing secondary radial, which is given off in a similar manner as is the plate which supports the first arm in *Steganocrinus sculptus* (Pl. 18, fig. 3); this explains sufficiently the form of the third radials, which are here truncate above instead of axillary as usually. The arms are unknown, but we judge from the enormous size of the so-called arm openings, which form large breaks, that the body in this genus was extended into lateral appendages, and gave off numerous arms.

Generic Diagnosis.—Body oblong, contracted between the arm bases, except the posterior side, which toward the dome bulges considerably, thereby producing some irregularity in the general form. Calyx, cup- or urn-shaped, beautifully ornamented with radiating striæ.

Underbasals five, forming a pentagon, the plates of equal size, quadrangular, the sides of the outer angles shorter. Basals five, large, sometimes fully as large as the first radials, four of them equal and angular above, the posterior one considerably higher and its upper side truncate. Primary radials 3(?) $\times$ 5, wider than high, all three hexagonal and with truncate upper side, decreasing in size upward; the third not more than one-fourth the size of the first. Higher orders of radials unknown, but probably formed into free rays which give off arms laterally.

The interradial plates extend uninterruptedly into the vault, those of the calyx and vault being undistinguishable; indeed, in this genus it almost appears as if the interradial pieces of the calyx extend up to the proximal vault pieces. The first interradial rests slightly between the upper sloping sides of the first and between the second radials, with a number of series above, composed of two or three plates each. The first anal plate rests directly upon the posterior basal, which is of such great height that the upper side of the anal is horizontally in line with the top of the first interradial. There are three plates in the second and all succeeding series, arranged longitudinally, forming three rows, of which the plates of the median one are wider and marked by an elevated ridge.

Form of the vault unsymmetrical, bulging at the posterior side, with a subcentral anal tube; plates rather large and nodose, the radial ones decreasing in size toward the arms.

The apical dome plates, although not distinguished by size, are readily recognized by their position. Length of anal tube unknown.

Column pentagonal, central canal very small.

Geological Position, etc.—*Lampterocrinus* is only known from the Niagara group of America.

1861. **Lampterocrinus inflatus** Hall. (**Balanocr. inflatus**) Geol. Rep. Wis. (Rep. of Progress), p. 22; **Lampterocr. inflatus**, 1868, 20th Rep. N. Y. St. Cab. Nat. Hist., p. 328, Pl. 10, fig. 6. Niagara gr. Racine, Wisconsin.

This species is described from internal casts, but there can be no doubt as to its generic identity; the specific characters, however, are undeterminable.

1860. **Lampterocr. Tennesseensis** Roemer. Type of the genus. Silur. Fauna West. Tenn., p. 37, Pl. 4, figs. 1 a, b. Niagara gr. Western Tennessee.

Syn. **Balanocr. sculptus** Troost, 1850. Catalogue name.

7. SAGENOCRINUS Angelin.

1843. Austin. Ann. and Mag. Nat. Hist. (ser. i), xi, p. 205.
1857. Pictét. Traité de Paléont., iv, p. 323.
1878. Angelin. Iconogr. Crin. Suec., p. 8.
1879. Zittel. Handb. d. Palæont., i, p. 375.

Syn. *Rhodocrinus* (in part) Miller, 1821; *Actinocrinus* (in part) Phillips, 1839; Salter, 1859, *Glyptocrinus* d'Orbigny (not Hall), 1850, Prodr., i, p. 46.

Syn. *Megistocrinus* Angelin (not Owen and Shumard), 1878, Iconogr. Crin. Suec., p. 8.

The genus *Sagenocrinus* was based upon a species from Dudley, England, which had been referred by Miller to his *Rhodocr. verus*, and which he believed to occur both in the Subcarboniferous and the Upper Silurian. The Subcarboniferous specimens are now conceded to be distinct, constituting the type of *Rhodocrinus*, and they have in contrast to the Silurian forms the arms constructed of double joints. The Silurian species, with three underbasals and single arm joints, was separated by Phillips as *Actinocr. expansus*, and in 1843 was made by Austin the type of *Sagenocrinus*. Miller's figure $\frac{1}{A}$. p. 106, is evidently ideal, made up from the arms of *Sagenocr. expansus*, and the body of *Rhodocr. verus*. The body in the former has perfectly smooth plates, and the latter has certainly not single-jointed arms, as these do not occur in this family beyond the Silurian. *Sagenocrinus* differs from *Rhodocrinus* in having only three underbasals, in the form of the body, and in the arm structure. It is possible that Wirtgen and Zeiler's *Rhodocr. gonatodes* is a *Sagenocrinus* if not a *Thylacocrinus*. The species is only known from casts.

Austin places *Sagenocrinus* with the Periechocrinidæ, Pictét with the Actinocriniens, Angelin in a family by itself, which he arranges systematically next to the Taxocrinidæ. It cannot be denied that *Sagenocr. expansus*, in its general structure, and particularly in the arms, resembles some species of *Taxocrinus*, but the body lacks entirely the articulate structure. Zittel places it in a subdivision of the Glyptocrinidæ.

Generic Diagnosis.—General form including arms, oblong. Calyx cyathiform; without ridges along the radial regions, and without marked surface ornamentation; symmetry slightly bilateral.

Underbasals three, unequal, anchylosed, forming a pentagon. Basals five,[1] differing somewhat in form, generally four of them acute above, the fifth truncate. Primary radials 3×5, of nearly equal size, the first and third of a like form, but reversed. Secondary radials 4×10, rather large, their upper and lower sides parallel. The upper plate bifurcating, giving off from each side a primary arm—making twenty in all—which at intervals divide again. The branches are toward the inner side of the ray, and remain simple throughout. The arms taper rapidly near the ends, and—if the fragment figured by Angelin, Iconogr., Pl. 28, fig. 8, belongs to this genus, of which we entertain some doubt—the upper parts coil spirally inward once or twice. They are composed of single joints, which are wide and short, quadrangular, with sutures nearly parallel, except the bifurcating plates which are depressed pentagonal. Pinnules short (Angelin).

Interradial spaces not depressed, plates numerous, composed of four or more series of two plates each, very gradually decreasing in size. The first plate rests deeply between the first radials, almost touching the upper angle of the basals. The first anal plate rests upon the truncate side of the posterior basal, supporting two plates in the second, and three in the third series. Interaxillaries one or more.

General form and structure of the vault not known, but it evidently was elevated near the arm regions, and composed of a large number of small plates. Anus unknown.

The column, according to Angelin (Pl. 27, fig. 8), is tripartite (?) and perforated with a large pentalobate canal.

[1] Angelin gives the number of basals (parabasals) as six, which is evidently a mistake, nor do we believe that the sixth plate represents an anal plate, as no plate of that kind has ever been observed below the line of radials.

1839. **Sagenocrinus expansus** Phillips. (**Actinocr. expansus**) Murchison's Silur. Syst., p. 674, Pl. 17. fig. 9; Austin, 1843, **Sagenocr. expansus** Ann. and Mag. Nat. Hist., xi (ser. i), p. 205; Morris, 1843, Cat. Brit. Foss. (ed. i), p. 58; d'Orbigny, 1850, **Glyptocr. expansus,** Prodr. de Paleont., i, p. 46; Pictét, 1857, **Sagenocr. expansus,** Traité le Paléont., iv, p. 323; Salter, 1859, **Glyptocr. expansus,** Silur. Syst. (ed. ii), p. 512, Pl. 15, figs. 1, 2; Angelin, 1878, Icon. Crin. Suec., p. 8, Pl. 15, figs. 6, 8 and (?) Pl. 27, figs. 8 a, b and (?) Pl. 28, fig. 8. Upper Silur. Dudley, England.

Syn. **Rhodocr. verus** Miller (in part). Nat. Hist. of Crin., p. 106, Pl. 1, fig. 1 a. Dudley, Engl.

c. Rhodocrinites.

8. **LYRIOCRINUS** Hall.

1852. Hall. Paleont. New York, ii, p. 197.
1857. Pictét. Traité de Paléont., iv, p. 329.
1866. Shumard. Trans. Acad. Sci. St. Louis, ii, p. 379.
1867. Hall. 20th Rep. N. Y. St. Cab. Nat. Hist., p. 325.
1879. Hall. 28th Rep. N. Y. St. Cab. Nat. Hist. (ed. ii), p. 139.

Syn. *Marsupiocrinites* (not Phill.), Hall 1843. Geol. 4th Distr. New York, p. 114.

Syn. *Rhodocrinus* (not Miller), Hall 1863. Trans. Albany Inst., p. 198.

The genus *Lyriocrinus* was proposed for a species which had been previously described by Hall under *Marsupiocrinites.* It was supposed to possess only one ring of plates beneath the radials, but when afterwards five small underbasals were discovered, it was referred by Shumard (1866) subgenerically under *Rhodocrinus*, and this arrangement was adopted by Hall. *Lyriocrinus* is at least as distinct from *Rhodocrinus* as either *Glyptocrinus* or *Glyptaster*, which those authors acknowledge as genera without question.

In 1863—Trans. Albany Inst., p. 198—Hall described as *Rhodocr. melissa* a new species from Waldron, Ind., which we have always suspected to be closely allied to *Lyriocrinus*, and which, as we have lately ascertained to our satisfaction, belongs to that genus. We are indebted to Wm. F. Gurley, Esq., of Danville, Ill., for the loan of some excellent specimens, which enabled us to examine not only the construction of the arms, but also of the vault which was heretofore imperfectly known.[1]

Pictét places this genus under the Carpocrinidæ, Zittel under

[1] In the second edition of the 28th Rep. New York St. Cab., which came to hand after this was written; also Hall refers that species but parenthetically to *Lyriocrinus.*

Angelin's Calyptocrinidæ, with which it has some superficial resemblance in the form of the calyx, and in the arrangement of the radial and interradial plates, but from which it is otherwise very distinct. Its closest affinities are with *Ripidocrinus* Beyrich, in which, however, the arms are very differently constructed.

Generic Diagnosis.—Form of calyx depressed, subglobose, or nearly hemispherical; symmetry more or less perfectly equilateral. Plates heavy, their surface flat or sometimes a little concave, smooth, or finely granulose. Vault very low, scarcely rising above the height of the calyx.

Underbasals five, very small, abruptly and deeply depressed, concealed by the column. Basals five, of uniform size, either heptagonal and supporting upon the upper truncate side the first interradial, or four of them hexagonal, angular above, and only the posterior one truncate for the support of the first anal plate. Primary radials 3×5, of nearly equal size; the first pentagonal; the second and third hexagonal. The latter is truncate above, and supports within the axil of the secondary radials which are given off from the upper sloping sides of the primary radials, a comparatively large, elongate, hexagonal interaxillary plate, which extends to the height of the first arm joints. Secondary radials 2×10, the first large, pentagonal, the second shorter, and supporting the arms.

Interradial plates four to five, in three series; the first large, heptagonal; the two plates of the second series a little smaller than the first, but yet comparatively large; the third series small, composed of one or two plates, which are enclosed by the secondary radials. The anal area is frequently not distinct from the four others, but it has occasionally three plates in the second series. The plates of the lower calyx are of about uniform size, but the last secondary radials, the interaxillary, and the upper series of interradial plates are considerably smaller.

Vault almost flat, composed of a large number of convex plates, which are depressed in the interradial regions. Anus subcentral or excentric, in form of a strong tube, constructed of similar plates as the vault; length unknown. Apical dome plates well defined, twice as large as the other vault pieces. Ambulacral or arm passages directed upward, and passing at the edge through the vault. Arms ten, which remain simple, placed wide apart, strong, gradually tapering to the tips, and constructed, from the radials up, of two series of wide and short interlocking pieces. Arm furrows wide and deep; pinnules present, but their exact form not known.

Column round; central canal small.

Geological Position, etc.—*Lyriocrinus* occurs only in rocks at the age of the Niagara limestone of America.

We recognize only two species; *L. sculptilis* Hall, a third species is described from mere casts, and very doubtful.

1843. **Lyriocrinus dactylus** Hall. (**Marsupiocrinites dactylus**) Type of the genus. Geol. Rep. 4th Distr. N. York, p. 114; Hall, 1852, **Lyriocr. dactylus**, Paleont. N. Y., Pl. 44, figs. 1 a–g; Pictét, 1857, Traité de Paléont., iv, p. 329, Pl. 101, fig. 12. Niagara gr. Lockport, N. York.

1863. **Lyriocr. melissa** Hall. (**Rhodocr. melissa**) Trans. Albany Inst., p. 198: also 28th Rep. N. Y. St. Cab. Nat. Hist. (ed. ii), p. 139, Pl. 15, figs. 18–22. Niagara gr. Waldron, Ind.

9. RIPIDOCRINUS Beyrich.

1879. Zittel. Handb. der Palæont., i, p. 377.

Syn. *Rhodocrinus* Goldfuss. Petrefact. Germ., i, p. 211; Agassiz, 1835, Mem. Soc. Neuchat., i, p. 196; Müller, 1841, Verhandl. d. Berl. Akad., i; Roemer, Verh. Naturh. Verein f. Rheinl., viii, p. 358; and 1855, Lethæa Geogn., ii, p. 241; Pictét, 1857, Traité de Paléont., iv, p. 314; Schultze, 1867, Echin. Eifl. Kalk, p. 53.

Beyrich's name *Ripidocrinus*, so far as we now know, was first published by Zittel to include *Rhodocr. crenatus* Goldf. This species differs very materially in the arm structure from *Rhodocrinus* as established by Miller. In the general form of the body and the arrangement of the plates, it resembles *Lyriocrinus* Hall, but the arm structure separates them widely.

Generic Diagnosis.—Calyx cup- or urn-shaped, sometimes subglobose, lower portions more or less truncate, the basals spread out horizontally from the column; plates heavy, highly ornamented; symmetry equilateral. Body extended into free rays with lateral arms.

Underbasals five, closely anchylosed, small, forming a pentagon, deeply depressed, and generally hidden from view by the large column; central perforation large, pentalobate.

Basals five, equal, irregularly hexagonal, the lower side in line with the sides of the inner pentagon; the lower lateral sides, by which the plates are united, extremely short; upper lateral margins, which enclose the first radials, unusually long; upper side truncate supporting the first interradial, and parallel with the lower one. Owing to this construction, the basals have a subquadrangular outline, and the lower angle of the first radials almost touches the upper angle of the underbasals.

Primary radials 3×5, of nearly equal size, the first pentagonal, the second hexagonal, the third again pentagonal, and supporting two secondary radials (2×10). The first plate larger than the second, the latter axillary, but the sloping sides not of equal width. The longer side, next to the middle of the ray, supports an indefinite number of radials, and these extend into free appendages; while the other, shorter side, gives off laterally the first arm. There are two of these appendages to each ray, which at the base are connected by one or more interaxillary plates, they are thick, puffy, cylindrical, three or four times as long as the body, decreasing in width upwards. The plates which constitute the outer or dorsal side of the appendages are short, very wide, with parallel sutures, and from them, at certain intervals—from every fourth or fifth plate, and from alternate sides—the true arms arise. The latter are not given off strictly laterally, as the separation from the main trunk actually begins in the median portion of the two or three preceding plates of each order, which show more or less deep oblique incisions. All arms have nearly the same length, and hence do not reach the same general height, those nearer the body are comparatively heavier. The four or five proximal plates of the first arm are laterally connected with the main trunks of the ray, the succeeding arms become detached sooner, and the upper ones are free from their base up. Each arm tapers to a sharp point, is composed of two series of interlocking plates, with closely arranged, sword-like pinnules.

Interradial series composed of six to eight plates; the first large, heptagonal, supported upon the truncate upper side of the basals, between the first radials and the lower sloping side of the second, thus separating the entire radial series; the second range is composed of two somewhat smaller plates, the third of two or three pieces, with one or two plates above. The posterior side is but rarely distinct, it has exceptionally three pieces in the second series.

Vault scarcely rising above the limits of the calyx, slightly elevated in the radial regions. It is constructed of an immense number of small irregularly arranged plates, which decrease in size rapidly toward the periphery. At the edge of the vault there are twenty ambulacral openings, ten of which are larger and connecting with the ten appendages, the ten smaller ones with their first lateral arm. Apical dome plates well developed, much larger than the rest of the plates, and more convex. Anus excentric, in form of a simple opening.

Column heavy, round, sometimes with lateral excrescences; central canal large, pentalobate.

Geological Position, etc.—The only known species of this genus occurs in the Stringocephalenkalk of the Eifel.

1826. **Ripidocrinus crenatus** Goldfuss. (**Rhodocr. crenatus**) Petref. Germ., i, p. 211, Pl. 64, fig. 3; also Agassiz, 1835, Soc. Neuchat., i, p. 196; Roemer, Verh. Naturh. Verein f. Rheinl., viii, p. 358, Pl. 1, fig. 1, and Lethæa Geogn. ii, p. 241, Pl. 4, figs. 17, a-b; Pictét, 1857, Traité de Paléont, iv, p. 314, Pl. 100, fig. 10; Schultze, 1867, Echin. Eifl. Kalk, p. 53, Pl. 7, figs. 1 a-n; Zittel, 1879, Handb. der Palæont, p. 377, fig. 263. Devonian. Eifel, Germ.
Syn. **Rhodocr. tessellatus** Steininger. Geogn. Beschreibung der Eifel, p. 36.

10. THYLACOCRINUS Oehlert.

1878. Oehlert. Extract du Bull. Soc. Géol. de France (ser. 3), vii, (November No.).
1879. Zittel. Handb. d. Palæont., i, p. 375.

This genus was placed by Zittel among his Glyptocrinidæ, but it agrees much closer with some species of *Rhodocrinus*, from which it differs in having very much longer, heavier and undivided arms. This difference would perhaps entitle it only to a subgeneric rank, if not the arms in the Rhodocrinidæ generally were short, thin and bifurcating.

Generic Diagnosis.—Body large, globular. Calyx inflated at the lower part, somewhat constricted toward the arm regions; plates thin, convex, without special ornamentation; symmetry almost equilateral.

Underbasals five, small, forming a pentagonal disk. Basals five, hexagonal, upper and lower sides parallel, the lower resting against the straight sides of the inner pentagon, the upper supporting the first interradials. Primary radials 3×5; the first hexagonal; the second larger than the first; the third supporting 2×10 secondary radials, and these in turn the arms.

Arms heavy, extremely long, five or six times the height of the calyx, simple throughout. The proximal joints are single, quadrangular, but they change directly into wedge-form, and gradually into a double series of interlocking pieces. Pinnules closely arranged.

Interradials numerous, the lower one resting upon the basals. There are from ten to twelve in the typical species, with a few additional plates at the anal side.

Dome elevated, composed of a large number of small pieces. Anus and column unknown.

The only known species is :—

Thylacocrinus Oehlert. Extr. du Bull. Soc. Géol. de France (ser. 3), vii, Pl. 1, fig. 1. Devon. St. Germain, France.

11. ANTHEMOCRINUS nov. gen.

(*ἀνθεμον*, a blossom ; *κρῖνον*, a lily).

Syn. *Eucrinus* Angelin. (in part). Iconogr. Crin. Suec.

Among the species described by Angelin under *Eucrinus*, there are two which differ materially from the rest in having only two primary radials, a single interradial, and this plate resting directly upon the basals; also in the arm structure. These characters, in our opinion, are sufficient to justify the removal of the species from *Eucrinus*, and we propose to establish for them the genus *Anthemocrinus*, with Angelin's *Eucr. venustus* = *Anthemocrinus venustus* as type.

Generic Diagnosis.—Calyx depressed, subglobose, composed of comparatively few plates, which in both known specimens are convex and striated.

Underbasals five (Angelin), small. Basals five, large, subequal, hexagonal, the upper side truncated for the support of an interradial plate. Primary radials 2×5, both pentagonal, wider than high, of nearly equal size and similar form; the first and second meeting by straight margins. The second plate supports upon each sloping side a single secondary radial, which in turn supports a heavy arm, this soon divides, sometimes a second time, and the branches after each division are half as large as the arm below. All the arms and branches, from the base up, are composed of two rows of joints, alternately arranged, very slightly interlocking. The first arm joints are enclosed within the body walls by one or two interbrachial plates. The branching of the arms and the whole arm structure is very similar to that of *Periechocrinus*.

There is properly only a single plate in each interradial area, and this, as stated, rests upon the truncate upper side of the basals between both primary radials, and extends to the arm bases. It is the largest plate of the entire calyx, hexagonal, higher than wide, and supports upon its upper side—between the arms—the interbrachial plates above mentioned. The anal area, if we interpret Angelin's figure correctly, differs in having above its first plate a row of smaller plates, longitudinally arranged as in *Glyptaster* and *Eucrinus*, and these support the anus.

Vault and anal aperture unknown. Column round.

Geological Position, etc.—The two known species are from the Upper Silurian of Sweden.

* **Anthemocrinus minor** Angelin. (**Eucr. minor**) Icon. Crin. Succ., p. 25, Pl. 15, fig. 5, Upper Silurian. Gothland, Sweden.

* **Anthemocr. venustus** Angelin. Type of the genus (**Eucr. venustus**). Icon. Crin. Succ., p. 25, Pl. 15, figs. 7, 16. Upper Silurian. Gothland, Sweden.

12. RHODOCRINUS Miller.

1821. Miller. Natur. Hist. of the Crinoidea, p. 106.
1835. Agassiz. Mem. Soc. Sci., Neuchat., i, p. 196.
1841. Müller. Monatsb. Berl. Akad., i, p. 209.
1843. Austin. Ann. and Mag. Nat. Hist., x, p. 109.
1850. D'Orbigny. Prodr. de Paléont, i, p. 104.
1853. De Koninck and Lehon. Recher. Crin. Carb. Belg., p. 103.
1855. Roemer. Lethæa Geogn. (Ausg. 3), p. 240.
1855. Wirtgen and Zeiler. Verh. Naturh. Verein f. Rheinl., xii, p. 11.
1858. Hall. Geol. Rep. Iowa, i, pt. ii, p. 556.
1861. Hall. Bost. Journ. Nat. Hist., p. 322.
1879. Zittel. Handb. der Palæont, i, p. 376

(Not *Rhodocrinus* Goldf. 1826, Petref. Germ. i, p. 212; nor Billings, 1859, Geol. Rep. Canada, Decade iv, p. 61; nor Schultze, 1867, Echin, Eifl. Kalk, p. 53; nor Roemer, 1851, Verh. Naturh. Verein f. Rheinl., viii, p. 358).

Syn. *Acanthocrinus* F. Roemer. 1850, Neues Jahrb. f. Mineralogie p. 79; Müller (Wirtgen and Zeiler) 1855, Verh. Naturh. Verein, xii, p. 8; Pictét, 1857, Traité de Paléont, iv, p. 100, Hall, 1862, (subgenus of *Rhodocrinus*) 15th Rep. N. Y. St. Cab. Nat. Hist., p. 125.

Rhodocrinus verus, according to Miller, occurs in both the Mountain limestone and in the Upper Silurian, and it was said to have three basal plates. As we have before shown, Miller confounded two very different species, which have since been recognized as distinct genera. The Silurian form, with three underbasals and single arm joints, is now known as *Sagenocr. expansus;* the Carboniferous form, which took Miller's specific name, is universally regarded as the type of *Rhodocrinus*, having five underbasals instead of three, and the arms composed of two rows of interlocking plates.

Before the true number of underbasals in *Rhodocrinus* was ascertained, Phillips, in 1836 proposed for some allied species, in which he discovered five proximal plates, the genus *Gilbertsocrinus*, but these species for other reasons have since been referred to *Ollacrinus*, which was proposed by Cumberland in 1826. *Rhodocr. crenatus* Goldfuss has been referred to *Ripidocrinus*, and *Rhodocr. quinquelobus* Schultze to *Eucrinus*.

The genus *Rhodocrinus*, as now restricted, is decidedly Subcarboniferous. The few Devonian species which we are unable to separate from it bear more or less resemblance to *Acanthocrinus* Roemer, and have been partly referred to that genus by other writers. We have examined with great care the figures of *Acanthocr. longispinus* from Niederlahnstein as given by Wirtgen and Zeiler, and some excellent specimens of our own, but have failed to discover any characters by which this form may be separated even subgenerically. The spinous projections on the apical plates (basals and first radials) are also found in some of the Subcarboniferous species in all degrees of variation, and are more or less the rule in *Ollacrinus*. It is even not improbable that Roemer's imperfect type specimen *A. longispinus*, which was said to be from the Subcarboniferous, is really an *Ollacrinus*, and generically distinct from the Devonian specimens which Wirtgen and Zeiler identified with that species.

The two Austins placed *Rhodocrinus* under the Actinocrinidæ, D'Orbigny and Pictét under the Cyathocrinidæ, Roemer and Zittel made it the type of a family.

Generic Diagnosis.—Body subglobose to semi-ovate, often wider than high, with a concavity at the base, which frequently includes not only basals but partly the first radial plates. Calyx constricted toward the arm bases, its symmetry almost perfectly equilateral; surface of plates from entirely smooth to convex and nodose, or striated with regular nodes or spines on basal, first radial, and first interradial plates.

Underbasals five, small, spreading horizontally, and hidden by the column, though sometimes slightly visible beyond its periphery. Basals five, equal, comparatively large, heptagonal, upper side truncate. Primary radials 3×4, generally as high as wide, decreasing in size upward, the series separated laterally by interradial plates; the first heptagonal; the second from quadrangular to hexagonal, according to the size of the first radials; the third irregular in form. The latter, in the more depressed Subcarboniferous forms, supports only from one to two secondary radials; in Devonian species, there are sometimes three. None of the plates project outward, the upper one, which is also the arm-bearing plate, is excavated at its upper edge, and this, together with a similar excavation in the corresponding dome plates, forms an oblong ambulacral passage, two to each ray, which are separated by an interbrachial plate. The arms of the different rays are widely separated; they are long, delicate, cylindrical, branching, and constructed of two rows of alternate plates, which interlock from the base up. Pinnules small.

Interradial and anal areæ very wide and closely similar, the latter having sometimes one or two additional plates without disturbing the general symmetry of the body. The first plates, which are large, rest upon the truncate upper side of the basals, and laterally between the first radials; the second and third series consists of from two to three plates each, and the plates are of comparatively large size, those of the succeeding series much smaller, and passing gradually into vault pieces.

Vault flat, compressed and narrow, owing to the constriction at the upper part of the calyx; composed of a large number of irregular pieces, among which the apical dome plates are not easily distinguished; radial portions generally protuberant. Anus excentric, protruding like a proboscis, and consisting of almost microscopic plates, possibly capable of expansion or contraction by the animal.

Column round, and composed near the body of very uneven plates; perforation small, pentagonal.

Geological Position, etc.—The genus *Rhodocrinus* ranges from the Devonian to the middle portion of the Subcarboniferous, both in America and Europe.

We recognize the following species:—

1844. **Rhodocrinus abnormis** McCoy. Carb. Foss. Ireland, p. 180, Pl. 26, fig. 3. Mount. limest. Ireland.

1861. **Rhodocr. Barrisi** Hall. Desc. New Sp. Crin., p. 9; also Bost. Journ. Nat. Hist., p. 322, Pl. 6, figs. 16, 17. Upper Burlington limest. Burlington, Iowa.

Syn. **Rhodocr. Barrisi** var. **divergens** Hall, 1861. Desc. New Sp. Crin., p. 9; also Bost. Journ. Nat. Hist., p. 324, Pl. 6, fig. 18.

A comparison with the type specimen and with others in our cabinet, proves beyond doubt that the original **R. Barrisi** was described from a very young specimen, and this explains fully the additional bifurcation in the variety or older specimen.

1836. **Rhodocr. globosus** Phillips. (**Actinocr. globosus**) Geol. Yorkshire, p. 206, Pl. 4, figs. 26, 29. Mount. limest. Yorkshire, Engl.

1855. (?) **Rhodocr. gonatodes** Wirtgen and Zeiler. Verh. Naturh. Verein Jahrg., xii, p. 12, Pl. 3, fig. 3, and Pl. 4, figs. 1, 2, and Pl. 5, fig. 3; Müller, Ibid., pp. 22, 23, 25, Pl. x, fig. 1. Grauwacke. Niederlahnstein, Germ.

This species is only known from casts, and may possibly belong to some other allied genus.

1862. **Rhodocr. gracilis** Hall. (**Rhodocr.—Acanthocr.—gracilis**) 15th Rep. N. Y. Cab. Nat. Hist., p. 127. Hamilton gr. Ontario Co., N. Y.

1861. (?) **Rhodocr. Halli** Lyon. Proc. Acad. Nat. Sci. Phila., p. 412, Pl. 4, figs. 5 a, b. Niagara gr. Near Louisville, Ky.

This species is certainly not **Rhodocrinus**, but the type specimen is too imperfect for accurate diagnosis.

1850. (?) **Rhodocr. longispina** A. Roemer. (**Acanthocr. longispina**) Neues Jahrb. der Mineralogie, p. 679, Pl. 4b; Wirtgen and Zeiler, 1855, Jahrb. Naturh. Verein., xii, p. 8, Pl. 2, figs. 1, 2, and Pl. 3, fig. 1; also Pictét, 1857, Traité de Paléont., iv, p. 314, Pl. 100, fig. 11. Posidomyen Schiefer, Harz. (Roemer). Grauwacke, near Coblenz (Wirtgen and Zeiler).

1866. **Rhodocr. nanus** Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 254; also, 1868, Geol. Rep. Ill., iii, p. 476, Pl. 18, figs. 2, a, b. Lower Burlington limest. Burlington, Iowa.

1862, **Rhodocr. nodulosus** Hall. (**Acanthocr. nodulosus**) 15th Rep. N. Y. St. Cab. Nat. Hist., p. 126, Pl. 1, fig 8. Hamilton gr. Ontario Co., N. York.

1862. **Rhodocr. spinosus** Hall. 15th Rep. N. Y. St. Cab. Nat. Hist., p. 127, Photog. Pls., 1875, Pl. 1, fig. 10. Hamilton gr. Ontario Co., N. Y.

1853. **Rhodocr. stellaris** de Kon. and Leh. Recher. Crin. Carb. Belg., p. 109, Pl. 1, figs. 14 a, b, c (figured by Cumberland, 1819, as Encrinus). Mount. limest. Bristol, Engl., and Tournay, Belg.

1853. **Rhodocr. uniarticulatus** de Kon. and Leh. Recher. Crin. Carb. Belg., p. 107, Pl 1, figs. 13 a, b, c. Mount. limestone. Visé, Belg.

1860. **Rhodocr. Varsoviensis** Hall. Supp. Geol. Rep. Iowa, p. 80. Warsaw limest. Warsaw, Ill.

1821. **Rhodocr. verus** Miller. Type of the genus. Nat. Hist. of Crin., p. 107, with figures; Agassiz, 1835, Mem. Soc. Sci. Neuchat., i, p. 196; Roemer, 1855, Lethæa Geogn. (Ausg. 3), p. 241, Pl. 4, figs. 2 a-e; Bronn, Ibid. (Ausg. 1, 2). Mount. limest. Near Bristol, Eng.

1879. **Rhodocr. vesperalis** White. Proc. U. S. National Museum, p. 252, Pl. 1, figs. 11, 12. Upper Coal Measures? 30 miles west of Humbolt, Kans.

We doubt if this fossil came from the coal measures, neither *Actinocrinus* nor *Rhodocrinus* have ever been found to occur later than the age of the Warsaw limestone.

1861. **Rhodocr. Wachsmuthi** Hall. Desc. New Sp. Crin., p. 18. Lower Burlington limest. Burlington, Iowa.

1861. **Rhodocr. Whitei** Hall. Desc. New Sp. Crin., p. 9; Bost. Journ. Nat. Hist., p. 324, Phot. Plates, 1875, Pl. 6, figs. 19, 20, 21.

Var. **burlingtonensis** Hall. Desc. New Pal. Crin., 1861, p. 9; also Bost. Journ. Nat. Hist., p. 325. Lower Burlington limestone. Burlington, Iowa.

1858. **Rhodocr. Wortheni** Hall. Geol. Rep. Iowa, i, pt. ii, p. 556, Pl. 9, figs. 8 a, b, c. Lower Burlington limest. Burlington, Iowa.

13. OLLACRINUS Cumberland.

(Pl. 18, fig. 2, and Pl. 19, fig. 1.)

1826. Cumberland. Appendix to Reliquiæ Conservata.
1877. Wachsmuth. Amer. Journ. Sci. and Arts, xiv, p. 125.
1879. Wachsmuth and Springer. Proc. Acad. Nat. Sci. Phila, p. 261.
1879. Zittel. Handb. der Palæont, i, p. 375.

Syn. *Gilbertsocrinus* Phill. Geol. Yorkshire, pt. ii, p. 207; d'Orbigny, 1850, Prodr. de Paléont., i, p. 155; Meek and Worth., 1866, Geol. Rep. Ill. ii, p. 217.

Syn. *Goniasteroidocrinus* Lyon and Casseday. Amer. Journ. Sci. and Arts, vol. 28 (ser. 2), p. 233; Meek and Worthen, 1869 (Subgenus of *Gilbertsocrinus*), Proc. Acad. Nat. Sci. Phila., p. 75 and 1873, Geol. Rep. Ill., v, p. 389.

Syn. *Trematocrinus* Hall. Supp. Geol. Rep. Iowa, p. 70; Meek and Worthen, 1860, Proc. Acad. Nat. Sci. Phila., p. 383.

Syn. *Rhodocrinus* (in part) de Koninck and Lehon. Recher. Crin. Carb. Belg., p. 104.

The form under consideration was first made known by Cumberland in the Appendix to his Reliquiæ Conservata, 1826, under the name *Ollacrinus*. He published no generic diagnosis nor specific name, but gave excellent figures, by which the type represented can be easily identified. It is characterized by a pentamerous figure, concave base, flat vault, excentric anal opening, spiniferous first radials, and by large oval-shaped interradial and anal spaces, with numerous plates. There are two sets of openings in the brachial regions, the largest supported by the secondary radials, and the others located nearly above them, being smaller, and perforated directly through the centre of pairs of plates in the margin of the vault.

In 1836, Phillips, in the Geology of Yorkshire, proposed the genus *Gilbertsocrinus*, and included in it Cumberland's type, which he described as *G. calcaratus*, and two other species. His figures are fairly good, but his descriptions are very meagre, and show no essential difference from *Rhodocrinus*. They contain no allusion to the two sets of openings,[1] so prominent in his figures, but he apparently considers the upper openings as belonging to "rounded arms, perforated in the centre."

De Koninck and Lehon, in 1854, declared that both *Ollacrinus* and *Gilbertsocrinus* were synonyms of *Rhodocrinus* and ought to be suppressed.

In 1859, Lyon and Casseday described a new species of this type from the upper Subcarboniferous rocks of Kentucky, and proposed for its reception the genus *Goniasteroidocrinus*, which is in every essential respect similar to the forms figured by Cumberland and Phillips, with the exception perhaps, that the upper sets of supposed arm openings, instead of being located directly above the ray, as seems to be the case in some of the British specimens, as figured, are situated "midway between the primary radials" or interradially. Their species—the well-known *G. tuberosus*—was found in excellent preservation, with all the appendages attached, and a good figure of it may be seen in the Geol. Rep. Ill., ii, p. 220. Lyon and Casseday took the upper and larger appendages to be arms, five in number, and below and between these, in the "interradial fields," as they say, they found clusters of from five to seven "long, pendulous cilia," bearing delicate pinnules. These "cilia" they afterwards refer with a query to arms.

A year later, Hall, without any reference to the above descriptions, described under the new generic name *Trematocrinus* a number of species from the Subcarboniferous of the West, of undoubted generic identity with Lyon's species. He, too, considered the interradial appendages to be arms, though he doubted if they could have performed the functions of ordinary arms, and the foramina above the secondary radials he supposed to be openings for fleshy arms or tentacles, not having seen in his specimens any indications of solid arms or even articulating plates. Soon afterwards, however, Hall described from the Devonian of New York his *Trematocr. spinigerus* (15th Rep. N. Y. St. Cab., p. 128), which has the interradial appendages from the vault, and also long arms like *Rhodocrinus* from the radial or ambulacral openings. He called the former "summit arms," and the latter "true arms."

In the second volume of the Ill. Geol. Rep., Meek and Worthen

[1] Attention was first called to these by Billings, Decade iii, Geol. Surv. Can.

gave an excellent description of the genus, and showed that the arms in this type proceed from the radial openings as in other crinoids, and that the interradial appendages are not arms at all. They state that the true arms are always pendant, apparently overlooking Hall's *T. spinigerus*, but this is not uniformly the case even in the Carboniferous species, as we afterwards discovered in Hall's *T. tuberculosus*, (see Proc. Phila. Acad. Nat. Sci., 1878, p. 262), whose arms stand erect, and fold over the dome. We also found the ventral furrow of the arms to be always on the inner side of the arm, next to the body, and accordingly on reverse sides in the erect and the pendant arms. It is possible that this feature may warrant a subdivision of the genus, but until we are better acquainted with the arms in the majority of the species we shall not attempt it.

Meek and Worthen proposed to arrange the British and American species under two sections, based upon the different positions of the so-called false arms, whether placed above the interradial regions as in the latter, or more radial as in the former. We do not attach much importance to this variation, especially in view of our interpretations of the relations and functions of these appendages, besides there is considerable variation in this respect among the American species. The arm openings are in some cases located well under the overhanging margins of the bases of the false arms, in others on either side of them. In no case, however, among American specimens have the false arms been observed to be directly over the ray, as represented in Phillips' diagram of *G. bursa*. and we are by no means satisfied that such was actually the case in the British species, for sometimes the basals alone are prominent and spiniferous, sometimes only the first radials, and it is possible that in some cases they have been confounded.

Some authors, notably Meek and Worthen, object to Cumberland's name *Ollacrinus* because it was not accompanied by any diagnosis or specific name, and give precedence to *Gilbertsocrinus*, the generic and specific descriptions of which disclose no characters to distinguish the genus from *Rhodocrinus*, and which, moreover, entirely overlooked the real characteristic features of this type. Cumberland's published figures give a distinct exposition of essential characters, which leave no room for doubt as to the type represented, and under the rules adopted by the British Association relative to descriptions by the earlier writers, this entitles the name *Ollacrinus* to priority, which leaves *Gilbertsocrinus*, *Goniasteroidocrinus* and *Trematocrinus* as synonyms.

The nearest affinities of this genus are with *Rhodocrinus*, with which it substantially agrees in the structure of the body below the arms, but from which it is conspicuously distinguished by the pseudo-brachial appendages, as well as the size and disposition of the true arms. The two genera are, however, connected through the transition form *O. spinigerus* Hall, which has the arms and body similar to many species of *Rhodocrinus*, yet the pseudo-brachial appendages of *Ollacrinus*.

These appendages are an extraordinary and most characteristic feature of the genus, and no trace of any similar structure has been observed in any other crinoid. The precise office of these organs has puzzled all writers hitherto, and must yet remain to some extent a matter of conjecture. Each of the five main trunks contain two longitudinal perforations running a little to either side of the centre, and one of these passes into each of the rounded branches into which the trunk divides, and pierces its centre to the extremity. They have no other opening, and no external furrows of any kind, but are simply ten thickened cylindrical tubes, which join in pairs by their outer walls near the body, where the two together have a transversely flattened elliptic outline. The passages penetrate the body independently, near—and usually somewhat above—the arm openings, though sometimes directly between the openings of the arms of two different rays. Inside the walls they unite with the arm furrows, in a similar manner as the lateral pore passages in *Batocrinus*, and in view of all the facts, we entertain no doubt, that these openings are of the same nature as those which we have called respiratory pores in the Actinocrinidæ and Platycrinidæ, and which instead of being simple openings, with probably soft parts attached, are here extended into tubes forming a part of the calcareous test. There are five pairs of these elongated pores, and it makes no material difference whether they enter the body a little more radially or interradially, they are placed near the arm bases, and soon connect with the arm passages within the body, as the respiratory pores in *Batocrinus*. In many species there are deep depressions in the vault, opposite the base of each appendage, which are paved with a great number of small irregular polygonal plates. It is not at all improbable that these areæ were susceptible of a certain amount of contraction and expansion, and that they performed an important function in connection with the tubular extensions, in the introduction and expulsion of water.

Generic Diagnosis.—Body generally large, subglobose, about equilaterally pentamerous; plates of the calyx convex to nodose or spiniferous; base concave, vault flat, its margins extended into five free tubular appendages, situated between, or partly above the rays.

Underbasals five, small, pentagonal, forming a flat impressed pentagon, entirely involved in the basal concavity, and sometimes hidden by the column. Basals five, hexagonal or obtusely heptagonal, truncate above, and like the first radials often produced into sharp spines, which extend obliquely downward Primary radials 3 × 5, the first larger than the rest, heptagonal, the second hexagonal, the third hexagonal or heptagonal and supporting on its upper sloping sides the secondary radials, in two series of two to three plates each, which diverge rapidly, arching over the interradial spaces, and completely separating them from the vault. The last secondary radial supports the small delicate arms, its inner sloping side being indented by the arm opening, while its outer side bears an additional plate, which meets with a similar plate of the adjoining ray, and the two together form the base of a false arm.

Interradial and anal areæ scarcely distinguishable from each other; large, oval, sometimes slightly depressed. They are occupied by from ten to eighteen pieces, of which there is one large hexagonal plate in the first range, resting on the truncate upper side of the basals, and between two first radials. This is succeeded by from three to five ranges, the second, third and fourth consisting of three—rarely four—plates, and those above of two and one plate. Interaxillary plates two to eight or ten, the upper ones connecting with the vault and the false arms.

Arms four to nine to the ray, according to the species, the number of primary arms being perhaps restricted to four, the additional ones being produced by branching very close to the body. They are slender and delicate, composed of a double series of interlocking plates, and they bear minute pinnules

The arm openings are situated in rather large, deep depressions, lying under the edges of the pseudo-brachial appendages, but only when the latter are very large, on either side of them when they are small. In the latter case, so far as observed, the arms are erect and folded over the dome, in the former pendant, but in either case the ambulacral furrow lies to the inner or under side of the arms, close to the body, showing the pendant position to be the normal one.

Vault depressed, generally flat, composed of numerous, somewhat convex, polygonal plates, among which the apical and radial dome plates may be readily distinguished by their greater size. The interradial regions are occupied by a large number of small pieces, which are generally found more or less depressed just in front of the base of each false arm. The structure is such that these parts may have been flexible and capable of contraction or expansion. Anal opening directly through the vault, not protruding, situated about midway between the centre and the margin.

The margin of the dome above, and generally between the arm bases of different rays, is extended into five pseudo-brachial appendages, which near the body are comparatively heavy, nearly solid, transversely elliptic, composed of two rows of semi-elliptical joints, rounded on the outside, and joining in the middle by straight, vertical faces. At from four to eight joints from the body, each trunk divides into two rounded branches tapering to a point, which are perforated throughout their length by a small central passage. these passages enter the body in pairs through the main appendages, and thence diverge toward the arm furrows, with which they unite. There are no other openings, nor any external furrows, these organs being simply heavy calcareous tubes, with a jointed structure like that of the column.

Column round, composed of joints alternately larger and smaller; central perforation of medium size, pentagonal.

Geological Position, etc.—*Ollacrinus* is essentially a Subcarboniferous genus, all the known species being from rocks of that age, except a single species which is from the Hamilton group of New York, and this is a transition form. It occurs both in Europe and America.

We recognize the following species:—

*1836. **Ollacrinus bursa** Phill. (**Gilbertsocr. bursa**) Geol. Yorkshire, p. 207, Pl. 4, figs. 24, 25; Austin, 1842, **Rhodocr. bursa**, Ann. and Mag. Nat. Hist., p. 109; also d'Orbigny, **Gilbertsocr. bursa**, Prodr. de Paléont., i, p. 155. Mount. limest, England.

*1836. **Ollacr. calcaratus** Phill. (**Gilbertsocr. calcaratus**) Geol. Yorkshire p. 207, Pl. 4, fig. 22; d'Orbigny, 1850, Prodr. de Paléont., i, p. 155; Austin, 1842, **Rhodocr. calcaratus**, Ann. and Mag. Nat. Hist., p. 109. Mount. limest. England. (Cumberland's original figure in the Reliquiæ Conservata, 1826, represents this species.)

*1860. **Ollacr. fiscellus** Meek and Worth. (**Trematocr. fiscellus**) Proc. Acad. Nat. Sci. Phila., p. 383; also 1865, **Gilbertsocr.** (**Goniasteroidocr.**) **fiscellus**, Ibid., p. 167; also 1866, **Gilbertsocr. fiscellus**, Geol. Rep. Ill., ii, p. 222, Pl. 15, fig. 5. Lower Burlington limest. Burlington, Iowa.

*1836. **Ollacr. mammilaris** Phill. (**Gilbertsocr. mammilaris**) Geol. Yorkshire, p. 207, Pl. 4, fig. 23; also d'Orbigny, 1850, Prodr. de Paléont., i, p. 155; Austin, 1842, **Rhodocr. mammilaris**, Ann. and Mag. Nat. Hist., p. 109. Mount. limest. England.

1869. **Ollacr. obovatus** Meek and Worth. (**Goniasteroidocr. obovatus**) Proc. Acad. Nat. Sci. Phila., p. 76; Geol. Rep. Ill., v, p. 391, Pl. 4, fig. 6; Wachsm. and Spr., 1878, **Ollacr. obovatus**, Proc. Acad. Nat. Sci. Phila., p. 263. Uppermost part of Upper Burlington limest. Burlington, Iowa.

*1860. **Ollacr. reticulatus** Hall. (**Trematocr. reticulatus**) Desc. New Sp. Crin., p. 9; also Bost. Journ. Nat. Hist., p. 325. Lower Burlington limest. Burlington, Iowa.

*1860. **Ollacr. robustus** Hall. (**Trematocr. robustus**) Supp. Geol. Rep. Iowa., p. 77. Lower part of Keokuk limest. Nauvoo, Ill., and Keokuk, Iowa.

1843. (?) **O. simplex** Portlock. (**Gilbertsocr. simplex**) Geol. Londonderry, p. 350, Pl. 16, figs. 3 and 13. Fermanaugh, Ireland. Mount. limestone. (This species may possibly belong to **Rhodocrinus**, variety **Acanthocrinus**; the upper portions of the body are not known.)

*1862. **Ollacr. spinigerus** Hall. (**Trematocr. spinigerus**) 15th Rep. N. Y. St. Cab. Nat. Hist., p. 128. Hamilton gr, Devonian. Ontario Co., N. Y.

*1869. **Ollacr. tenuiradiatus** Meek and Worth. (**Goniasteroidocr. tenuiradiatus**) Proc. Acad. Nat. Sci. Phila., p. 75; Geol. Rep. Ill., v, p. 389, Pl. 11, fig. 1. Lower Burl. limest. Burlington, Iowa.

1860. **Ollacr. tuberculosus** Hall. (**Trematocr. tuberculosus**) Supp. Geol. Rep. Iowa, p. 75; Wachsm. and Spr., 1878. **Ollacr. tuberculosus** Proc. Acad. Nat. Sci. Phila., p. 263. Upper Burlington limest. Burlington, Iowa.

Syn **Trematocr. papillatus** Hall, 1860. Supp. Geol. Rep. Iowa, p. 78. Synon. (Wachsm. and Spr., 1878).

*1859. **Ollacr. tuberosus** Lyon and Cass. (**Goniasteroidocr. tuberosus**, and type of that genus). Amer. Journ. Sci. and Arts, vol. 28, (ser. 2) p. 233; Wachsm. and Spr., Proc. Acad. Nat. Sci. Phila., p. 263. Keokuk limest. Crawfordville, Ind., and Hardin Co., Ky.

1860. **Ollacr. typus** Hall. (**Trematocr. typus**, type of that genus). Supp. Geol. Rep. Iowa., p. 73; Wachsm. and Spr. **Ollacr. typus**. Proc. Acad. Nat. Sci. Phila., p. 262. Upper Burlington limest. Burlington, Iowa.

Doubtful Genera.

The following genera, which evidently belong to the Sphæroidocrinidæ, are too imperfectly defined to be grouped systematically.

1. (?) **CONDYLOCRINUS** Eichwald.

1860. Eichwald. Lethæa Rossica, i, p. 612.

From Eichwald's description, it is impossible to get a correct understanding of this genus. He describes it as having ten basals, three radials, two rows of plates placed above the radials, and numerous other little plates irregularly arranged; the plates tumid, and the calyx covered with a membranous integument (?).

From Eichwald's figure, we are inclined to place the genus with the Rhodocrinidæ, perhaps in the neighborhood of *Thylacocrinus*, provided we are right in supposing that it has five small underbasals within the ten so-called basals. We take the ten latter, which are said to be tumid, as representing five basals alternating with the five first radials. There are 3×5 primary, and evidently two rows of secondary radials, separated by numerous interradial and perhaps interaxillary plates.

Eichwald has referred to it a single species :—

1860. **Condylocrinus verrucosus** Eichwald. Lethæa Rossica, p. 612, Pl. 31, fig. 51. Silurian. Russia.

2. (?) **SCHIZOCRINUS** Hall.

1847. Hall. Palæont. New York, i, p. 81.
1879. Zittel. Handb. der Palæont., i, p. 371 (Steiidiocrinidæ).

The genus was founded upon very imperfect material, but evidently occupies a position near *Glyptocrinus*, if not identical with it. It probably had, like that genus, small or rudimentary underbasals hidden by the column.

Hall describes it with five pelvis plates (our basals); 2×5 costals (the first and second radials); 1×5 scapulars (the third primary radials); 1×5 brachials or arm plates (according to figure a fourth series of primary radials, but probably longitudinally divided, and represented by two plates forming the first series of secondary radials); and above these a double cuneiform arm plate supporting the hand and fingers, we should say a second series of secondary radials, which support the primary arms.

The interradial areæ are composed of several series of two plates each, except the first series which has but one piece, resting in the upper notch between two adjoining first radials. It is not known whether the anal side is distinct, nor has the dome been observed.

Arms short, branching, single jointed. Column round.

These characters, even if correctly interpreted, are not sufficient to distinguish *Schizocrinus* from *Glyptocrinus*. We are inclined to think that the type specimen of *Sch. nodosus* is a young specimen of some *Glyptocrinus*, unless, perhaps, *Schizocrinus* represents palæontologically an earlier stage of the former. The interradial and interaxillary plates seem to be less developed, the arms are short, simple jointed, and the second division of the ray, which in *Glyptocrinus* generally takes place in the body, occurs in the free arms. Hall's second species, still more fragmentary, is probably a very different thing.

Geological Position, etc.—Both species are from the Trenton limestone of New York.

1847. **Schizocrinus nodosus** Hall. Palæont. New York, vol. i, p. 81, Pl. 27, figs. 1 a-p. Trenton limest. Herkimer Co., New York.

1847. (?) **Schizocr. striatus** Hall. Palæont. New York, vol. i, p. 316, Pl. 28, figs. 4 a, b, c. Trenton limest. Middleville, New York.

3. (?) SCYPHOCRINUS Hall (not Zenker, 1833).

(?) CUPULOCRINUS D'Orbigny.)

1847. *Scyphocrinus* Hall. Palæont. New York, vol. i, p. 85.

1850. *Cupulocrinus* d'Orbigny. Prodr. de Paléont., i, p. 23.

(*Scyphocrinus* Zenker, 1833. Beitr. Naturgesch d. Urwald, p. 26, Pl. 4. and Münster, Beitr. iii, p. 112.)

The name being preoccupied by Zenker, d'Orbigny proposed in its place *Cupulocrinus* with *Scyphocrinus heterocostalis* Hall, and a species of *Taxocrinus* as the types.

The form has been generally considered as closely allied to *Schizocrinus*, in which we cannot concur. We think d'Orbigny is correct in placing it with—or near—*Taxocrinus*, but to verify this, better specimens are required, and we will not attempt a generic description from the present material.

(? 1847. **Scyphocr. heterocostalis** Hall. Palæont. New York, vol. i, p. 85, figs. 3 a-f. Herkimer Co., New York.

4. (?) **HADROCRINUS** Lyon.

1869. Lyon. Trans. Amer. Philos. Soc., vol. xiii, p. 445.
1879. Zittel. Handb. der Palæont., i, p. 377.
Syn. (?) *Coronocrinus* Hall. Palæont. New York, iii, p. 124.

The name was proposed for certain crinoidal remains, which had been obtained from the Devonian, near Louisville, Kentucky. The specimens were all fragmentary, but enough is preserved to show a great resemblance to *Dolatocrinus*, and it seems to us that this form should be, like *Stereocrinus*, placed subgenerically under it. *Hadrocrinus* differs from *Dolatocrinus* in the smaller size of the basals, and in having only two primary radials; it differs from this and *Stereocrinus* in the numerous bifurcations within the rays, and in having the arms arranged continuously around the body, and not in groups. The genus *Coronocrinus* proposed by Hall, which was founded upon mere fragments, is in all probability identical with *Hadrocrinus*.

According to Lyon, the body is very large and broad, the calyx low vasiform, the dome hemispherical. Basals three, small, hidden by the column, and only seen when viewed from the inner side. Primary radials 2 × 5, the second axillary. Higher orders of radials numerous, each one composed of two series, and the plates all forming a part of the calyx. The uppermost plate excavated, and forming with the dome plates a large ambulacral or arm opening. The openings are numerous, arranged continuously around the body, and are at no place separated by interradial pieces. Interradial areæ composed of few, three or four pieces, which, like all the radial pieces, are comparatively narrow and long, and of very uniform size throughout, thereby producing the great width in the body. It is not known whether the anal area is distinct or not. Interaxillaries two to four or more. Arms unknown. Column round, rapidly tapering downward; perforation round near the calyx, at a distance below pentalobate.

Geological Position, etc.—From the Devonian of Kentucky. We only recognize two of Lyon's species. *Hadrocrinus pentagonus* is very imperfectly known, and in all probability belongs to a very different group.

1869. **Hadrocrinus discus** Lyon. Trans. Amer. Philos. Soc., vol. xiii, p. 448, Pl. 26, fig. a. Corniferous limest., Devonian. Falls of the Ohio.

1869. **Hadrocr. plenissimus** Lyon. Trans. Amer. Philos. Soc., vol. xiii, p. 445, Pl. 26, figs. B 1–3. Corniferous limest., Devonian. Falls of the Ohio, near Jeffersonville, Ind.

LIST OF SYNONYMS, CORRECTIONS AND IMPERFECTLY DEFINED SPECIES.

Abracrinus d'Orbigny.

A. simplex d'Orb., see *Carpocrinus simplex.*

Acanthocrinus Roemer, syn. of *Rhodocrinus.*

A. longispina Roemer, see *Rhodocr. longispina.*
A. nodulosus Hall, see *Rhodocr. nodulosus.*
A. gracilis Hall, see *Rhodocr. gracilis.*

Actinocrinus Miller.

A. abnormis Lyon, see *Megistocr. abnormis.*
A. aculeatus Austin, not sufficiently defined.
A. ægilops Hall, see *Teleiocr. ægilops.*
A. æqualis Hall, see *Batocr. æqualis.*
A. æquibrachiatus McChesney, see *Batocr. æquibrachiatus.*
A. ——— var. *alatus* Hall, syn. of *Batocr. æquibrachiatus.*
A. Agassizi Troost. Not defined.
A. althea Hall, see *Teleiocr. althea.*
A. amphora Portlock, syn. of *Amphoracr. Gilbertsoni.*
A. amplus Meek and Worth., see *Periechocr. amplus.*
A. Andrewsianus McChesney, see *Batocr. Andrewsianus.*
A. araneolus Meek and Worth., see *Steganocr. araneolus.*
A. asterias McChesney, syn. of *Batocr. verrucosus.*
A. asteriscus Hall, syn. of *Batocr. æquibrachiatus.*
A. arthriticus Phill., see *Gissocr. arthriticus.*
A. atlas McCoy, see *Amphoracr.* (?) *atlas* Roemer.
A. brevicalyx Rose. Not found the description.
A. brevicornis Hall, see *Megistocr. brevicornis.*
A. brevimanus Angelin, see *Periechocr. brevimanus.*
A. brevis Hall, see *Agaricocr. brevis.*
A. biturbinatus Hall, see *Batocr. biturbinatus.*
A. calyculoides Hall, see *Eretmocr. calyculoides.*
A. calyculus Hall, see *Batocr. calyculus.*
A. calypso Hall, see *Gennæocr. calypso.*
A. canaliculatus Hall, see *Dorycr. canaliculatus.*
A. carica Hall, see *Eretmocr. carica.*
A. caroli Hall, syn. of *Batocr. calyculus.*
A. Cassedayi Lyon, see *Batocr. Cassedayi.*
A. catafractus Aust. Not sufficiently defined.
A. cauliculus Hall, see *Gennæocr. cauliculus.*
A. chloris Hall, syn. of *Actinocr. tenuisculptus.*
A. Christyi Shumard, see *Batocr. Christyi,*
A. Christyi Hall, see *Perieochocr. Christyi.*

A. cingulatus Goldf. Described from detached columns.
A. clavigerus Hall, syn. of *Batocr. similis.*
A. clio Hall, see *Eretmocr. clio.*
A. clivosus Hall, see *Teleiocr. clivosus.*
A. clœlia Hall, see *Eretmocr. clœlia.*
A. clypeatus Hall, see *Batocr. clypeatus.*
A. concavus Meek and Worth., see *Dorycr. concavus.*
A. concinnus Shumard, see *Steganocr. concinnus.*
A. corbulis Hall, see *Eretmocr. corbulis.*
A. corniculus Hall, syn. of *Agaricocr. brevis.*
A. cornigerus Hall, see *Dorycr. cornigerus.*
A. cornigerus Shumard, syn. of *Gennæocr. Kentuckiensis,*
A. cornutus Troost. Not defined.
A. coronatus Hall, *Eretmocr. coronatus.*
A. Correyi Lyon, probably (?) *Agaricocrinus.*
A. costatus Eichwald. Detached column.
A. costatus Bigsby, see *Actinocr. costus* McCoy.
A. crassus Austin. Not defined.
A. cyathiformis Sandberger. Badly defined.
A. decadactylus Portlock (not Goldf.). Insufficiently described.
A. decornis Hall, see *Dorycr. decornis.*
A. delicatus Meek and Worth., the young *Teleiocr. umbrosus.*
A. desideratus Hall, syn. of *Dorycr. Missouriensis.*
A. discoideus Hall, see *Batocr. discoideus.*
A. divaricatus Hall, syn. of *Dorycr. cornigerus,*
A. divergens Hall, see *Amphoracr. divergens.*
A. ——— var. *multiramosus* Meek and Worth., syn. of *Amphoracr. divergens.*
A. dodecadactylus Meek and Worth., see *Batocr. dodecadactylus.*
A. doris Hall, syn. of *Batocr. æqualis.*
A. dubius Eichwald. Detached columns.
A. elephantinus Austin. Not sufficiently defined.
A. eris Hall, see *Agaricocr. eris.*
A. erodus Hall, see *Teleiocr. erodus.*
A. eryx Hall, syn. of *Actinocr. glans.*
A. eucharis Hall, see *Gennæocr. eucharis.*
A. Evansii Owen and Shum., see *Megistocr. Evansii.*
A. expansus Phillips, see *Sagenocr. expansus.*
A. fibula Troost. Catalogue name.
A. fiscellus Hall, see *Agaricocr. fiscellus.*
A. formosus Hall, syn. of *Batocr. discoideus.*
A. gemmiformis Hall, *Eretmocr. gemmiformis.*
A. gibbosus Troost. Catalogue name.
A. Gilbertsoni Miller, see *Amphoracr. Gilbertsoni.*
A. Gilbertsoni de Konink, syn. of *Actinocr. stellaris* de Kon.
A. globosus Phillips, see *Rhodocr. globosus.*
A. glyptus Hall, see *Strotocr. glyptus.*
A. Gouldi Hall, see *Dorycr. Gouldi.*

A. granulatus Goldf. Detached columns.
A. granulatus Austin. Not defined. See *Amphoracrinus.*
A. Hageri McChesney, see *Batocr. Hageri.*
A. helice Hall, see *Agaricocr. helice.*
A. Humboldti Troost. Catalogue name.
A. icosidactylus Casseday, see *Batocr. icosidactylus.*
A. Indianensis Lyon and Cass., see *Batocr. Indianensis.*
A. inflatus Hall, syn. of *Amphoracr. spinobrachiatus.*
A. inornatus Hall, syn. of *Batocr. clypeatus.*
A. insculptus Hall, see *Teleiocr. insculptus.*
A. interradiatus Angelin, syn. of *Periechocr. Lindstromi.*
A. irregularis Lyon and Cass., see *Batocr. irregularis.*
A. Kentuckiensis Shum., see *Batocr. Kentuckiensis.*
A. Konincki Shum., see *Eretmocr. Konincki,*
A. lævis Miller. Detached columns.
A. lævissimus Austin. Not defined.
A. lagina Hall, syn. of *Actinocr. proboscidialis.*
A. laguncŭlus Hall, see *Batocr. lagunculus.*
A. latus Hall, see *Megistocr. latus.*
A. laura Hall, see *Batocr. laura.*
A. lepidus Hall, see *Batocr. lepidus.*
A. leucosia Hall, see *Eretmocr. leucosia.*
A. liratus Hall, see *Teleiocr. liratus.*
A. locellus Hall, syn. of *Actinocr. reticulatus* Hall.
A. longidigitatus Angelin, see *Periechocr. longidigitatus.*
A. longimanus Angelin, see *Periechocrinus.*
A. longirostris Hall, see *Batocr. longirostris.*
A. longispinus Austin. Not defined.
A. major Angelin. Rhodocrinidæ, genus (?).
A. mammillatus de Koninck (Bigsby). Not seen description.
A. matuta Hall, see *Eretmocr. matuta.*
A. ——— var. *attenuata* Hall. see *Eretmocr. attenuata.*
A. medius Angelin. Rhodocrinidæ, genus (?).
A. Meekii Lyon, see *Macrostylocr. Meekii.*
A. minor Hall, syn. of *Megistocr. brevicornis.*
A. Mississippiensis Roemer, see *Dorycr. Mississippiensis.*
A. ——— var. *spiniger* Meek and Worth., syn. of *D. Mississippiensis.*
A. Missouriensis Shumard, see *Dorycr. Missouriensis.*
A. moniliferus Goldf. Detached columns.
A. moniliformis Miller, see *Periechocr. moniliformis.*
A *Mortoni* Troost. Catalogue name.
A. multicornis Lyon, see *Centrocr. multicornis.*
A. mundulus Hall, see *Batocr. mundulus.*
A. muricatus Goldf. Detached columns.
A. multibrachiatus var. *echinatus*, see *A. multibrachiatus.*
A. Nashvillæ Troost, see *Batocr. Nashvillæ.*
A. ——— var. *subtractus* White, see *Batocr. Nashvillæ.*

A *nodulosus* Goldf. Detached columns.

A. *nubilis* Angelin, *Periechocr. nubilis.*

A. *nyssa* Hall, see *Gennæocr. nyssa.*

A. *oblatus* Hall, syn. of *Batocr. rotundus.*

A. *obpyramidalis* Winchell and Marcy. Internal cast.

A. *olliculus* Hall, syn. of *Periechocr. Whitei.*

A. *ornatus* Hall, see *Physetocr. ornatus.*

A. *papillatus* Hall, syn. of *Batocr. clypeatus.*

A. *Parkinsoni* de Koninck (?). Not seen the description.

A. *parvus* Shumard, see *Dorycr. parvus.*

A. *pendens* Hall, syn. of *Dorycr. unicornis.*

A. *pentagonus* Hall, see *Steganocr. pentagonus.*

A. *pentaspinus* Lyon, see *Centrocr. pentaspinus.*

A. *perumbrosus* Hall, syn. of *Strotocr. regalis.*

A. *pistilliformis* Meek and Worth., see *Batocr. pistilliformis.*

A. *pistillus* Meek and Worth., see *Batocr. pistillus.*

A. *planobasilis* Hall, syn. of *Amphoracr. divergens.*

A. *planodiscus* Hall, see *Batocr. planodiscus.*

A. *plumosus* Hall. Detached arms.

A. *pocillum* Hall, see *Gennæocr. pocillum.*

A. *polydactylus* Bonny (not Miller), *Melocr. pachydactylus.*

A. *præcursor* Hall, see *Dorycr.* (?) *præcursor.*

A. *prumiensis* Wirtgen and Zeiler, see *Dorycr. prumiensis.*

A. *pulcher* (Salter MS.) McCoy, see under *Periechocrinus.*

A. *pyramidatus* Hall, see *Agaricocr. pyramidatus.*

A. *pyriformis* Ad. Roemer. Not seen description.

A. *pyriformis* Shumard, see *Batocr. pyriformis.*

A. *pyriformis* var. *rudis* M. and W., syn. of *Batocr. pistilliformis.*

A. *quadrispinus* White, syn. of *Amphoracr. divergens.*

A. *quaternarius* Hall, syn. of *Actinocr. proboscidialis.*

A. ——— *spiniferus* Hall, syn. of *Actinocr. proboscidialis.*

A. *quinquangularis* Angelin, see *Periechocr. quinquangularis.*

A. *quinquelobus* Hall, syn. of *Dorycr. cornigerus.*

A. *radiatus* Angelin, see *Periechocr. radiatus.*

A. *ramulosus* Hall, see *Eretmocr. ramulosus.*

A. *regalis* Hall, see *Strotocr. regalis.*

A. *regularis* Hisinger = *Hypanthocr. regularis.*

A. *remibrachiatus* Hall, see *Eretmocr. remibrachiatus.*

A. *retiarius* Phillips. Detached columns.

A. *rotundus* Yandell and Shum., see *Batocr. rotundus.*

A. *rudis* Hall, see *Teleiocr. rudis.*

A. *rusticus* Hall, syn. of *Actinocr. scitulus.*

A. *Schultzianus* Angelin, see *Periechocr. Schultzianus.*

A. *sculptus* Miller. Detached columns.

A. *sculptus* Hall, see *Steganocr. sculptus.*

A. *semiradiatus* Hall, see *Periechocr. semiradiatus.*

A. *senarius* Hall, syn. of *Physetocr. ornatus.*

A. securus Hall, syn. of *Actinocr. sexarmatus.*
A. Sillimani Meek and Worth., syn. of *Actinocr. scitulus.*
A. similis Hall, see *Batocrinus similis.*
A. simplex Phillips, see *Carpocrinus simplex.*
A. sinuosus Hall, see *Batocr. sinuosus.*
A. speciosus Meek and Worth., syn. of *Strotocr. regalis.*
A. spinobrachiatus Hall, see *Amphoracr. spinobrachiatus.*
A. spinulosus Hall, see *Dorycr. spinulosus.*
A. steropes Hall, see *Batocr. steropes.*
A. striatus Münster. Not known to us.
A. subaculeatus Hall, see *Dorycr. subaculeatus.*
A. subæqualis McChesney, syn. of *Batocr. discoideus.*
A. subturbinatus Meek and Worth., syn. of *Dorycr. parvus.*
A. subumbrosus Hall, syn. of *Teleiocr. liratus,*
A. subventricosus McChesney, syn. of *Physetocr. ventricosus.*
A. superlatus Hall, syn. of *Megistocr. brevicornis.*
A. symmetricus Hall, syn. of *Dorycr. parvus.*
A. tenuidiscus Hall, see *Periechocr. tenuidiscus.*
A. tenuiradiatus Hall, 1861, see *Teleiocr. tenuiradiatus.*
A. tenuiradiatus Hall, 1847, Palæocrystes.
A. tenuistriatus Phillips. Detached columns.
A. tesseratus Goldf. Detached plates and columns.
A. tesseracontadactylus Goldf., see *Abacocr. tesseracontadactylus.*
A. tesseracontadactylus Hisinger, syn. of *Carpocr. simplex.*
A. themis Hall, syn. of *Actinocr. proboscidialis.*
A. thetis Hall, syn. of *Actinocr. sexarmatus.*
A. thoas Hall, syn. of *Actinocr. reticulatus.*
A. tholus Hall, syn. of *Actinocr. glans.*
A. tricornis Hall, syn. of *Dorycr. unicornis.*
A. trinodus Hall syn. of *Dorycr. parvus.*
A. turbinatus Hall, see *Batocr. turbinatus.*
A. ——— var. *elegans* Hall, syn. of *Batocr. turbinatus.*
A. umbrosus Hall, see *Teleiocr. umbrosus.*
A. unicornis Owen and Shum., see *Dorycr. unicornis.*
A. unispinus Hall, see *Dorycr. unispinus.*
A. urna Troost. Catalogue name.
A. urnæformis McChesney, syn. of *Eretmocr. Konincki.*
A. validus Meek and Worth., syn. of *Steganocr. concinnus.*
A. ventricosus Hall, see *Physetocr. ventricosus.*
A. ——— *cancellatus* Hall, syn. of *Physetocr. ventricosus.*
A. ——— *internodius* Hall, syn. of *Physetocr. ventricosus.*
A. Verneuili Troost, see *Melocr. Verneuili.*
A. Verneuilianus Shum., see *Eretmocr. Verneuilianus.*
A. viminalis Hall, see *Amphoracr. viminalis.*
A. Wachsmuthi White (1862), syn. of *Actinocr. scitulus.*
A. Wachsmuthi White (1880), see *Batocr. Wachsmuthi.*
A. Whitei Hall, see *Periechocr. Whitei.*

A. Whitfieldi Hall, syn. of *Periechocr. Christyi.*
A. Yandelli Shumard, see *Batocr. Yandelli.*

Agaricocrinus Troost.

A. bellatrema Hall, syn. of *Agaricocr. ornatrema.*
A. bullatus Hall, syn. of *Agaricocr. americanus.*
A. corrugatus Hall, syn. of *Agaricocr. pyramidatus.*
A. excavatus Hall, syn. of *Agaricocr. americanus.*
A. nodosus Meek and Worth., syn. of *Agaricocr. americanus.*
A. pentagonus var. *convexus*, see *Agaricocr. convexus.*
A. tuberosus Troost., syn. of *Agaricocr. americanus.*

Alloprosallocrinus Lyon and Casseday.

A. depressus Lyon and Cass. Not sufficiently defined.
A. euconus Meek and Worth., see *Batocr. euconus.*

Amblacrinus d'Orbigny. Not sufficiently defined.

A. rosaceus (Roemer) d'Orbigny, see *Coccocr. rosaceus.*

Amphoracrinus Austin.

A. americanus Roemer, see *Agaricocr. americanus.*
A. bellatrema Hall, syn. of *Agaricocr. ornotrema.*
A. concavus (Actinocr.) Meek and Worth., see *Dorycr. concavus.*
A. corrugatus Hall, syn. of *Agaricocr. pyramidatus.*
A. crassus Austin. Insufficiently defined.
A. excavatus Hall, syn. of *Agaricocr. americanus.*
A. granulatus Austin. Not sufficiently defined.
A. inflatus Meek and Worth. (Hall's *Actinocr. inflatus*, 1860), syn. of *Amphoracr. spinobrachiatus.*
A. inflatus (Hall's *Agaricocr.—Amphoracr.—inflatus*, 1861), see *Agaricocr. inflatus.*
A. ornotrema Hall, see *Agaricocr. ornotrema.*
A. planobasilis Hall (Meek and Worth.), syn. of *Amphoracr. divergens.*
A. planoconvexus Hall, *Agaricocr. planoconvexus.*
A. quadrispinus White (Meek and Worth.), syn. of *Amphoracr. spinobrachiatus.*
A. subturbinatus Meek and Worth., syn. of *Dorycr. parvus.*

Aspidocrinus Hall. The root (?) of a crinoid.

A. callosus Hall. Body unknown.
A. digitatus Hall. Body unknown.
A. scutelliformis Hall. Body unknown.

Asterocrinus Lyon (not Münster), syn. of *Pterotocrinus.*

A. capitalis Lyon, see *Pterotocr. capitalis.*
A. coronatus Lyon, see *Pterotocr. coronatus.*

Astrocrinites Conrad (not Cumberland nor Austin), syn. of *Melocrinus.*

A. pachydactylus Hall, see *Melocr. pachydactylus.*

Astropodia Ure, see *Platycrinus.*

Balanocrinus Troost (not Agassiz), syn. of *Lampterocrinus.*

B. inflatus Hall, see *Lampterocr. inflatus.*
B. sculptus Troost, syn of *Lampterocr. tennesseensis* Roemer.

Batocrinus Casseday.

B. asteriscus Hall (Meek and Worth.), syn. of *Batocr. æquibrachiatus.*
B. clavigerus Hall (M. and W.), syn. of *Batocr. clavigerus.*
B. doris Hall (M. and W.), syn. of *Batocr. æqualis.*
B. formosus Hall (M. and W.), syn. of *Batocr. clypeatus.*
B. inornatus Hall (M. and W.), syn. of *Batocr. clypeatus.*
B. Konincki Shumard (M. and W.), see *Eretmocr. Konincki.*
B. subæqualis McChesney (M. and W.), syn. of *Batocr. clypeatus.*
B. urnæformis Hall (M. and W.), see *Eretmocr. urnæformis.*

Brachiocrinus Hall. Based on detached arm fragments.

B. nodosarius Hall. Arm fragments.

Cacabocrinus Troost, syn. of *Dolatocrinus.*

C. glyptus Hall, see *Dolatocr. glyptus.*
C. ——— var. *intermedius* Hall, see *Dolatocr. glyptus.*
C. lamellosus Hall, see *Dolatocr. lamellosus.*
C. liratus Hall, see *Dolatocr. liratus.*
C. ——— var. *multilira* Hall, syn. of *Dolatocr. liratus.*
C. speciosus Hall, see *Dolatocr. speciosus.*
C. Troosti Hall, see *Dolatocr. Troosti.*

Calathocrinus Hall (not von Meyer), syn. of *Teleiocrinus.*

Castanocrinus Roemer, syn. of *Melocrinus* Goldfuss.

Centrocrinus Austin (not Wachsm. and Spr.), syn. of *Platycrinus.*

Cœlocrinus Meek and Worth. (not *Cœliocr.* White), syn. of *Dorycrinus.*

C. concavus M. and Worth., see *Dorycr. concavus.*

Clonocrinus Oehlert. (not Quenst.), syn. of *Melocrinus.*

C. Bigsbyi Oehlert., see *Melocr. Bigsbyi.*

Condylocrinus Eichwald, see doubtful genera.

Conocrinites Troost. Not defined.

C. Leæ, Troost. Catalogue name.
C. tuberculosus Troost. Catalogue name.

Cophinus Koenig. Detached columns.

Coronocrinus Hall, see *Hadrocr.* (Doubtful genera.)

C. polydactylus Hall. Small fragmentary pieces.

Crumenæcrinites Troost. Not defined.

C. ovalis Troost. Catalogue name.

Ctenocrinus Bronn, syn. of *Melocr.* Goldfuss.

C. bainbridgensis Hall, see *Melocr. bainbridgensis.*
C. decadactylus Goldf., see *Melocr. decadactylus.*
C. lamellosus Eichwald. Detached columns.
C. notatus Eichwald. Detached columns.
C. punctatus Eichwald. Columns.
C. stellaris Roemer, see *Melocr. stellaris.*
C. typus Bronn, see *Melocr. typus.*

Cupellæcrinus Troost. Not defined.

C. Buchii Troost. Catalogue name.
C. corrugatus Troost. Catalogue name.
C. inflatus Troost. Catalogue name.
C. lævis Troost. Catalogue name.
C. magnificus Troost. Catalogue name.
C. pentagonalis Troost. Catalogue name.
C. rosæformis Troost. Catalogue name.
C. stellatus Troost. Catalogue name.
C. striatus Troost. Catalogue name.

Cyathocrinus Miller.

C. fasciatus Hall, syn. of *Macrostylocr. Meekii* Lyon.
C. tesseracontadactylus Hisinger (Salter), see *Carpocr. simplex.*

Cystocrinus Roemer. Detached columns.

C. Tennesseensis Roemer. Detached columns.

Cytocrinus Roemer, syn. of *Melocrinus* Goldf.

C. lævis Roemer, see *Melocr. lævis.*

Dæmonocrinites Troost. Not defined.

Decadactylocrinites Owen. Not defined.

Dichocrinus Münster.

D. cornigerus Shum., syn. of *Talarocr. cornigerus.*
D. elegans Cass. and Lyon (not de Kon. and Leh.), see *Talarocr. elegans.*
D. expansus Meek and Worth. (not de Kon. and Leh.), see *Dichocr. polydactylus.*
D. insularis Eichw., see *Hexacr. insularis.*
D. lachrymosus Hall, syn. of *Platyr. subspinulosus* Hall.
D. protuberans Hall, *Pterotocr. protuberans.*
D. sculptus Cass. and Lyon (not de Kon. and Leh.), see *Dichocr. ornatus.*
D. septuosus de Kon., based upon detached plates.
D. sexlobatus Shum., see *Talarocr. sexlobatus.*
D. symmetricus Cass. and Lyon, see *Talarocr. symmetricus.*

Dimerocrinus Phillips.

D. icosidactylus Phill., see *Eucrinus icosidactylus.*
D. oligoptilus Pacht. = *Taxocrinus oligoptilus.*

Dimorphocrinus d'Orbigny, (Pentremites).

D. pentangularis d'Orb., in part *Platycr.* (?) *pentangularis* Miller.

Doliolocrinus Troost. Not defined.

Donacicrinites Troost. Not defined.

D. simplex Troost. Catalogue name.

Echinus dubius Schlotheim, see *Actinocr. lævis*, Miller.

Edwardsocrinus d'Orbigny, syn of *Platycrinus.*

E. ornatus McCoy, see *Platycr. ornatus.*

Eucalyptocrinus rosaceus Hisinger (not Goldf.), see *Marsupiocr. rosaceus.*

Eucrinus Angelin.

E. minor Angelin, see *Anthemocr. minor.*
E. venustus Angelin, see *Anthemocr. venustus.*

Eugeniacrinites hexagonus Münster, see *Platycr. spinosus* Quenstadt.

Forbesiocrinus Pratteni McChesney, see *Melocr. Pratteni* (?).

Geocrinus d'Orbigny, syn. of *Periechocrinus.*

G. moniliformis Miller, see *Periechocr. moniliformis.*

Gilbertsocrinus Phillips. syn. of *Ollacrinus* Cumberland.

G. bursa Phill., see *Ollacr. bursa.*
G. calcaratus Phill., see *Ollacr. calcaratus.*
G. fiscellus Meek and Worth., see *Ollacr. fiscellus*
G. mammillaris Phill., see *Ollacr. mamillaris.*
G. simplex Portlock, see *Ollacr. simplex.*

Glosterocrinus Hall. Not sufficiently defined.

G. elongatus Hall. A very imperfect specimen.

Glypytocrinus Hall.

G. armosus McChesney. Described from casts.
G. Baeri Meek, see *Reteocr. Baeri.*
G. basalis McCoy. Insufficiently described.
G. Carleyi Hall, see *Mariacr. Carleyi.*
G. cognatus S. A. Miller, see *Reteocr. cognatus.*
G. Dyeri var. *subglobosus* Meek, see *Glyptocr. subglobosus.*
G. expansus Phill. (d'Orb.), see *Sagenocr. expansus.*
G. gracilis Wetherby, see *Reteocr. gracilis.*
G. lacunosus Billings, see *Archæocr. lacunosus.*

G. libanus Safford. Not defined.
G. marginatus Billings, see *Archæocr. marginatus.*
G. O'Nealli Hall. see *Reteocr. O'Nealli.*
G. plumosus Hall. Detached columns and arms.
G. quinquepartitus Billings. Detached columns.
G. Richardsoni Westerby, see *Reteocr. Richardsoni.*
G. siphonatus McChesney. Described from casts.

Goniasteroidocrinus Lyon and Cass., syn. of *Ollacrinus.*
G. fiscellus Meek and Worth., see *Ollacr. fiscellus.*
G. obovatus Meek and Worth., see *Ollacr. obovatus.*
G. tenuiradiatus Meek and Worth., see *Ollacr. tenuiradiatus.*
G. tuberosus Lyon and Cass., see *Ollacr. tuberosus.*

Habrocrinus Angelin, syn. of *Carpocrinus* Müller.
H. anulatus Angel., see *Carpocr. anulatus.*
H. cariosolus Angel., see *Carpocr. cariosolus.*
H. comtus Angel., see *Carpocr. comtus.*
H. decadactylus Angel., see *Carpocr. decadactylus.*
H. grandis Angel., see *Carpocr. grandis.*
H. granulatus Angel., see *Carpocr. granulatus.*
H. lævis Angel., see *Carpocr. lævis.*
H. longimanus Angel., see *Carpocr. longimanus.*
H. ornatissimus Angel., see *Carpocr. ornatissimus.*
H. ornatus Angel., see *Carpocr. ornatus.*
H. pinnulatus Angel., *Carpocr. pinnulatus.*
H. robustus Angel., see *Carpocr. robustus.*
H. tenuis Angel., see *Carpocr. tenuis.*
H. umbonatus Angel., see *Carpocr. umbonatus.*

Hadrocrinus Lyon. See doubtful genera.
H. pentagonus Lyon. Imperfectly known.

Harmocrinus Angelin, syn. of *Stelidiocrinus.*
H. longimanus Angel., see *Stelidiocr. longimanus.*

Hexacrinus Goldfuss.
H. decagonus Goldf. (Bigsby), see *Storthingocrinus.*
H. depressus Austin, syn. of *Hexacr. interscapularis.*
H. eboraceus Hall (Bigsby), see *Platycr. eboraceus.*
H. Eriensis Hall (Bigsby), see *Platycr. Eriensis.*
H fritillus Müller (Bigsby), see *Storthingocrinus.*
H. melo Austin, syn. of *Hexacr. interscapularis.*
H. nodiger Eichwald. Described from detached columns.

Icosidactylocrinites Troost. Not defined.

Lyriocrinus Hall.
L. sculptilis Hall. Described from an indistinct cast.

Macrostylocrinus Hall.

M. fasciatus Hall, syn. of *Macrostylocr. Meekii.*

Mariacrinus Hall (partly syn. of *Melocrinus.*

M. macropetalus Hall (compare with *Corymbocrinus*).
M. nobilissimus Hall, see *Melocr. nobilissimus.*
M. pachydactylus Hall, see *Melocr. pachydactylus.*
M. paucidactylus Hall, see *Melocr. paucidactylus.*
M. penniger Salter (MS.). No description published.
M. stoloniferus Hall. Described from columns.

Marsupiocrinus Phillips.

M. dactylus Hall, see *Lyriocr. dactylus.*
M. dubius Angelin. Evidently an Actinocrinoid.

Medusacrinus Austin. Not defined.

Megistocrinus Owen and Shumard (not Angelin).

M. infelix Winchell and Marcy, see *Periechocr. Christyi* (Hall).
M. Marcouanus Winch. and Marcy, see *Periechocr. Christyi* (Hall).
M. necis Winch. and Marcy. Described from casts.
M. parvirostris Meek and Worth., see *Megistocr. Evansii.*
M. plenus White, syn. of *Megistocr. Evansii.*
M. Whitei Hall, see *Periechocr. Whitei.*

Melocrinus Goldfuss.

M. amphora Goldfuss, syn. of *Amphoracr. Gilbertsoni.*
M. sculptus Hall. Described from basal plates.
M. angustus Angelin, see *Mariacr. angustus.*
M. obconicus Hall, see *Mariacr. obconicus.*
M. lævis Goldf. (not Roemer), syn. of *Melocr. gibbosus.*
M. fornicatus Goldf., syn. of *Melocr. pyramidalis.*

Ophiocrinus Angelin. Preoccupied by Salter, 1852, and Semper, 1868.

Pentagonites Rafinesque. Described from detached plates.

Periechocrinus Austin.

P. anulatus Angelin. Described from detached plates.
P. costatus Austin, syn. of *Periechocr. moniliformis.*
P. geometricus Angelin. Detached plates.
P. globosus Austin. Not defined.
P. grandiscutatus Angelin. Detached plates.
P. lævis Angelin (not Portlock), see *Periechocr. minor* W. and Spr.
P. multicostatus Angelin. Detached plates.
P. undulatus Angelin. Detached plates.

Phillipsocrinus McCoy, see *Melocrinus* and *Actinocrinus.*

P. caryocrinoides McCoy. Probably a malformed *Actinocrinus.*

Phœnicocrinus Austin, syn. of *Carpocrinus* Müller.

P. simplex Phillips (Austin), see *Carpocr. simplex.*

Pionocrinus Angelin, syn. of *Carpocrinus* Müller.

P. affinis Angelin, see *Carpocr. affinis.*
P. elegantulus Angelin, see *Carpocr. elegantulus.*
P. farctus Angelin, see *Carpocr. farctus.*
P. pulchellus Angelin, see *Carpocr. pulchellus.*
P. simplex Phillips (Angel.), see *Carpocr. simplex.*

Platycrinus Miller.

P. anaglypticus Goldfuss, see *Hexacr. anaglypticus.*
P. alutaceus Goldf. syn. of *Symbathocr. alutaceus.*
P. anndixoni Troost. Not defined.
P. annulatus Goldf., syn. of *Hexacr. anaglypticus.*
P. antheliontes Austin, syn. of *Platycr. pileatus.*
P. armatus Münster. (We have not seen the description.)
P. asper Goldf. (not Meek and Worth.), *Storthingocr. fritillus.*
P. brevis Goldf., see *Hexacr. brevis.*
P. Buchii Roemer, see *Hexacr. Buchii* (?).
P. clytis Hall, syn. of *Platycr. scobina* Meek and Worth.
P. compressus Eichwald. Pieces of column.
P. decagonus Goldf., see *Storthingocrinus.*
P. decoratus F. A. Roemer (?).
P. depressus Aust. (not Owen and Shum., nor Sandberger), syn. of *Hexacr. interscapularis.*
P. depressus Goldf., syn. *of Hexacr. interscapularis* Schultze (? W. and S.).
P. depressus Owen. Not defined.
P. echinatus Sandberger, syn. of *Hexacr. ornatus.*
P. ellipticus Austin (not Phill.). Not defined.
P. elongatus Goldf., see *Hexacrinus elongatus.*
P. elongatus Phillips, see *Dichocr. elongatus.*
P. excavatus Hall, syn. of *Platycr. discoideus.*
P. exsculptus Goldf., see *Hexacr. exsculptus.*
P. exsertus Hall, syn. of *Platycr. burlingtonensis.*
P. frondosus Goldf., syn. of *Hexacr. anaglypticus.*
P. granifer Roemer, syn. of *Hexacr. interscapularis.*
P. granuliferus A. Roemer, see *Hexacr. granuliferus.*
P. Goldfussi Münster, syn. of *Hexacr. elongatus.*
P. Huntsvillæ Troost. Catalogue name.
P. insculptus Troost. Catalogue name.
P. insularis Eichwald, perhaps *Hexacrinus* (?).
P. inornatus McChesney, syn. of *Platycr. burlingtonensis.*
P. interscapularis Phill. (not Miller), *Hexacr. interscapularis.*
P. lævigatus Goldfuss, syn. of *Hexacr. anaglypticus.*
P. Leæ Lyon, see *Hexacr. Leæ.*
P. melo Austin, syn. of *Hexacr. interscapularis.*

P. Milleri McCoy (Pictét), *Cyathocrinus* (?).
P. minutus Schnurr, syn. of *Storthingocr. fritillus.*
P. multibrachiatus Meek and Worth., syn. of *Platycr. discoideus.*
P. muricatus Goldf., syn. of *Hexacr. anaglypticus.*
P. nodulosus Goldf. (not Hall), see *Symbathocr. nodulosus.*
P. nodobrachiatus Hall (1861, not 1858), see *Pl. perasper.*
P. nodosus Wirtgen and Zeiler, see *Culicocr. nodosus.*
P. olla Hall (not de Kon.), syn. of *Pl. Halli* Shum.
P. ornatus Goldf. (not McCoy), see *Hexacr. ornatus.*
P. Oweni Meek and Worth., syn. of *Platycr. regalis* Hall.
P. parvus Hall, see *Cordylocr. parvus.*
P. pentangularis Miller. A Blastoid.
P. Phillipsii d'Orbigny, syn. of *Hexacr. macrotatus.*
P. planus Owen (not Owen and Shum). Not defined.
P. plumosus Hall, see *Cordylocr. plumosus.*
P. polydactylus Troost. Catalogue name.
P. punctobrachiatus Hall (probably not *Platycrinus*).
P. pusillus Goldf., syn. of *Storthingocr. fritillus.*
P. ramulosus Hall, see *Cordylocr. ramulosus.*
P. retiarius Phillips. (We found no description).
P. rosaceus Roemer, see *Coccocr. rosaceus.*
P. rosaceus Goldf., syn. of *Hexacr. callosus.*
P. rugosus Goldf. (not Miller), *Storthingocr. fritillus.*
P. scaber Goldf., *Storthingocr. fritillus.*
P. scobiculata-lineatus Goldf., *Storthingocrinus.*
P. stellaris Roemer, see *Hexacr. stellaris.*
P. striobrachiatus Hall, syn. of *Platycr. corrugatus.*
P. tabulatus Goldf., *Symbathocr. tabulatus.*
P. Tennesseensis F. Roemer, *Marsupiocr. Tennesseensis.*
P. tentaculatus Hall, see *Marsupiocr. tentaculatus.*
P. triacontadactylus, syn. of *Pl. trigintidactylus.*
P. truncatus Hall, syn. of *Platycr. americanus.*
P. ventricosus Goldf., see *Hexacr. ventricosus.*
P. verrucosus White, syn. of *Platycr. pocilliformis.*

Pleurocrinus Austin, see *Platycrinus.*

Pomatocrinus Koenig, MS., not published.

Pradocrinus de Verneuil, syn. of *Periechocrinus.*

P. Baylii de Verneuil, see *Periechocr. Baylii.*

Pterotocrinus Lyon and Casseday.

P. rugosus Lyon and Cass. Not sufficiently defined.

Pyxidocrinus Müller (see our remarks on Actinocrinidæ).

P. prumiensis Müller, see *Dorycr. prumiensis.*

Rhodocrinus Miller.

R. asperatus Billings. Not sufficiently known.
R. Barrisi (var.), *divergens* Hall, syn. of *Rh. Barrisi.*
R. bursa Phillips (Austin). See *Ollacr. bursa.*
R. calcaratus Phillips (Austin), see *Ollacr. calcaratus.*
R. canaliculatus Goldf. Detached columns.
R. costatus Austin. Not sufficiently defined.
R. crenatus Goldf., see *Rhipidocr. crenatus.*
R. echinatus Schlottheim. Detached columns.
R. gigas Billings. Detached columns.
R. granulatus Austin. Not sufficiently defined.
R. gyratus Goldf. Detached columns.
R. melissa Hall, see *Lyriocr. melissa.*
R. mammillaris Phill. (Austin), *Ollacr. mammillaris.*
R. microbasilis Billings, see *Archæocr. microbasilis.*
R. mutabilis Austin. Not defined.
R. pyriformis Billings, see *Archæocr. pyriformis.*
R. quinquangularis Miller. Detached columns.
R. quinquelobus Schultze, see *Eucrinus quinquelobus.*
R. quinquepartitus Goldf. Detached columns.
R. rectus Hall, (Probably a Cystidean.)
R. simplex Portlock (?).
R. tessellatus Steininger, syn. of *Rhipidocr. crenatus.*
R. tortuosus Roemer. Detached columns.

Saccocrinus Hall, syn. of *Periechocrinus.*

S. Christyi Hall, see *Periechocr. Christyi.*
S. semiradiatus Hall. Described from a cast.
S. speciosus Hall, see *Periechocr. speciosus.*
S. tennesseensis Troost. Not defined.
S. Whitfieldi Hall, syn. of *Periechocr. Christyi.*

Sagenocrinus Austin.

S. giganteus Austin. Not sufficiently defined.

Schizocrinus Hall, see "doubtful genera."

Scyphocrinus Hall (not Zenker). Ibid.

Sphærocrinus Meek and Worth. (not Roemer), see *Dorycrinus.*

S. concavus Meek and Worth., see *Dorycr. concavus.*

Sphenocrinus Eichwald. Described from pieces of column.

Strotocrinus Meek and Worthen.

S. asperrimus Meek and Worth., see *Actinocr. asperrimus.*
S. ægilops Hall (M. and W.), see *Teleiocr. ægilops.*
S. althea Hall (M. and W.), see *Teleiocr. althea.*

S. bloomfieldensis S. A. Miller, syn. of *Strotocr. regalis.*
S. ectypus Meek and Worthen, see *Actinocr. ectypus.*
S. erodus Hall, see *Teleiocr. erodus.*
S. insculptus Hall (M. W.), see *Teleiocr. insculptus.*
S. liratus Hall (M. and W.), see *Teleiocr. liratus.*
S. rudis Hall (M. & W.), see *Teleiocr. rudis.*
S. subumbrosus Hall (M. and W.), syn. of *Teleiocr. liratus.*
S. umbrosus Hall (M. and W.), see *Teleiocr. umbrosus.*

Syringocrinus Billings. Imperfectly known.
S. paradoxus Billings. Parts of the arms (?).

Taxocrinus simplex Phill. (Austin), see *Carpocr. simplex.*

Technocrinus Hall.
T. sculptus Hall. Described from basal plates.
T. striatus Hall. Described from basal plates.

Tetramerocrinites Austin. Insufficiently and evidently incorrectly defined.
T. formosus Austin. Undeterminable.

Trematocrinus Hall.
T. fiscellus Meek and Worth., see *Ollacr. fiscellus.*
T. papillatus Hall, see *Ollacr. tuberculosus.*
T. reticulatus Hall, see *Ollacr. reticulatus.*
T. robustus Hall, see *Ollacr. robustus.*
T. spinigerus Hall, see *Ollacr. spinigerus.*
T. tuberculosus Hall, see *Ollacr. tuberculosus.*
T. typus Hall, see *Ollacr. typus.*

Triplaricrinites Goldf. A catalogue name.

Trochicrinites Pander, syn. of *Periechocrinus.*
T. gotlandicus Pander, see *Periechocr. gotlandicus.*

Trybliocrinus Geinitz (?).

Thysanocrinus Hall, syn. of *Dimerocrinus.*
T. aculeatus Hall. Described from fragmentary arms.
T. canaliculatus Hall. Arm fragments.
T. microbasilis Billings, see *Archæocr. microbasilis.*
T. immaturus Hall, see *Dimerocr. immaturus.*
T. liliiformis Hall, see *Dimerocr. liliiformis.*
T. microbasilis Billings, see *Archæocr. microbasilis.*
T. pyriformis Billings, see *Archæocr. pyriformis.*

Turbinocrinus Troost. Not defined.

EXPLANATION OF THE PLATES.

The following letters denote the same parts throughout all the plates.

u = underbasals.
b = basals.
r = radials (r^1 primary radials, r^2 secondary radials, etc.).
i = interradials.
d = interaxillary plates.
cd = central dome plate.
pd = proximal dome plates.
rd = radial dome plates (rd^2 = secondary radial dome plates).
id = interradial dome plates.
dd = interbrachial dome plates.
a — arm plates.
fa = fixed arm plates.
fp = fixed pinnules.
x = anal plates.
xd = anal dome plates.
A = arms.
AO = arm openings.
FR = free rays.
IA = interradial appendages.
RP = respiratory pores.
H = hydrospires.
AT = ambulacral tubes beneath the vault.
G = galleries beneath the vault.
I = interpalmar spaces.
X — anus.
C — column.

EXPLANATION OF PLATE 17.

Fig. 1. *Platycrinus regalis* Hall. The plates in calyx and vault.
Fig. 2. *Ollacrinus tuberculosus* Hall. The plates in the calyx, and those of the interradial appendages and arms.

EXPLANATION OF PLATE 18.

Fig. 1. Extended rim of *Strotocrinus regalis* (dorsal side). All plates below the secondary radials broken away, exposing to view the inner floor of the vault. (This figure in connection with figs. 2, 3, 4, 5, 6, 7, is designed to illustrate the character of a continuous rim and of free rays as extensions of the body, their relations to the arms, and the derivation of the arms from pinnules.)

Fig. 2. *Strotocrinus subumbrosus* Hall. Half of one ray, showing the mode of branching. The medium lines indicate the course of the radial ridges at the surface of the plates.

Fig. 3. *Steganocrinus sculptus* Hall. Showing the free rays and the lateral arms.

Fig. 4. Side view of a portion of a free ray in *Steganocr. sculptus*, showing the ventral covering, and the position of arm openings and respiratory pores.

Fig. 5. Transverse section of the same, showing the form of the inner passage.

Fig. 6. *Reteocrinus Richardsoni* Wetherby. A part of one of the rays within the calyx, showing the fixation of pinnules by means of intercalated plates.

Fig. 7. *Eucladocrinus millebrachiatus* W. and Sp. Ventral side of body, with free rays and lateral arms.

Fig. 8. Showing the position of the apical dome plates in *Batocrinus pyriformis*, a species with a large, almost central anal tube.

Fig. 9. Arrangement of plates in the dome of *Agaricocrinus*.

Fig. 10. Apical dome plates of *Steganocrinus sculptus*.

EXPLANATION OF PLATE 19.

Fig. 1. Vault of *Ollacrinus tuberosus* L. and C., showing the five depressed, oval-shaped groups of small plates opposite the interradial appendages.

Fig. 2. *Batocrinus discoideus*, showing the plates in the calyx. The adjoining plates of the dome added to show the exact position of arm openings and respiratory pores. (The pores are not visible where the arms are attached, but here figured to point out their position.)

Fig. 3. Ventral covering of *Granatocrinus Sayi*, showing the apical and other dome plates, also the extension of this covering over the ambulacral furrows. (O = so-called ovarian openings, f = forked plate, d = deltoid pieces.)

Fig. 4. *Batocrinus discoideus* Hall. Horizontal section through the arm openings and respiratory pores, exposing their passages through the test.

Fig. 5. Natural cast of *Physetocrinus ventricosus*, showing the position of certain pores or pits upon the inner floor of the vault, represented in the cast as small cones.

Fig. 6. Cross-section at midway of *Granatocrinus Norwoodi* Shumard. Showing the hydrospires. (l = lancet piece ; AG - ambulacral and food passage.)

Fig. 7. *Teleiocrinus* with traces of hydrospires, fig. *a*, portions of two pairs of ambulacral tubes within the radiating tunnels beneath the vault, exposing the upper or ventral side. Fig. *b*, transverse section of the same, indicating two compartments along the tunnels, separated by partition (*p*), the upper containing the ambulacral tubes, the lower the hydrospires. (Compare with fig. 8.)

Fig. 8. A pair of ambulacral tubes in *Actinocrinus glans* Hall, as seen from the inner side. Their exit into the arm passages concealed by a delicate partition (*p*), partly surrounding the tubes, and separating them from the hydrospires; the partition being evidently a continuation of the delicate network which lines the inner floor of the vault. The hydrospires are not preserved, but they probably rested, as in fig. 7, beneath the ambulacral tubes. *AO* represents the arm openings seen from the inner side of the body.

Fig. 9. Internal cast of the vault and free rays in *Actinocrinus multiradiatus*. The ridges radiating to the rays represent furrows at the inner floor of the test.

Fig. 10. Œsophageal network of *Eretmocrinus Verneuilianus* Shum.

Fig. 11. The same organ in *Teleiocrinus rudis* Hall.

Fig, 12. The same in *Batocrinus*, one convolution partly removed.

Fig. 13. The same in a different species of *Batocrinus*.

Fig. 14. A part of the same organ in *Ollacrinus tuberosus*.

Fig. 15. A portion of the network magnified. (From a specimen of *Actinocrinus glans*.)

Fig. 16. *Batocrinus longirostris* Hall. The test partly removed, exposing to view the intervisceral plexus.

Fig. 17. The œsophageal network seen from the base.

August 2.

The President, Dr. Ruschenberger, in the chair.

Eight persons present.

A paper entitled "Remarks on the Molluscan Genera Hippagus, Verticordia and Pecchiola," by Angelo Heilprin, was presented for publication.

August 9.

The President, Dr. Ruschenberger, in the chair.

Eleven persons present.

August 16.

The President, Dr. Ruschenberger, in the chair.

Nine persons present.

August 23.

The President, Dr. Ruschenberger, in the chair.

Nine persons present.

The death of Mr. John Welsh, Jr., a member, was announced.

August 30.

The President, Dr. Ruschenberger, in the chair.

Eight persons present.

The death of Mr. Robert Kilvington, a member, was announced.

The following were ordered to be printed:—

A REVISION OF THE CIS-MISSISSIPPI TERTIARY PECTENS OF THE UNITED STATES.

BY ANGELO HEILPRIN.

In the accompanying notes the author has attempted to give a complete list of all the *Pectens* thus far described from the tertiary deposits of the United States east of the Mississippi River, indicating, as far as possible, their range in time and their geographical distribution. The rather hap-hazard method in which the tertiary palæontology of a great portion of the United States has thus far been treated has rendered the statement of this last a matter of great difficulty, and doubtless the range, both in time and space, of many of the species herein enumerated, will require emendation when more accurate data will have been brought directly from the field itself.

The titles of the various works quoted are indicated by the following abbreviations:—

J. A. N. S.	Journal of the Academy of Natural Sciences of Phila.
Proc. A. N. S.	Proceedings of the Academy of Natural Sciences.
A. J. Science.	American Journal of Science and Arts.
A. J. Conchol.	American Journal of Conchology.
Mioc. Foss.	Conrad's "Fossils of the Medial Tertiary of the United States."
Syn. Org. Rem.	Morton's "Synopsis of the Organic Remains of the Cretaceous Group."
Plioc. Foss.	"Pleiocene Fossils of South Carolina," by Tuomey and Holmes.

The generic names placed in parentheses indicate the names under which the given species apper in the "Smithsonian Check Lists" of 1864 and 1866.

Eocene.

P. anisopleura Conr. N. Car.

Kerr, "Geol. Survey of North Carolina," 1875, Appendix, p. 18.

P. calvatus Mort. (Camptonectes) S. Car.

Syn. Org. Remains, p. 58 (*Jacksonian*).

P. Carolinensis Conr. N. Car.

Kerr, "Geol. Survey of North Carolina," 1875, Appendix, p. 18.

? **P. Clairbornensis** Conr. (Camptonectes). Ala.

Smithsonian Check List, 1866.

I have been unable to discover the description of this species. A specimen with this name in the Academy's collection, and marked in Conrad's handwriting, scarcely admits of positive specific determination. It has been considerably eroded, and appears as though it may have been either closely related to, or identical with *P. calvatus* (Mort.).

P. Deshayesii Lea. Ala.
"Contributions to Geology," p. 87.
P. Lyelli Lea. "Contr. to Geol.," p. 88 (young).

Both of Lea's figured specimens are in the Academy's collection, and show beyond doubt that they belong to one and the same species, what there is of *P. Lyelli* corresponding precisely to the earlier formed portion of *P. Deshayesii.* This last must be carefully distinguished from the *P. Deshayesii* of Nyst ("*Coqu. et Polyp. Foss.*," p. 288), which was founded on the erroneous supposition that Lea's species was only a variety of *P. opercularis*, Lam.; a new specific name should therefore be given to the Belgian *Pecten.*

P. elixatus Conr. (Janira), *Jacksonian ?* S. Car.
Proc. A. N. S., ii, p. 174.

P. Knieskerni Conr. N. J.
A. J. Conchol., v, p. 40 (described from a cast).

P. membranosus Mort. *Jacksonian.* Ala.; S. Car.; N. Car.
Syn. Org. Rem., p. 59.

P. nuperus Conr. *Jacksonian.* Miss.
Proc. A. N. S., vii, p. 259.

P. scintillatus Conr. (Camptonectes). Miss.
A. J. Conchol., i, p. 140, as *Eburneopecten.*

Oligocene.

P. anatipes Mort. Ala.
Syn. Org. Rem., p. 58.

P. perplanus Mort. Ala.; Miss.
Syn. Org. Rem., p. 58.
P. Spillmani Gabb. J. A. N. S., 2d series, iv, p. 402.

The original specimen of *P. Spillmani* in the Academy's collection agrees thoroughly with *P. perplanus*, and is marked as its equivalent in Gabb's handwriting.

P. Poulsoni Mort. (Janira). Ala.; Miss.
Syn. Org. Rem., p. 59.

MIOCENE.

P. biformis Conr. Va.

Proc. A. N. S., i, p. 306. Mioc. Foss., p. 73.

This species appears at first sight to be closely related to the *P. Danicus* of Chemnitz, from which, however, it can be readily distinguished by the profound notch under the ear of the right valve, the greater concavity of the opercular valve, and the more prominent and irregular lines on the inferior moiety of the ribs of the convex valve.

P. cerinus Conr. Md.

A. J. Conchol., v, p. 39.

P. comparilis Tuomey and Holmes. Va.; N. Car.

Plioc. Foss., p. 29.
P. eboreus Conr. (in part).
= Specimen marked by Conrad as *P. Yorkensis.*
P. micropleura (young) H. C. Lea. Transactions Am. Philosoph. Society, ix, p. 245.

The specimens which constitute the *P. comparilis* of Tuomey and Holmes were included by Conrad in his *P. eboreus*, but the two can be readily distinguished from each other in the character of the ribs, which in *P. comparilis* are considerably more elevated, and much more distinctly marked off from the general surface of the valve. I have retained as the type of Conrad's *P. eboreus* the forms agreeing with the figure in the "Fossils of the Medial Tertiary of the United States." The *P. comparilis* bears in many respects a close resemblance to *P. purpuratus* Lam., from the coast of Peru, but it may be easily distinguished by the ribs in the interior faces of the valves passing prominently to the umbonal region, whereas in *P. purpuratus* they become indistinct a short distance from the margin, and appear, moreover, much broader. *P. comparilis* is, again, less ventricose on the umbonal region, but more convex toward the basal margin. The intermediate scaly rib between the principal ones present in *P. purpuratus* is wanting in *P. comparilis*. The ears are in *P. comparilis* less prominently marked by the radiating lines.

P. decemnarius Conr. Va.

J. A. N. S., vii, p. 151. Mioc. Foss., p. 49.

P. dispalatus Conr. Va.

Mioc. Foss., 74.

P. eboreus Conr. Va.; N. Car.

A. J. Science, xxiii, p. 341. Mioc. Foss., p. 48.

P. Holbrooki Rav. Proc. A. N. S., ii, p. 96.

Two species were included by Conrad under this name, the second being the one subsequently described by Tuomey and Holmes as *P. comparilis*.

P. Edgecombensis Conr. N. Car.

Proc. A. N. S., 1862, p. 291. Not figured.

The species is described from a specimen in the Smithsonian Institution which I have not had an opportunity to examine.

P. fraternus Conr. Va.

Proc. A. N. S., 1862, p. 291.

? P. tricarinatus Conr. A. J. Conchol., iii, p. 189.

I have not seen a specimen of *P. fraternus*, but its specific description accords well with the specimen marked in Conrad's handwriting *P. tricarinatus*, which I have good reason to believe is the very specimen from which the description of *P. fraternus* has been taken.

P. Humphreysii Conr. (*Oligocene ?*). Md.; N. J.

Proceedings of the National Institution, p. 194.

The convex valve of the average specimens of this species very closely approximates the recent *P. laqueatus* of Sowerby ("Thesaurus Conchyliorum," i, p. 46), from the northwest coast of America, both in outline and ornamentation, but differs in the lesser number (only six instead of eight), lesser prominence, and greater irregularity of the ribs, which also spread out broader towards the basal margin. The valve is, moreover, considerably less ventricose than in *P. laqueatus*. I have been unable to make any comparisons between the opercular valves.

P. Jeffersonius Say. Md.; N. Car.; Va.

J. A. N. S., iv, p. 133. Conrad, Mioc. Foss., p. 46.

P. Madisonius Say. Md.; N. Car.; Va.

J. A. N. S., iv, p. 134. Conrad, Mioc. Foss., p. 48.

P. Magellanicus Gmelin. Md.; N. Car.; Va.

Syst. Nat., 3317.

P. Clintonius Say. J. A. N. S., iv, p. 135.

P. princepoides Emmons. N. Car. Geol. Surv., 1858, p. 280.

I have compared both young and old specimens of the *P. Clintonius* with those of *P. Magellanicus*, and have no hesitation in stating that they all belong to but one species. Some of the fossil specimens do not differ nearly as much from the recent one as the individual specimens of the latter do among themselves. The statement of Say that the sides of the shell (*P. Clintonius*) below the auricles slope much more rapidly downwards than in *G. Magellanicus* is erroneous; nor is there any appreciable difference in the character of the radiating striæ.

P. Peedeënsis Tuomey and Holmes. N. Car.
Plioc. Foss., p. 30. (See *P. Peedeënsis* under PLIOCENE).

The only authority I have (in addition to the statement of Emmons) for stating that this species is found in the Miocene deposits of North Carolina rests on an examination of one solitary valve of a specimen marked by Conrad *P.* (*Liropecten*) *Carolinensis* (described in Kerr's Geol. Rep. of North Carolina, Appendix, p. 18), which, as far as I have been able to determine, does not differ essentially from the *P. Peedeënsis* of Tuomey and Holmes. The specific name, *Carolinensis*, is preoccupied by an Eocene species.

P. Rogersi Conr. Va.
J. A. N. S., vii, p. 151. Mioc. Foss., p. 45.

P. septemnarius Say. Md.; Va.
J. A. N. S., iv, p. 136. Conr., Mioc. Foss., p. 47.

I am inclined to believe that this species will be found to be a mere variety of *P. Jeffersonius* Say; want of a sufficient number of specimens with which to make the comparison has prevented me from making a positive determination.

?**P. tricarinatus** Conr. Va.
A. J. Conchol., iii, p. 189.
= *P. fraternus?* Conr. (See *P. fraternus.*)

P. tricenarius Conr. Va.
Proc. A. N. S., i, p. 306. Mioc. Foss., p. 74.

P. vicenarius Conr. N. Car.
Proc. A. N. S., i, p. 306.

Closely related to *P. comparilis* T. & H.

P. Virginianus Conr. Va.
Mioc. Foss., p. 46.
P. tenuis H. C. Lea. Trans. Am. Philos. Soc., ix, p. 246.

Mr. Searles Wood ("British Crag Mollusca," Bivalves, p. 25. Palæont. Soc. Reports, 1856), states that this shell somewhat resembles the *P. Gerardii* of Nyst, found in the Coralline Crag of England, but that it differs among other characters in being broader than high, and in having the auricles more developed. I have compared Conrad's specimens with Wood's figure, and find the statement concerning the ears to be correct; the relative dimensions of the shell are, however, not constant.

Pliocene.

I have adopted Tuomey's determination of the South Carolina post-Eocene deposits, there being as yet not sufficient evidence to prove that they are of Miocene age, as insisted upon by Conrad.

P. affinis Tuomey and Holmes. S. Car.
Plioc. Foss., p. 26.

I have seen no specimens of this species.

P. comparilis Tuomey and Holmes. S. Car.
Plioc. Foss., p. 29.

P. eboreus Conr. S. Car.
Mioc. Foss., p. 48.
Tuomey and Holmes, Plioc. Foss., p. 28.

P. hemicyclus (Rav.?) Tuomey and Holmes. S. Car.
Plioc. Foss., p. 25 (name quoted from Ravenel).

The opercular valve of this species is of the exact outline, and very much the appearance of the similar valve of *P. excavatus* Sowerby (= *P. Sinensis?*), but is considerably less concave. It is of the shape and concavity of *P. Jacobæus*, but with more numerous ribs. The right valve is less convex than in *P. excavatus*, and wanting on its ribs the prominent lines found in *P. Jacobæus*.

P. Marylandicus Wagner. N. Car.
J. A. N. S., viii, p. 51, Pl. 1, fig. 2 (very poorly figured).

Described from the Pliocene of North Carolina, but more probably Miocene.

This species very closely resembles in form, texture and ornamentation *P. Islandicus* Müll., but is less prominently ribbed, especially on the ears (where the ribs are also more numerous).

P. Mortoni Ravenel (Amussium). S. Car.
Proc. A. N. S., ii, p. 96.

This species differs from the *P. Japonicus* Gmel., in its larger size, thinner texture, and in having the internal ribs arranged in a series of much narrower pairs, i. e., the two ribs of each pair are set closer to each other, and the intervening spaces between the individual pairs is very much greater. The supposed distinction pointed out by Tuomey and Holmes that the number of ribs in *P. Mortoni* is less than in *P. Japonicus* — namely, forty, whereas in the latter, it is forty-six—does not hold, since the number in *P. Japonicus* is very variable even in the valves of the same individual, one specimen showing thirty-four in one valve, and forty-four in the other.

P. Peedeënsis Tuomey and Holmes. S. Car.

Plioc. Foss., p. 30.

P. (*Liropecten*) *Carolinensis* Conr. (Kerr's Geol. Report of North Carolina, Appendix, p. 18), appears to be but a variety of this species, having more ribs (twelve).

This species is stated by Tuomey and Holmes to be "very closely related to, if not identical with *P. nodosus* of the Gulf of Mexico." It appears to me that the resemblance exists only in the fact of the ribs in both species being knobbed, broken into nodes, otherwise the ornamentation is very distinct, the very prominent radiating ridges on and between the ribs in *P. nodosus* being wanting in *P. Peedeënsis*, where they are replaced by fine impressed lines.

P. septemnarius Say. S. Car.

J. A. N. S., iv, p. 36. Conr., Mioc. Foss., p. 47.
Tuomey and Holmes, p. 31.
P. Jeffersonius var. ?

Pecten dislocatus Say, is described from the post-Pliocene deposits of South Carolina by Holmes ("Post-Pliocene Fossils of South Carolina," p. 12), and specimens of *P. hemicyclus* from the same deposits, are in the collections of the Academy. Specimens of *P. irradians* Linn., distinctly showing the color marks, also occur in the newer formations, but I have been unable to determine the locality or localities whence they have been obtained.

REMARKS ON THE MOLLUSCAN GENERA HIPPAGUS, VERTICORDIA AND PECCHIOLIA.

BY ANGELO HEILPRIN.

The genus *Hippagus* was founded by Dr. Isaac Lea, in 1833 (Contributions to Geology, p. 72), for a small cordiform fossil shell from the Eocene deposits of Alabama, whose external appearance bore a somewhat general resemblance to *Isocardia*. Its affinities with that genus were at the time pointed out by that naturalist, who did not hesitate to class it in its immediate neighborhood, despite the great differences that were presented by the structure of the hinge in the two genera. To my knowledge, only two species, one other than the American, are as yet known to belong to this genus, the second one being a species from the Arrialoor Cretaceous group of Strípermatúr, India, discovered by the late C. Aemilius Oldham, and to which Stoliczka has applied the specific name of *Aemilianus* (Palæontologia Indica, Memoirs Geol. Surv. India, Cretaceous Fauna, iii, p. 262). In 1846 Mr. Searles Wood published in the seventh volume of Sowerby's Mineral Conchology, p. 67, his diagnosis of a new genus of fossil shell, for which he some years previously proposed the name *Verticordia*, and which was intended to embrace the only species known at the time, a fossil of the English crag (the *Cryptodon? Verticordia* of the "Catalogue of the Crag Mollusca," Annals and Magazine of Natural History, 1840, vi, p. 247). Almost simultaneously with the discovery of the Crag fossil, Philippi discovered in Calabria, South Italy, a very closely allied form, which, on the strength of the transcript of the characters of Lea's genus, as given by Bronn in the Lethæa Geognostica, he referred to *Hippagus* (sp. *acuticostatus*) (Enumeratio Molluscorum Siciliæ, 1844, ii, p. 42). Probably guided by the views of Philippi, Sowerby (*loc. cit.*) considered the new genus of Wood as untenable, and accordingly referred the English fossil in question likewise (although with doubt) to the genus *Hippagus*, imposing upon it the new specific name of *cardiiformis* (Min. Conch., vii, p. 68). Sowerby's example, singularly enough, is followed by Wood in his "Monograph of the Crag Mollusca" (Palæontographical Soc. Reports, ii, p. 149, 1851–3), who now renounces his genus, referring his species to

Hippagus, with the original specific name modified into *Verticordius*. Both the English and the Italian species have very little in common with Lea's *Hippagus*, which is edentulous, and belong properly to the genus *Verticordia* (*Trigonulina* of D'Orbigny), as reconstituted by conchologists.

Another singular fossil, long known to palæontologists as the *Chama ? arietina* of Brocchi (Conchiologie Fossile Subapennina, ii, p. 668), and which systematists generally referred to *Isocardia*, was thought by Sismonda (Synopsis Method. Anim. Invert. Ped. Foss., p. 18; *fide* Hörnes, Die fossilen Mollusken des Tertiär-Beckens von Wien, ii, p. 169) to be referable to the genus *Hippagus* of Lea, but the dentiferous conformation of the hinge did not escape the attention of Meneghini, who, in 1851 (Considerazioni sulla Geolog. Stratigr. della Toscana, p. 180), constituted it into the genus *Pecchiolia*, restoring to it the original specific name of *argentea*, proposed, in 1797, by Mariti. Deshayes in (about ?) 1860 (Animaux sans Vertèbres, Bassin de Paris, i, p. 809), described a minute fossil from the Paris basin under the name of *Hippagus Leanus*, which, in the prominence and recurved nature of its beaks, to some extent recalls the *Hippagus isocardioides* of Lea, but which differs in the presence, in each valve, of a cardinal tooth.

Deshayes was apparently doubtful as to the true generic position assigned to his species, inasmuch as he states that a more complete study of the American shell may lead to the separation of the two species into distinct genera. Having shown the correctness of Lea's figure and description, by the discovery of the allied Indian form, Stoliczka proposes (Palæontologia Indica, Cretaceous Fauna, iii, p. 225) the generic name of *Allopagus*, for the species from the Paris basin, which name it ought to retain. It will thus be seen that fossil shells belonging to no less than four distinct genera have been alternately referred to the American genus *Hippagus*.

All these agree, more or less, with each other in the closed and nacreous or semi-nacreous shell, recurved umbones, simple pallial impression, and the internal or subinternal arrangements of the ligaments. They differ in the dentiferous character of the hinge. The opinions of naturalists have been greatly at variance as to the position to be assigned to these genera in a natural classification, and, indeed, there appears to be no small difficuly in arriving at a satisfactory conclusion as to their proper generic affinities. Philippi (*loc. cit.*, p. 41) classed his species under the *Cardiacea*, immediately after the genus *Isocardia*, a somewhat similar view being entertained by Oronzio Costa as to the position of his genus *Iphigenia* (= *Verticordia* ? Wood.[1] Seguenza, Jour. de Conchyliologie, 2d ser., iv, 1860, p. 290), which he placed in the proximity of the *Carditæ*. Seguenza states (*loc. cit.*) that the same views were entertained by Woodward in his "Manual of Mollusca," but that author seems to have overlooked the remark in the supplement to the work just mentioned (p. 471; and second edition, 1868, p. 472), whereby the genus is referred "undoubtedly" to the *Trigoniadæ*. The relationship with *Trigonia* is maintained by H. and A. Adams in their "Genera of Recent Mollusca," 1858, ii, p. 531), and by Deshayes in his valuable remarks on the family *Trigonea* Lamarck, and the genera *Verticordia* and *Hippagus* (Animaux sans Vertèbres, Bassin de Paris, i, pp. 805–10), although the last named naturalist in his review of the *Cardiacaa* (*loc. cit.*, p. 529), distinctly states that, for the time being, the genus *Pecchiolia* (misprinted *Petchiola*), which, on pages 806 and 810, he points out to be indisputably linked to *Verticordia* and *Hippagus*, will probably have to be referred to that family. According to Pecchioli (Revue et Magasin de Zoologie, 1852, p. 577) Meneghini, on establishing this genus, considered it as allied to *Diceras* of Lamarck, a view to some extent shared by Stoliczka, who, on proposing the family *Verticordiidæ* for the genera *Pecchiolia*, *Verticordia* and *Allopagus* (*loc. cit.*, p. 224), places the same in his order *Chamacea*. Lea's *Hippagus* is found a refuge among the *Ungulinidæ*, near *Scacchia*, the affinity with which, it must be confessed, appears to us as rather remote. Mr. Arthur Adams states in his observations on *Verticordia Japonica* (Annals and Magazine of Natural History, 3d series, ix, 1862, p. 224), that the animal has no relation to *Trigonia*, but, on the contrary, that "its position, judging both from the nature of the animal and the form of the

[1] I have been unable to gain access to Costa's work, and therefore cannot, from personal observation, pronounce upon the value of the genus *Iphigenia*; its identity with *Verticordia* is given upon the authority of Seguenza, but judging from this author's descriptions and figures of his two species of *Verticordia*, it would appear that he had confounded with that genus the genus *Pecchiolia*.

shell, would seem to be in the family Bucardiidæ, the animal differing from *Bucardia* (*Isocardia*) *cor* in the posterior [mantle] opening being fringed." The shell of this species, Mr. Adams further adds, is very different from that of *V. novemcostata* Adams and Reeve, from the China Sea, and very similar to the *V. granulata* of Seguenza, a Tertiary Sicilian fossil. Whether this last is a true *Verticordia* I am not in a position to judge, not having seen any specimens, but if the figures illustrating Seguenza's descriptions be correctly executed, they appear to represent a species of fossil very different from the *Verticordia cardiiformis* of Wood, the typical species of the genus *Verticordia*. The same may be said of Seguenza's figure of *V. acuticostata*, the species described by Philippi from the newer Tertiaries of Calabria, and which was considered by Wood, as identical with the species from the English Crag; the absence of a lunule (very prominent in *Verticordia*), the prominently recurved spiral umbones, and the great ventricosity of the shell, would seem to indicate a form much more nearly allied to *Pecchiolia*. If, however, as Seguenza states (*loc. cit.*, p. 293), "les valves des individus jeunes de cette espèce (d'un diamètre de 4 à 8 millimètres) sont minces, plus circulaires, moins renflées, et s'accordent parfaitement avec la figure de M. Philippi . . ." the question is settled as far as the identity of the Sicilian and Calabrian fossils is concerned, and a strong relationship between the genera *Verticordia* and *Pecchiolia* would be indicated; but it is at the same time very singular, and what makes it appear somewhat suspicious, that in the second species stated by Seguenza to belong to the genus *Verticordia*—*V. granulata*—there should be considerable differences in the character of the hinge, and, moreover, a deep lunule ("lunula profunda, cordata, ecostata, granulis carens") should be present. An indubitable species of *Verticordia*, the *V. Emmonsii* Conr., has been described from the Miocene deposits of North Carolina; the *V. Parisiensis* Deshayes, from the Paris basin, is at best but very doubtful. Although *Verticordia* and *Pecchiolia* may be very closely related forms (and their positions, everything considered, if the observations of Mr. Adams on *V. Japonica* be correct, would be about as near to *Isocardia* as to any other recent genus), there does not appear to be as yet sufficient evidence for uniting the two genera, as has been done by some conchologists. *V. granulata* and *V.*

acuticostata (*et conseq.*, *V. cardiiformis* for Gwyn Jeffreys) are stated to be also living forms, both inhabiting the Japanese seas, and the former also the Mediterranean (Gwyn Jeffrys, "Mediterranean Mollusca," Annals and Mag. of Nat. Hist., 4th ser., vi, 1870, p. 73; "Japanese Marine Shells and Fishes," Journal Linnean Society, Zoology, xii, 1874, p. 101; Jour. Linn. Soc., xiv, 1879, p. 420); these species are all classed by Mr. Jeffreys as *Pecchiolia*, and placed among the *Corbulidæ*, and if the determinations have been correctly made, they go far to confirm the observations of Seguenza as to the variability of the genus *Verticordia* (and of its passage into *Pecchiolia*). But in addition to these forms of so-called *Pecchiolia*, we have the *P.* [*Lyonsiella*] *abyssicola* of M. Sars (Selsk. Forh., 1868, p. 257; G. O. Sars, "On some remarkable Forms of Animal Life," 1872, i, p. 25; Zoological Record, 1872, p. 166; G. O. Sars, Bidrag til Kundskaben om Norges Arktiske Fauna, 1878, p. 108, Pl. 20, fig. 5), an Arctic form certainly very distinct in the totality of its characters from at least some, if not all, of the preceding, but which is nevertheless admitted by Mr. Jeffreys into the genus *Pecchiolia*, and placed alongside two new species of his own description, *P. gibbosa* and *P. tornata* (Annals and Mag. Nat. Hist., 4th ser., xviii, 1876, p. 494). It certainly scarcely appears possible that three such very distinct forms (at least as they appear to me) as are represented by the *Chama arietina* of Brocchi (*Pecchiolia argentea* Meneg.), *Verticordia cardiiformis* of Wood, and *Lyonsiella abyssicola* of Sars, can belong to the same genus. The shell of this last is said to be thin, pellucid, inequivalve, and gaping posteriorly, whereas in *C. arietina* it is comparatively thick, equivalve, and completely closed. Nor does Sars' description of the animal of his species at all accord with Adams' observations on *Verticordia Japonica*. In the former the foot is said to be long, subcylindrical, and provided with a byssus, whereas in the latter it was found to be "small, triangular, and compressed." Again, in the former, the siphons are separate, subsessile, with the branchial not prominent (anal prominent), whereas in *V. Japonica* the "sessile siphonal orifices" are "close together, the branchial larger than the anal." The supposed pallial sinus stated to exist in *Chama arietina* by Pecchioli, was probably founded on an imperfection in the shell, since the pallial impression is stated to be simple by Hörnes, whose description and figures are drawn from Italian specimens. The form of the Arctic shell recalls the *Verticordia Parisiensis* of Deshayes, which, however, differs in the presence of a cardinal hinge tooth; the pallial sinus represented in the figure (vol. i, Pl. x, fig. 12) is stated by the French conchologist to have been erroneously placed there by the artist, and, therefore, cannot be taken as a character separating it from *L. abyssicola*, in which the pallial impression is also non-sinuate ("hele, ikke bagtil indbugtede Kappe linie"). Finally, in the list of deep-sea mollusca dredged in the Bay of Biscay (Annals and Mag. Nat. Hist., October, 1880, p. 316), Mr. Gwyn Jeffreys revives the generic term *Verticordia* for a newly-discovered species, *V. insculpta;* is this species likewise to fall under *Pecchiolia?*

The similarity existing between Lea's genus *Hippagus* and *Crenella*, as exemplified by *C. glandula* Totten, a relation first pointed out by Jeffreys (Annals and Mag. Nat. Hist., 4th ser., vi, 1870, p. 73), is certainly very great, but yet there appear to be sufficient differences to warrant a generic separation. The umbones in *Hippagus* are much more prominently developed and spirally twisted, and, as far as I have been enabled to determine, there are no crenulations on the hinge-line; these, however, may have been eroded in the specimens (Lea's types in the collection of the Academy of Natural Sciences) examined. The structure of the shell appears to have been also considerably heavier than in *Crenella*. The *H. Aemilianus* of Stoliczka scarcely appears to differ from the *H. isocardioïdes*.

NOTE.—While preparing the preceding remarks on the genus *Verticordia* the author inadvertently overlooked the notice of that genus by Searles Wood, as contained in his "Monograph of the Eocene Mollusca" (Palæont. Soc. Reports, 1871). Reference is there made to the existence of an ossicle in the hinge, which led Mr. A. Adams to consider the genus as belonging to the *Anatinidæ*, and, therefore, as distantly removed from the *Bucardiidæ*, with which it had been previously placed by that author. This view is not concurred in by Mr. Wood, who, while in doubt as to its true relationship, places the genus in a family apart by itself—the *Verticordidæ* (a family name first proposed by Stoliczka). The genus *Pecchiolia* is stated to be synonymous with *Verticordia*, but no grounds are given for so considering it.

SEPTEMBER 6.

The President, Dr. RUSCHENBERGER, in the chair.

Seven persons present.

SEPTEMBER 13.

The President, Dr. RUSCHENBERGER, in the chair.

Seventeen members present.

On Hieracium aurantiacum.—Mr. JOHN H. REDFIELD stated at the meeting of the Botanical Section that he had recently found about two miles north of Tannersville, in the Catskill Mts., N. Y., *Hieracium aurantiacum* L., growing abundantly over a stony hill-side pasture, at an elevation of about 2500 feet above tide. This plant is a native of elevated regions in central Europe, and is a recent introduction to our Flora. Its prolific runners favor a rapid spread, and the farmers near the Tannersville locality already complain of it as a troublesome weed, so that there is reason to fear it may become an unwelcome permanent resident.

Mr. Meehan stated that he had received the same plant from correspondents in New England, who had supposed it indigenous, but that he had no doubt it was in all cases introduced. It had also been collected in the Catskills this season by Miss Cope of Germantown.

Note upon Plantago elongata Pursh.—Mr. JOHN H. REDFIELD remarked that Dr. Gray, in the new Synoptical Flora of N. Am., ii, 392, says, that this plant "of Bradbury's collection on the Missouri, is unknown, probably a glabrate form of *P. Patagonica.*" Pursh's specimen ticketed (probably by Lambert) *P. elongata*, and noted as from Bradbury, has recently been found in the Academy's Herbarium and proves to be unmistakably *P. pusilla* Nutt.

SEPTEMBER 20.

The President, Dr. RUSCHENBERGER, in the chair.

Twenty persons present.

A paper entitled "Note on the approximate position of the Eocene deposits of Maryland," by Angelo Heilprin, was presented for publication.

SEPTEMBER 27.

The President, Dr. RUSCHENBERGER, in the chair.

Eighteen persons present.

Dr. E. C. Hine was elected a member.

OCTOBER 4.

Mr. J. H. REDFIELD, in the chair.

Nineteen persons present.

How Orb-Weaving Spiders make the Framework or Foundations of Webs.—Rev. Dr. H. C. McCOOK said that he had given attention during the past summer to the mode of constructing webs prevailing among orb-weaving spiders. He had been led to make some special studies of the extent to which air currents are utilized in laying the foundation lines upon which the orbs are hung, by a remark of Rev. O. Pickard-Cambridge in his work on the Spiders of Dorset.[1] "Spider lines," he says, "may frequently be observed strained across open spaces of many feet and even yards in extent. This has been explained by some naturalists to have been done by the help of a current of air carrying the thread across. I cannot, of course, say that it has never been thus effected; though I have certainly never myself witnessed it. I have, however, on several occasions seen a spider fix its line, then run down to the ground, across the intervening space, and so up the opposite side, trailing its line as it went; and then having hauled in the slack, it fixed the line to the desired spot. This, I believe, to be the usual mode of proceeding in such cases."

Dr. McCook was satisfied that on both the above points this distinguished araneologist had failed to possess himself of all the facts; but he took up the points in question anew during the summer, and made notes of his studies. His previous opinion was fully confirmed. He had in a great number of cases observed orb-weavers passing from point to point by means of lines emitted from their spinnerets and entangled upon adjacent foliage or other objects. These mimic "wire-bridges" were of various lengths owing to the direction of the wind, and the relative positions of the spider and the standing objects around it. Lines of two, three and four feet were frequent; lines of from seven to ten occurred pretty often; he had measured one twenty-six feet long, and in several cases had seen them strung entirely

[1] Vol. i, Introduction, p. xxi.

across country roads of from thirty to forty feet. Many of these lines he had seen carried by the wind directly from the spiders' spinnerets, had observed the entanglement, had seen the animal draw the threads taut and then cross upon them. That all the lines were similarly formed and used he had no doubt.

It was more difficult to determine the other question, viz.: Whether the lines used for the foundations of orb-webs were formed in the same way. Undoubtedly, such lines are often made precisely as asserted by Mr. Cambridge. Dr. McCook had many times observed this; he had seen an orb-weaver after traversing a considerable space by a series of successive bridge-lines settle upon a site between the forked twigs of a bush and carry her foundation lines around in the manner described. But, on the other hand, he was prepared to say that the air-laid bridge-lines were also used for the foundations or frames of orbs.

1. First, he had observed that the hours in the evening at which the greatest activity in web-weaving began, were those in which also began the formation of the bridge-lines. The latter action quite invariably preceded the former.

2. Again, a study of the foundation lines of many webs gave more or less conclusive evidence that they were laid by the aid of air currents. For example, the webs of some species, as *Acrosoma mitrata*, *A. spinea* and *A. rugosa*, were frequently found strung between young trees separated by two or three yards. That these builders might have dropped to the ground, crept over wood, grass and dry leaves carrying the thread in the free outstretched claw, is, perhaps, not impossible, but did not seem at all probable to the speaker, although short spaces over smooth surfaces might well be cleared in this way. One web he found spun upon lines stretched from the balustrade of a bridge that spans a deep glen in Fairmount Park, to the foliage of a tree that springs out of the glen at least twenty-five feet below. Unless foundations were formed by line-bridging the interspace of a yard or more, it must be inferred that the spider had dropped from the balustrade to the glen, crossed the interval to the trunk of the tree, ascended it, and having made the detour of nearly sixty feet to the point directly opposite that from which she started, drawn her long line taut, and so completed her foundation. Dr. McCook thought that such a supposition could not be entertained, and it was clear that a breeze carried the line across from the spider's spinnerets.

Even stronger examples of circumstantial evidence were noted. Very many webs of *Tetragnatha extensa* and *T. grallator* were seen spread upon bushes overhanging pools and streams of water; others were seen stretched between separated water-plants, or from such plants to the shore. Either the foundation lines were borne by air currents, or the spiders must have crossed upon the water, carrying their lines. The latter supposition is not wholly untenable, the speaker thought, but would hardly be raised by any one who had studied the spinning habits of the creature.

One other example may be cited. At Cape May, by the Landing, where pleasure boats used for sailing upon the inlet are stored, there is an immense colony of Epëiroids, chiefly *Epeira strix*, *E. vulgaris* and *E. domiciliorum* (Hentz). Great numbers of these spiders had their lines strung between the opposite, exterior walls of the boat-houses, which are built upon piles driven into the water. These lines were about nine feet long, stretched over the water at heights varying from one to ten feet. Most of them passed from wall to wall; many were fastened at one end upon piles and sticks driven here and there between the houses. Even if one were to admit that *Tetragnatha* could carry a free line over the smooth surface of an inland pool, it is past belief that the above named Epeiras performed the same act upon the rough waters of an inlet of the Atlantic Ocean. The only reasonable conclusion is that bridge-lines were formed by air currents.

3 It was greatly desired that to the above cases of circumstantial proof, might be added actual observations of the use for foundations of those lines stretched by air currents. Three summer evenings were devoted to obtaining this result, without complete success. On one evening the observer was interrupted and called off at the very critical period of his observation; on the other two evenings the wind was unfavorable. But some valuable results were obtained, and the webs of three adult individuals of *Epeira strix*, one male and two females, were selected, the den or nest of each spider located, and the web entirely destroyed, including the foundation lines. The latter precaution was made necessary by the fact that orb-weavers had been noticed to use the same foundation lines, for many days, for the erection of their new webs. Young spiders had been seen on several occasions to utilize the radii and foundations of abandoned webs of adults, as the frame-lines of their small orbs. The great value which may attach to these old foundations appeared strikingly in subsequent studies, and also the difficulty if not impossibility of procuring suitable foundations for the webs of large spiders, without the aid of the wind.

Two of the webs (one of the females) were so situated that the prevailing air currents so carried the lines that they could not possibly find an entanglement. In consequence, neither of these spiders succeeded, during two entire evenings, up to half-past ten o'clock, in making a web. They frequently attempted it in vain. One, which was more closely watched, was in motion during the whole period, passing up and down, from limb to limb, apparently desirous of fixing her orb in the former site, but completely confused and foiled. The site was one, moreover, which would have allowed her to carry around a thread with comparative ease, being a dead sapling that forked near the ground. The spider domiciled during the day on the ground, but had her orb at the top of the forks, a height of six feet. Thus the space to traverse in passing from the top of one of the forks to a similar point on the opposite one, presented comparatively few difficulties. But no attempt was made to carry the line around, and as the wind had evidently not changed during the night, no web appeared upon the tree in the morning. During the next evening the same restless movement along the bare limbs of the sapling was repeated, and was terminated at a late hour by a rare accident. A large moth, attracted by the lantern, became entangled upon a single short thread strung between two small twigs, whereupon *Strix* pounced upon it, swathed and fell to feeding on it. Next morning a tiny orb-web had been built around the shell of the moth at the point of capture.

During both evenings this spider at frequent intervals poised herself at the extremity of twigs, and emitted threads from her spinnerets which entangled upon some of the short twigs, but never upon the opposite fork, as the wind was steadily contrary. No other entanglement was secured, as there was no object in the direction of the wind for a great distance. However, Dr. McCook could, at any time, obtain an entanglement upon his hand by arresting the thread. By imitating the motion of a swaying leaf or limb, the spider was caused to perceive the attachment, and immediately ventured upon the line. Once the thread fastened upon the observer's face, and the animal was allowed to cross the line (four or five feet) until within a few inches of the face, when she took in the situation, instantly cut the line and swung downward and backward over the long arc, and, after a few oscillations, climbed up the line to the point of departure. Her willingness to use the air-currents for making transit lines was thus quite as manifest as her inability. The third spider exhibited a like behavior.

4. The third individual, a male, did not attempt to spin an orb in the former site; the wind was unfavorable, but there would not have been much difficulty in carrying a cord around. He came out of his rolled-leaf den at 7.20 P. M., and for more than an hour labored to secure a web foundation. He was located upon a dead end of a bough of a tree, with many branching twigs. As with the former individual, so with this: many efforts were made to obtain foundations by sending out threads from the spinnerets, and to this end he tried most of the numerous points of the twigs covering the territory which he seemed to have chosen as his general range. One of these, a little pendant which hung in the centre of the group, was taken as the basis of a most interesting operation. The spider dropped from the pendant by a line three or four inches long, grasped the line by one of the second pair of feet, and rapidly formed a triangular basket of threads by connecting the point of seizure with lines reaching to the feet of the remaining second and the third and fourth pairs. In this basket he hung head upwards, the body held at an angle

of about 45°, the two fore-feet meanwhile stretched out, and groping in the air, as though feeling for the presence of obstructions, of enemies or of floating threads. At the same time he elevated his spinnerets and emitted a line which was drawn out at great length by the air, but secured no entanglement. The body of the spider had a gentle lateral oscillation, which appeared to the observer to result from a voluntary twisting of the central rope by the animal, but may have been caused by the air; the effect, in either case, was to give the line a wider swing, and much increase the chances of entanglement.

However, there was no entanglement, and the spider dropped several inches farther down, and repeated exactly the process as described above. This was repeated again and again, and when the observer allowed the line to attach to his person the spider at once proceeded to satisfy himself of the fact, and then to venture a crossing. In all these actions there was evidences of a habitual mode of securing transit by bridge-lines.

During the intervals of these attempts, and indeed preceding them, the spider passed back and forth along all the branching twigs, leaving behind him trailed threads or lines connecting the ends, many of which seemed to be purely tentative. At last a central point was taken, a short thread dropped therefrom and attached to one of these tentative lines. The confused network of circumjacent lines was gathered together in a little flossy ball at the point of union, which was now made the centre of the orb, the first drop line and the two divisions of the cross line constituting the three original radii. From there the spider proceeded to lay in the radii and complete the orb. The speaker described this process in full, as illustrated by the industry of this and other individuals. The time occupied in constructing the orb proper was half an hour, while the work of prospecting for, and obtaining a foundation consumed more than an hour. Even then the orb was very irregular, and showed decided traces of the want of the usual well and orderly laid foundations. An examination of a number of web-sites which had been marked upon the same grounds, showed that in every case where the surroundings had allowed an easy and good entanglement by the wind, the spiders had made webs at an early hour, and with straight and regular foundations.

Dr. McCook concluded that the above observations, although not wholly conclusive in themselves, were sufficient warrant for the belief that air currents have a large part in placing the original framework or foundation lines of orb-webs, and that spiders habitually make use of them for that purpose. He doubted, however, whether there was anything like a deliberate purpose to connect the point of occupancy with any special opposite point. It seemed to him that the spider acted in the matter very much at hap-hazard, but with a general instinct of the fact that such behavior would somewhere secure available attachments. Many of her bridge lines were evidently tentative and were chiefly at the mercy of the breeze, although some observations seemed to indicate a limited control of the thread by manipulation.

He added that on previous occasions he had actually observed the laying in, by air currents, of lines which were immediately used for foundations. The above studies had been undertaken simply to verify such studies, and because he had retained but the briefest notes of former observations. While this use of air currents is certainly placed beyond doubt, it is as certainly not the only mode of laying foundation lines, and is dependent very much upon the site chosen, the condition of the wind, the abundance of prey, etc. Webs built in large open spaces are perhaps always laid out by bridge-lines. In more contracted sites, the frame-lines are generally carried around, and often a foundation is the result of both methods.[1]

OCTOBER 11.

The President, Dr. RUSCHENBERGER, in the chair.

Three hundred and sixty-four persons present.

On the Nature of the Diphtheritic Contagium.—Dr. H. C. WOOD stated that the researches which formed the basis of his remarks had been made under the auspices, and, indeed, at the suggestion of the National Board of Health, by Dr. Henry F. Formad and himself, who were jointly responsible for the facts and inductions and jointly deserving of whatever reprobation or approbation might be due. The full text of the work is now in the hands of the National Board, and will be shortly published by them.

In the spring of 1880 work was begun by inoculating rabbits with diptheritic membrane taken from the throats of patients at Philadelphia. It was found that only in a very few cases was anything like diphtheria produced in the rabbit by inoculating with the membrane. The inoculations were practiced by putting pieces of the material sometimes under the skin, sometimes deep in the muscles. Many rabbits died after some weeks, not of diphtheria, but of tuberculosis. In a series of experiments it was shown that this tuberculosis was an indirect and not a direct result of the inoculation, and that any apparent relation between the two diseases is only apparent, not real. Next, the tracheas of a series of rabbits were opened and false membrane inserted. It

[1] Since these notes were communicated, a copy of *Nature* (Sept. 22, 1881) has been received, in which it is said that Mr. Cambridge in the second volume of his *Spiders of Dorset* modifies the opinion above quoted concerning the influence of air currents. I have not yet received that volume but make this statement on the authority of the journal referred to.—H. C. McC.

was found that under these circumstances a severe trachitis was frequently produced, and was attended by an abundant formation of pseudo-membrane. Careful studies made of the false membrane of diphtheria and of this false membrane showed that the two were identical, both containing in abundance fibrin fibres, corpuscular elements, and various forms of micrococci. To determine whether other inflammations of the trachea than that caused by diphtheria or its membrane are accompanied by the formation of false membrane, a number of experiments were made, and it was demonstrated that the production of false membrane has nothing specific in it, but that any trachitis of sufficient severity is accompanied by this product. Careful studies also showed that this false membrane does not differ in its constitution from that of true diphtheria, except it be that the micrococci are not so abundant in it. They always found some micrococci, and in some of these traumatic pseudo-membranes they were almost as numerous as in the diphtheritic exudation.

Last spring they resumed their investigations. Having heard that there was a very severe epidemic in Ludington, Michigan, Dr. Formad was despatched to examine cases and collect material. He found a small town situated upon the shore of Lake Michigan, in the centre of the lumber region, with inhabitants mostly engaged in the lumber trade and in managing very numerous large saw-mills. The town was all built upon high ground except the Third Ward. This occupied a low swamp which had been filled in largely with sawdust. The soil was so moist that a hole dug in it would fill at once with water, and but few houses had any attempts at cellars. It was in this district that the disease had prevailed. Almost all the children had had it, and one-third of them were said to have died. Dr. Formad examined a large number of cases, obtained a supply of diphtheritic membrane and brought home pieces of the internal organ of a child upon whom he had made an autopsy. In every case the blood was found more or less full of micrococci, some free, others in zoogloæ masses, others in the white blood-corpuscles. The organs brought home also all contained micrococci, which were especially abundant in the kidneys, where they formed numerous thrombi, choking up and distending the blood vessels. In the summer of 1880 they examined the blood of several cases of endemic Philadelphia diphtheria, and in no case found any new elements in it. But during the present summer they had found micrococci in the blood of Philadelphia diphtheritic patients, showing that the differences in the diseases are simply in degree, not in kind.

Experiments were now made with the Ludington material upon animals. Inoculations were practiced under the skin, deep in the muscles, and in the trachea. In all cases the result was similar. A grayish exudation appeared at the seat of inoculation, along with much local inflammation, the animal sickened, and in the course of a few days death occurred. The local symptoms increased and widened. In some cases the false membrane spread from where the poison had been put in the trachea up to the mouth. The blood examined during life or after death was found to contain micrococci precisely similar to those found in the Ludington cases, and in a few instances micrococci were found in abundance in the internal organs. Studies made upon the blood of these animals, as well as upon the Ludington cases, show that the micrococci first attack the white blood-corpuscles, in which they move with a vibratile motion. Under their influence the corpuscles alter their appearances, losing their granulations. They finally become full of the micrococci, which now are quiescent and increase until the corpuscle bursts and the contents escape as an irregular, transparent mass full of micrococci, and form the so-called zoogloæ masses. In the diphtheritic membrane the micrococci exists frequently in balls, and it is plain that these collections are merely leucocytes full of the plant. The bone-marrow of the animal was found full of leucocytes and cells containing micrococci.

The question now arose, is the disease produced by diphtheritic inoculation in the rabbit diphtheria? They concluded that it is, because the poison producing it is the same, the symptoms manifested during life are the same, and the post-mortem lesions are identical. The contagious character of the disease is retained, as they succeeded in passing it from rabbit to rabbit.

Their next series of experiments were directed to determine whether the micrococci are or are not the cause of the affection. The experiments of Curtis and Satterthwaite, of New York, have shown that the infectious character of diphtheria depends upon its solid particles; for when an infusion of the membrane was filtered, it became less and less toxic in proportion as the filtration was more and more perfect; and when the infusion was filtered through clay, the filtrate was harmless.

The urine of patients suffering from malignant diphtheria is full of micrococci, and may contain no other solid material. Following the experiments of Letzerich, they filtered this urine and then dried the filter-paper. Upon experimenting they found this even more deadly in its effects than is the membrane. The symptoms and lesions following in the rabbit inoculation with such paper are precisely those which would have ensued had a piece of diphtheritic kidney or membrane been employed. This experiment shows that the solid particles of the membrane, which are the essential poison of malignant diphtheria, are the micrococci, which must be either the poison itself or the carriers or producers of the poison.

Culture.—Experiments were performed in the manner commended by Klein and that recommended by Sternberg. The first method seemed the best for the purpose of studying the development of the micrococcus itself; the second, the best for the obtaining of it in quantity for experimentation.

Micrococci were cultivated from the surface of ordinary sore throats, from furred tongue, from cases of mild diphtheria as commonly seen in Philadelphia, and from Ludington cases. There were no differences to be detected in the general or special appearance of the various micrococci, and no constant differences in size. They all formed similar shapes in the culture-apparatus; they had this difference, however,—whilst the Ludington micrococci grew most rapidly and eagerly, generation after generation up to the tenth, those from Philadelphia diphtheria ceased their growth in the fourth or fifth generation, whilst those taken from furred tongue, never got beyond the third transplantation. Various culture-fluids were used, but the results were identical. They concluded, therefore, that as no difference is detectable between the micrococci found in ordinary sore throat and those of diphtheria, save only in their reproductive activity, they are the same organisms in different states. As the result of some hundreds of cultures, they believe that the vitality under artificial culture is in direct proportion to the malignancy of the case from which the plant has been taken.

They next made a series of experiments of inoculating rabbits with cultivated micrococci, and succeeded in producing diphtheria with the second generation, but never with any later product. This success, taken in conjunction with the urine experiments already spoken of, seemed sufficient to establish the fact that the micrococci are the *fons et origo mali* of diphtheria. The experiments of Pasteur and others have proven that it is possible for an inert organism to be changed into one possessed of most virulent activity, or *vice versa*, and it was believed that direct proof could be offered that the micrococci of the mouth are really identical in species with the micrococci of diphtheria, and do not merely seem to be so. The Ludington membrane was exposed for some weeks to the air in a dried condition. There was no putridity or other change detectable in it; but, whereas formerly it had been most virulent, now it was inert, and its micrococci not only looked like those taken from an ordinary angina, but acted like them. They were not dead, they had still power of multiplication, but they no longer grew in the culture-fluid beyond the third or fourth generation. Certainly they were specifically the same as they had been, and certainly, therefore, the power of rapid growth in culture-fluids and in the body of the rabbit is not a specific character of the diphtheria *Micrococcus*.

As is well known, Pasteur attributes the change from an active to an inert organism to the influence of the oxygen of the air upon the organism. Whether this be true of the diphtheria *Micrococcus* is uncertain, but the effects of exposure of the dried membrane seem to point in such direction.

With the facts that are known in regard to the clinical history of diphtheria and those which they had determined in their research, it is easy to make out a theory of the disease which reconciles all existing differences of opinion and seems to be true.

A child gets a catarrhal angina or trachitis. Under the stimulation of the inflammation products the inert micrococci in the mouth begin to grow; and, if the conditions be favorable, the sluggish plant may be finally transformed into an active organism, and a self-generated diphtheria results. It is plain that if this be correct there must be every grade of case between one which is fatal and one which is checked before it fairly passes the bounds of an ordinary sore throat. Every practitioner knows that such diversity does exist. Again, conditions outside of the body favoring the passage of inert into active micrococci may exist, and the air at last become well loaded with organisms, which, alighting upon the tender throats of children, may begin to grow and themselves produce violent angina, trachitis, and finally fatal diphtheria.

In the first instance we have endemic diphtheria as we see it in Philadelphia; in the second, the malignant epidemic form of the disease as it existed in Ludington. It is also apparent that in the endemic cases the plant whose activity has been developed within the patient may escape with the breath, and a second case of diphtheria be produced by contagion. It is also plain that as the plant gradually in such a case passes from the inert to the active state, there must be degrees of activity in the contagium, one case being more apt to give the disease than is another; also that the malignant diphtheria must be more contagious than the mild endemic cases.

October 18.

The President, Dr. Ruschenberger, in the chair.

Twenty-seven persons present.

A paper entitled "Revision of the Tertiary Species of Arca of the Eastern and Southern United States," by Angelo Heilprin, was presented for publication.

The death of Dr. Benj. H. Coates, a member, was announced.

Notes on Mistletoes.—Mr. Thomas Meehan called attention to some fine specimens on the table of *Phoradendron juniperum*, var. *Libocedri* Engelmann, and *Arceuthobium occidentale* var. *abietinum* Engelmann, from Washoe Valley, Nevada, contributed by Mrs. Ross Lewers of Franktown and said it might be worth noting a few facts in relation to Mistletoes, which, though perhaps not wholly new to specialists, did not seem to be generally known.

The Mistletoe of the Eastern States had a general resemblance to that of Europe, *Viscum album*; but the old genus *Viscum* had been divided by modern botanists, although the lines of distinction were somewhat artificial. We had two genera, *Phoradendron* and *Arceuthobium*. Among the leading distinctions might be mentioned that the European branch of the family, *Viscum*, as now restricted, had the anther open by three pores on slits, our *Phoradendron* by two, while the *Arceuthobium* had but one. There were other slight differences in pollen grains, cotyledons, and form of the fruits. The European Mistletoe is usually founded on deciduous trees only, an instance being recorded where it had been found on the Scotch pine in Germany, and its American representative, *Phoradendron flavescens* Nuttall, seemed also confined to deciduous trees and shrubs.[1] This extends across the continent, a form being found on the Pacific coast still confined to deciduous plants; while another genus, *Arceuthobium*, seems wholly confined to the coniferous trees which are mixed with the deciduous ones. The name *Arceuthobium* is suggestive of this fact, it being derived from two Greek words signifying "living on the juniper." *Phoradendron*, on the other hand, meaning simply "living on, or stealing from trees." *Arceuthobium*, however, did not live wholly on junipers. In the herbarium of the Academy was a specimen of *A. occidentale*, growing on *Juniperus occidentalis*—these Nevada specimens were on *Pinus ponderosa*. The specimens of *Phoradendron juniperinum* were growing on *Libocedrus decurrens*, which, by the way, was, he believed, the first time this pretty cupressineous tree had been reported from the State of Nevada. Among the differences noted by Engelmann in the botany of California, between *Phoradendron* and *Arceuthobium*, was that while the former flowered in February and March, and matured its fruit "next winter," the fruit of the Californian species opened in the summer, and did not mature till the "second autumn." The European Mistletoe was stated by Bentham to open in spring, and perhaps this was so; it was formerly supposed to be the case with the American *Phoradendron flavescens*, but Mr. Wm. Canby had shown to the Academy recently, that in Delaware the flowers opened in the fall, and the fruit matured in the autumn of the following year, or just one year afterward. The flowers and fruit were on the trees at the same time together. If this were general with *Phoradendron*, it still lessened the distinctions between the genera. Usually *Phoradendron* bore leaves, while *Arceuthobium* was leafless—but the *Libocedrus* parasite was as destitute of leaves as an *Arceuthobium*, and the common observer would see little in their general aspects to distinguish

[1] Mr. Jos. Jeanes believes he saw a specimen some years ago on *Abies Canadensis.*

them. But there was one great difference in the genus, at least as represented by these two species. In opening the box which contained the specimens, the whole mass was covered with a dense viscid secretion, which rendered it very difficult to separate one branch from another. On leaving the lid open a little while, the watery particles soon evaporated, leaving a dry gummy deposit over the whole surface. While this was going on, the seeds were ejected with great force from their endocarps, being projected against the face with such force as to leave a stinging sensation. Dr. Engelmann has noted this power of ejection in the berries of this plant. The *Phoradendron* exhibited no trace of any such power, though there seemed to be little difference in the structure of the berries. The facts raised a nice teleological question. Birds did not seem to use the berries. As they were so viscid that the famous bird-lime is made from some species, it is probable the very viscidity would prevent the free use of the beak in any attempt to use the seeds. But it was believed that by becoming attached to the feet or feathers of birds, the seeds were widely distributed, and that in this way the plant had all the advantage necessary for distribution in the "struggle for life." But *Arceuthobium*, besides all the advantages to be derived from this mode of distribution, had an additional aid from a projecting force.

Did *Arceuthobium* at one time exist when or where there were no birds, and had it to depend on projection alone for its distributing power, and is the viscidity a later development? Did *Phoradendron* once possess the power, and has it abandoned it from having through the ages found out that it travels well enough without its exercise? Or is it rather, as the speaker himself inclined to believe, that nature loved to aim expressly at variety, and was continually exhibiting her power to accomplish the same end by a wonderful variety of means? But whatever might be thought of the various theories of development, and the laws of final causes which may have operated to produce changes, there could be but little doubt but parasitism was an acquired habit, and the endeavor to find out what these plants were, and how they behaved before they were parasites, was fast becoming one of the most interesting of biological studies.

The seeds ejected from the endocarp in *Arceuthobium* fastened themselves to the branches of trees by a glutinous mass at one end. This end was opposite to the radicle, which, in germinating, would have to push out from above, and curve downwards towards the branch in order to attach itself. He had not seen them during the process of germination, but as the testaceous covering was held fast by the glutinous secretion, it is probable the cotyledons would be drawn out as the plumule took its upright position, leaving the testa as an empty case fastened to the branch. Presuming that this must be the case with other Loranthaceous plants, it was difficult to understand the process by which the

East Indian species performed the locomotive feat recently noted by Dr. Watt, and which from its remarkable nature has had a wide publication. It was reported as the observation of Dr. Watt that a seed falling on and becoming attached to the coriaceous leaf of a *Memecylon*, would send out its radicle, which, curving down, formed a flattened disk by which it attached itself to the leaf. But, as if it knew that a leaf could not permanently support a perennial plant, the cotyledons were lifted and turned to the other side, when the end with the disk moved to another place, and in this way, the seed traveled to a more favorable spot. Without reflecting on the observation, Mr. Meehan believed it should be repeated in order to be sure of no mistake. In all plants in our country which fastened to an object through a disk at the end of a rootlet or tendril, as in *Ampelopsis* and *Bignonia capreolata*, the attachment was made while the disk was forming. A disk once formed, did not reattach itself to an object when removed from the original spot. In like manner the cotyledons, once removed from the endocarps, would have no viscidity with which to form a resisting power while the disk was unfastening itself from its undesirable location. There was, however, so much of singular behavior in the Mistletoe family that further observations were very desirable.

Dr. Geo H. Horn observed that the Mistletoe which was parasitic on the "Mesquite" in Arizona (*Phoradendron Californicum?*), had flowers and fruit together in the autumn.

Mr. Geo. W. Holstein observed that this was also the case with the species (*Phoradendron flavescens?*) which grew on the elms in Texas.

Dimorphism in a Willow.—Mr. THOMAS MEEHAN called attention to branches of a willow on the table, presented by a member, Mr. Edward Potts, which were gathered by his brother from one plant in the Adirondacks. Besides the certainty that they were from one plant, for which Mr. Potts was willing to vouch, he observed that the buds and other points indicated a community of origin. But while the normal leaves were broadly ovate—about two inches long by over one broad—the leaves on the other branch, though quite as long, were not over a line wide. The species so far as one could judge of a willow having mere leaves, appeared to be *Salix reticulata*. Dimorphism in foliage, is not uncommon in many trees, but it was worth noting that change by gradual modification was not the law in these variations. The change of one form to another quite dissimilar, was usually made by a wide leap, without any intermediate changes, and he believed this to be the rule in specific as well as individual development. It was nothing against the doctrine of evolution that there were "missing links."

Occurrence of the same species of Protozoa on both sides of the Atlantic.—Mr. RYDER remarked that during his sojourn at Cherry-stone, Virginia, he had met with another ciliated protozoan, *Licnophora cohnii*, in the waters of the Chesapeake, also found in the Mediterranean and North Sea, and now for the first time recorded as occurring in the American fauna. The existence of congeneric and conspecific protozoan forms on both sides of the Atlantic had been alluded to before by the speaker; of these he had noticed *Cothurniæ*, *Vorticellæ*, *Zoöthamnia*, *Freia producta*, *Tintinnus*, *Rhipidodendron*, and several *Gastrotricha* which appear conspecific with old world types.

OCTOBER 25.

The President, Dr. RUSCHENBERGER, in the chair.

Thirty-nine persons present.

Art. 3, Chap. XV, of the By-Laws was amended by adding after the word "election" in the second line, the words "and resignation."

Mr. W. N. Lockington was elected a member.

The following were ordered to be printed:—

NOTE ON THE APPROXIMATE POSITION OF THE EOCENE DEPOSITS OF MARYLAND.

BY ANGELO HEILPRIN.

The positive determination of the relation which the older Tertiary deposits of Maryland—those of Ft. Washington, near the City of Washington, and Piscataway and Upper Marlborough in Prince George's County—hold to the typical American Eocene series as exhibited in Alabama, can only be arrived at when a direct stratigraphical continuity can be traced between the deposits of the two states, or between their previously recognized representatives in the intervening states. This is due to the fact that several members of the Eocene series appear to be absent from this portion of the Atlantic border, but exactly which it has as yet been impossible to determine. The presence of strata of Jacksonian age has never been detected, nor have we any positive knowledge concerning the existence in the State of any beds which may be looked upon as the equivalents of the Orbitoide limestone, although Oligocene (Vicksburgian) strata may exist along the Chesapeake. But whether the deposits in question—Ft. Washington, Piscataway, and Upper Marlborough—represent the Claibornian, Buhrstone, or Eo-Lignitic is a matter of considerable uncertainty, perhaps largely due to their comparatively feeble development. Almost the only evidence we have bearing upon this point is derived from the character of the contained fossils, but even here the results obtained are far from satisfactory, and for two reasons: in the first place, the character of the Eocene fossils is largely uniform throughout the greater portion of the entire series, as is shown by nearly the lowest and highest exposures in the State of Alabama; and in the second place, the great distance intervening between the two localities—Alabama and Maryland—may readily account for certain differences in the general aspect of the two fossil faunas, which otherwise would probably be attributable to a non-contemporaneity in the periods of their introduction. The evidence afforded by lithological characters is almost equally unsatisfactory, since there is a frequent repetition of the general rock aspect—green sands, clays, and siliceous marls—observable at different stages of the series. Conrad, the only investigator whose observations on this subject are of scientific value, affirms that the majority of the fossil mollusca are of the Claiborne type, and he consequently correlates the beds containing them in a general way with those exposed on the Alabama River, although without specially indicating with what portion of the Claiborne section they were supposed to correspond. Indeed, about the only fossils obtained from the Maryland localities which can in any way be said to be either characteristic of or peculiar to them are *Panopea elongata*, *Pholadomya Marylandica*, *Pholas petrosa*, *Cucullæa* (*Latiarca*) *gigantea*, *Ostrea compressirostra*, and one or two doubtful species of *Crassatella*. All the species here named, if we except the doubtful *Crassatellas* and *Ostrea compressirostra* are good species, and if we further deduct *Cucullæa gigantea*, the only Eocene species of the genera to which they belong thus far discovered in the eastern or southern United States. On the whole, therefore, they afford little or no clue to the exact determination of the age of the deposits in which they occur. It is true that an examination of the homotaxial deposits of Europe shows the genera *Pholadomya* and *Panopea* to be more especially characteristic of the lower or even lowermost horizons of the Eocene series, as in the English and French basins, but no special inference can be drawn from this circumstance, since the species are not the same, and the genera survived through the succeeding periods to the present day. In the case of *Ostrea compressirostra*, however, we have a much more tangible point. The species, first described and figured by Say (Journal of the Academy of Natural Sciences, iv, p. 133), is certainly very intimately related to the *Ostrea Bellovacina* of Lamarck, and apparently undistinguishable from certain varieties of that species.[1] Now this species, although not exclusively restricted to the lowest Eocene beds, is nevertheless highly characteristic of the Thanet sands, below the London Clay proper and also below what was formerly designated as the "Plastic Clay" series, where it constitutes a true basement accumulation; and it holds almost precisely the same relation to the beds of the Paris basin, where, according to Deshayes (*Animaux s. Vertèbres*,

[1] The distinguishing characters of the beaks pointed out by Say do not seem to hold in many instances, as is proved by specimens of the *C. Bellovacina* from the "London Clay" of Bognor, England, in the collections of the Academy, which do not differ as much from certain American specimens as these last do among themselves.

Bassin de Paris, ii, p. 117) it occupies the horizon of the Bracheux sands. The species wherever found appears to be considerably restricted in its vertical range, and its occurrence, therefore, in some of the American deposits would seem to afford some more decided indication of the true age of those deposits than could be obtained from the character of the limited number of its contained fossils taken as a whole. Associated with *Ostrea compressirostra* were found casts of the large *Cucullæa gigantea* (Conrad, Journ. Ac. Nat. Sciences, vi, p. 215, 1830), a species which appears not to be represented in any of the equivalent European formations. But in Virginia, in beds which can be shown to be the direct equivalents of those of Maryland, there occurs in addition to the *C. gigantea* of Conrad, a second species of *Cucullæa*, the *C. onochela* of Rogers (Trans. Am. Philos. Soc., new ser., vi, p. 373; *Latiarca idonea* Conr., Proc. Acad. Nat. Sciences, 1872, p. 53—no locality stated), which, if not identical with the *C. crassatina* of Lamarck, from the Bracheux sands of the Paris basin, is certainly most intimately related to it, and can be considered in every way as its immediate representative.[1] It should also be stated that the only other species of *Cucullæa* described by Deshayes (*Animaux s. Vertèbr., Bassin de Paris*, i, p. 109) from the Paris basin (*C. incerta* Desh.) is found in the same horizon with the *C. crassatina*, and, likewise, the single species described by Searles Wood from the older Tertiaries of England is a *lower* Eocene form

If such comparisons are of any value stratigraphically we may fairly look upon the Maryland Eocene deposits—the Piscataway sands below, and the Marlborough rock above—as representing a horizon nearly equal to that of the Thanet sands of England and the Bracheux sands of the Paris basin, or of the British Bognor

[1] I have had no specimens of the European species with which to institute direct comparisons, but as the species is a large one, and with well-defined characters, I have relied upon the figures and characters as furnished by Deshayes (*Coquilles Fossiles, Environs de Paris*, i, p. 193; Atlas, Pl. xxxi, figs. 8 and 9), which are well known for their accuracy. The *C. crassatina* is catalogued by Prestwich (Quart. Journ. Geol. Soc., 1854, p. 109) and Morris ("Cat. Brit. Foss.," p. 197) as being also an English form, and as belonging to the Thanet series, but by Searles Wood ("Monograph of the Eocene Mollusca" Bivalves, in Palæont. Soc. Reports, 1861, p. 94), the species occurring at Herne Bay, Faversham, etc., is considered to be distinct (*C. decussata* Park).

rock (= London Clay).[1] In either case they would be near the base of the Eocene series.

In the scale of the American series as exhibited in Alabama, they would occupy a position probably near the base of the "Buhrstone," or possibly even lower, as the equivalents of the beds exposed on Bashia Creek, and Cave and Knight's Branches ("Eo-lignitic").

[1] The similarity existing between the Marlborough and Bognor rocks has been pointed out by Conrad (Proc. National Institution, p. 172, 1841).

A REVISION OF THE TERTIARY SPECIES OF ARCA OF THE EASTERN AND SOUTHERN UNITED STATES.

BY ANGELO HEILPRIN.

In the following enumeration I have reduced all the species to the single genus *Arca*, the various modifications of form and ornamentation not appearing to me to be either sufficiently well marked, or of sufficient importance, to constitute points for generic subdivision. The *Arca gigantea* and *A. onochela* are forms which would fall in the subgenus *Cucullæa.*

The names in parentheses are those under which the species are indicated in the "Smithsonian Check Lists" of 1864 and 1866; they are repeated here merely to facilitate comparisons with those lists, and in no way represent the views of the author on the subject of generic relationship.

EOCENE.

A. aspera Conr. (Barbatia; Calliarca) *Jacksonian.* Miss.
Proc. A. N. S., vii, p. 258, as *Navicula.*

A. cuculloides Conr. (Cucullarca). Ala.
Tert. Foss., 1st ed., p. 37.

A. gigantea Conr. (Latiarca). Md.
J. A. N. S., vi, p. 227.

? **A. lima** Conr. *Jacksonian.* Tex.
J. A. N. S., 2d ser., p. 125, as *Byssoarca.*
A. (*Byssoarca*) *Mississippiensis* Conr. J. A. N. S., 2d ser., p. 125 (young).
Cibota Mississippiensis Gabb. J. A. N. S., iv, 2d ser., p. 387.

I am somewhat doubtful as to the correct determination of his species by Gabb.

A. onochela Rogers (Latiarca). Va.
Trans. Am. Phil. Soc., 1839, p. 372, as *Cucullæa.*
Latiarca idonea Conr. Proc. A. N. S., 1872, p. 53 (no locality).

This species appears to be very closely related to, if not identical with the *Cucullæa crassatina* of Lamarck, from the lower Soissonnais sands of the Paris basin, and possibly also from the British Bognor rock.

A. protracta Rogers (Anadara). Va.
Trans. Am. Phil. Soc., new ser., v, p. 332.

I have seen no specimen of this species, and therefore rely solely upon the description and figure as given by Rogers; I am inclined to doubt its validity.

A. rhomboidella Lea. (Anomalocardia). Ala

"Contributions to Geology," p. 74.

A. Rogersi Heilpr. Va.

Arca (*Cucullæa*) *transversa* Rogers. Trans. Am. Phil. Soc., 1839, p. 373. Specific name *transversa*, preoccupied by Say.

I have seen no specimen of this species, and judging from the figures illustrative of Rogers' description it appears as though it may prove to be only a variety of *A. onochela*.

OLIGOCENE.

A. lima Conr. Miss.

J. A. N. S., i, 2d ser., p. 125, as *Byssoarca*.

A. (*Byssoarca*) *Mississippiensis* Conr. (young). J. A. N. S., i, 2d ser., p. 125.

This species is most closely related to the *A. rudis* Desh., an Eocene, Oligocene and Miocene (?) fossil of western and southern Europe; it differs from the recent *A. Helbingii* Brug. (= *A. barbata* L.?), of which the *A. rudis* is stated by Deshayes to be possibly only a variety, in the strong carination of the posterior slope.

A. Mississippiensis Conr. Miss.

J. A. N. S., i, 2d ser., p. 125.

A. subprotracta Heilpr. Miss.

Conrad, J. A. N. S., i, 2d ser., p. 126, as *Byssoarca protracta;* specific name preoccupied by Rogers, Trans. Am. Phil. Soc., new ser., v, p. 332.

MIOCENE.

A. arata Say (Scapharca). Md.

J. A. N. S., iv, p. 137. Conr., Mioc. Foss., p. 58.

This species is enumerated on the authority of Say and Conrad; I have seen no specimens of it, and am doubtful whether it is not a form subsequently described under a new name by Conrad. It seems to have been closely related either to *A. limula* or *A. Carolinensis*.

A. brevidesma Conr. N. Car.

Mioc. Foss., p. 62.

(Not enumerated in the "Smithsonian Check List" of 1864.)

A. buccula Conr. N. Car.
Mioc. Foss., p. 60.

(Not enumerated in the "Smithsonian Check List" of 1864.)

A. cælata Conr. (Barbatia). N. Car.
Mioc. Foss, p. 61.

A. callipleura Conr. (Scapharca). Md.
Mioc. Foss., p. 54.

A. Carolinensis Conr. (Nœtia). N. Car.
Proc. A. N. S., 1862, p. 290, as *A. ponderosa* var. *Carolinensis*.

This species differs from the recent *A. ponderosa* (Say) of the Atlantic coast in having a comparatively longer hinge margin, a much more elongated posterior slope, and the umbones less prominently incurved.

A. centenaria Say (Striarca). Va.; Md.; N. Car.
J. A. N. S., iv, p. 138. Conrad, Mioc. Foss., p. 55.
Emmons, Geol. N. Car., 1858, p. 284.

This species very closely resembles both in outline and general ornamentation the recent *A. solida* (Brod. and Swby.), but it lacks the posterior carination of that species, and the ribs are much less distinctly beaded.

A idonea Conr. (Scapharca). Md.; N. Car.
Tert. Fossils, 2d ed., p. 16. Mioc. Foss., p. 55.
Emmons, Geol. N. Car., p. 285.
A. stilicidium?* Conr. Tert. Foss., 2d ed., p. 15.

* This species is stated by Conrad (Mioc. Foss., p. 55) to be the young of *A. idonea*; I have not seen sufficient specimens of the former to determine this point with positiveness, but the variation scarcely appears to be of specific value. Both species are recorded in the "Smithsonian Check List" for 1864.

The *A. idonea* greatly resembles the *A. incongrua* of Say, a recent species from the southern Atlantic coasts of the United States, from which, however, it can be readily distinguished by several well-defined characters. In *A. idonea* the anterior ribs are narrower than the interspaces, whereas, in *A. incongrua* (where the ribs are much more prominently transversely barred) the reverse is very decidedly the case. Again, in *A. idonea* the hinge area is marked with several "diamond-shaped" longitudinal impressions, while in *A. incongrua* it is transversely striated. The shell in the recent species is also much more prominently inequivalve.

A. incile Say (Anadara). Va.; N. Car.
J. A. N. S., iv, p. 139. Conrad, Mioc. Foss., p. 56.
Emmons, Geol. N. Car., 1858, p. 284.

A. lienosa Say (Scapharca). N. Car.
American Conchology, Pl. 36, fig. 1.
Emmons, Geol. N. Car., p. 284.

This species appears to be undistinguishable from the recent *A. Floridana* Conr., the specific name of which will consequently have to be replaced by that of Say's species, which has priority.

A. limula Conr. (Nœtia). Va.; N. Car.
Tert. Foss., 2d ed., p. 15; Mioc. Foss., p. 60.

A. Mārylandicus Conr. (Barbatia). Md.
Mioc. Foss., p. 54, as *Byssoarca.*

A. plicatura Conr. (Scapharca). N. Car.
Mioc. Foss., p. 61.
A. improcera Conr. Mioc. Foss., p. 60 (young).
A. lineolata Conr. Mioc. Foss., p. 61.
A. æquicostata * Conr. Mioc. Foss., p. 60.

* I have seen no authenticated specimens of this last, but feel satisfied that it is no other than the *A. lineolata*, with the description of which it thoroughly agrees. A specimen of *A. lineolata*, so marked by Conrad, is the one from which the figure of *A. æquicostata* in Mioc. Foss. (Pl. 31, fig. 6) has been taken.

The *A. plicatura* (I have retained the name as best illustrative of the specific character of the fossil) differs principally from the recent *A. transversa* of Say in being a less capacious shell, and in having the posterior slope much less distinctly angulated or carinated. The young shells of both species appear to be undistinguishable from each other, and although there are sufficiently well-marked characters separating the full grown, I have but little hesitation in believing that the coast shell of the present day (which appears also as a post-Pliocene fossil) is only a derivative from the fossil form. The *A. plicatura* recalls the *A. diluvii*, from the European Miocene deposits.

A. propatula Conr. (Barbatia). Va.
Proc. A. N. S., i, p. 323; Mioc. Foss., p. 61.
? *Arca hians* Tuomey and Holmes. Plioc. Foss., p. 34.

The figure of this species in the "Pleiocene Fossils," very closely resembles the type specimen of Conrad's *A. propatula*, and I have but very little doubt (although I have not seen an authenticated specimen of *A. hians*) that the two species are in fact identical, despite the supposed distinctions pointed out by Tuomey and Holmes.

A. scalaris Conr. (Scapharca) N. Car.; Va.
Proc. A. N. S., i, p. 324; Mioc. Foss., p. 59.

A. subrostata Conr. (Scapharca). Md.
Proc. A. N. S., i, p. 30. Mioc. Foss., p. 58.
A. tenuicardo Conr. Am. Journ. of Conchology, v, p. 39.

A. subsinuata Conr. (Scapharca). N. Car.
Mioc. Foss., p. 62.

A. transversa Say (Scapharca). Va.; N. Car
J. A. N. S., ii, p. 269. Conrad, Foss. Shells Tert. Form., p. 15; Emmons, Geol. of North Carolina, 1858, p. 285.

I have but little doubt that the species here described is one of the various forms of *A. plicatura*.

A. triquetra Conr. (Scapharca), Md.
Proc. A. N. S., i, p. 305. Mioc. Foss., p. 59.
= *A. staminea?* Say, "American Conchology," p. 36, fig. 2. (In Say's description the anterior extremity of the shell is described as the posterior, and *vice versa*).

Somewhat resembles the recent *A. rhombea* (Born).

Pliocene.

A. cælata Conr. (Barbatia). S. Car.
Mioc. Foss., p. 61. Tuomey and Holmes, Plioc. Foss., p. 36.

A. centenaria Say (Striarca). S. Car.
J. A. N. S., iv, p. 138. Tuomey and Holmes, Plioc. Foss., p. 37.

A. incile Say (Anadara). S. Car.
J. A. N. S., iv, p. 139. Tuomey and Holmes, Plioc. Foss., p. 35.

A. incongrua Say (Scapharca). S. Car.
J. A. N. S., ii, p. 268. Tuomey and Holmes, Plioc. Foss., p. 45.

A. pexata Say (Argina). S. Car.
J. A. N. S., ii, p. 268. Tuomey and Holmes, Plioc. Foss., p. 46.

A. scalaris Conr. (Scapharca). S. Car.
Proc. A. N. S., i, p. 324. Tuomey and Holmes, Plioc. Foss., p. 43.

A. lienosa Say (Scapharca). S. Car.
American Conchology, Pl. 36, fig. 1. Tuomey and Holmes, Plioc. Foss., p. 40.

A. plicatura Conr. (Scapharca). S. Car.
Mioc. Foss., p. 61.
A. improcera (young) Conr.; Tuomey and Holmes, Plioc. Foss., p. 41.

? **A. propatula** Conr. (Barbatia). S. Car.

Proc. A. N. S., i, p. 323. Mioc. Foss., p. 61.

Arca hians, Tuomey and Holmes, Plioc. Foss., p. 34. See note under *A. propatula* (MIOCENE).

A. rustica Tuomey and Holmes (Scapharca). S. Car.

Mioc. Foss., p. 39.

I have seen no specimen of this species, and can therefore not pronounce upon its validity. The fragment illustrated in the "Pleiocene Fossils" scarcely admits of recognition.

A. trigintinaria Conr. (Anadara). S. Car.

Proc. A. N. S., 1862, p. 289, as *Anomalocardia*.

Arca Americana, *A. Carolinensis*, *A. incongrua*, *A. lienosa*, *A. pexata*, *A. ponderosa*, and *A. transversa* occur in the post-Pliocene deposits; *A. cœlata* is also reported from the South Carolina deposits of that age by F. S. Holmes.

NOVEMBER 1, 1881.

The President, Dr. RUSCHENBERGER, in the chair.

Thirty-four persons present.

Color in Autumn Leaves.—Mr. THOMAS MEEHAN referred to an excursion to the Salt Marshes of New Jersey, organized by a member of the Academy, Mr. Isaac C. Martindale, and generously seconded by the Camden and Atlantic Railroad Company, which furnished a special train of twelve cars for the company, with the privilege of stopping along the road at interesting botanical points. This gave unusual opportunity to examine the vegetation of the Salt Marshes, which, at this season of the year presented a scene of colored beauty unequaled perhaps in the whole world.

Mr. Meehan remarked that the vegetation which for the most part made up this flora, was either precisely the same as those which entered into the flora of similar localities in western Europe, or else of species so closely allied that only critical examination would show the distinction. The plant which gave the greatest brilliancy, chiefly on account of its numerical proportions, was *Salicornia herbacea*, the same plant which abounds along European shores. To the rich rosy red of this species *Salicornia mucronata* (of Bigelow, *S. Virginica* of most authors) added a rosy brown. Although this species is American there are forms of *S. herbacea* on the English coast, which approach it. The third species is *S. ambigua* of Michaux, a perennial species, and the analogue of the British *S. radicans*. This one never changes its bright green color till severe frost destroys it. The lively green very much enlivens the brilliancy of the orange, red and brown in the other marsh plants. The species precisely the same with those of England which gave color to the marshes besides these Salicornias were *Salsola Kali*, *Suæda maritima*, *Atriplex patula*, *Polygonum maritimum*, *Spartina stricta*, *Spartina juncea*, and *Ammophila arenaria*—the three last grasses which add much by their light browns to the richness of the whole. *Statice Limonium*, by its faded blue-gray tint, gave a peculiar element to the color. *Aster flexuosus*, closely related to *Aster Tripolium* of European marshes furnished a tint of purple-green. So far as could be observed of the many other species of plants which might be collected, these were the only ones giving character to the beautifully colored picture the marshes presented at this time.

The most interesting inquiry here presents itself—Why should plants common in the main to both continents, color so much more brightly in America than in Europe? We are reminded that what we see here in these marsh plants, does not hold good with close allies in other species. Among trees and shrubs there are some peculiar to each country, but closely allied, in which all the American allies color, while the European rarely do. He named on the American side, *Betula populifolia*, *Fraxinus sambucifolia*, *Quercus alba*, *Cratægus cordata*, *Ulmus Americana*, *Alnus serrulata*, *Castanea Americana*, as against *Betula alba*, *Fraxinus excelsior*, *Quercus Robur*, *Cratægus oxyacantha*, *Ulmus campestris*, *Alnus glutinosa* and *Castanea vesca*. The whole American line had autumn coloring, of which the parallel European line was wholly destitute. These trees did not lose this characteristic by removal to the other continent. In America there were many of the European species five or ten generations from seed, and yet these last generations showed no more disposition to embrace the color characteristics of their American cousins, than did the first progenitor brought from abroad. We were so accustomed to associate our bright clear autumn skies with the color of our autumn foliage, that facts like these stagger us. Why should several generations of these European trees resist our climatal influences? But we have to remember that the coloring of fruits and foliage is not wholly the result of chemical power; what for want of a better name we know as vital power, claims a share.

Some apples have color on the sunny side, while the rosy cheek never appears on those of the same variety hidden by the foliage, and in these cases it is self-evident sunlight is a cause of color. Yet if we pluck such a variety from the tree, and place it in the sunlight, it will not color, so that we see here that there must be a connection with the living principle in the tree to enable the solar rays to act. Yet it requires a relaxation of the leaf's hold on life to bring out these colors. At any time during the summer, a maturing leaf on an American tree exhibits bright color—yet if a dying leaf half-colored, be plucked from the parent stem, there is no further change in the tint. Many leaves pass through grades, as green, light yellow, orange, brown, to scarlet. If they are gathered at yellow or brown, they remain yellow or brown, and so on all through these stages. Coloring therefore, could not wholly be considered chemically, for though decay, which we take to be a chemical action, is going on during the coloring stage, complete separation from the living tree at once stops the process.

If we consider these two facts together, and then some other known natural laws, we may form some reasonable hypothesis. There is, for instance, the principle of heredity, so ably insisted on by Mr. Darwin, in connection with all living things. A force once applied to an object, exerts an influence after the power has been removed. A wheel runs round, after the hand which turns it is taken away, and a change in a plant brought about by any circumstance will continue in connection with that plant some generations after the circumstances have ceased to exist. That this is so has been proved by Naudin with hybrid, or perhaps we should say crossed, lettuces, and in other ways. Supposing then these closely allied species to have been originally of one parentage, how did the power in one case to change to bright color, or in the other to resist the tendency to color, originate? If by chemical power alone, it would occur at once, as a piece of white wood is at once browned by fire, but with the vital principle opposed to this chemically destructive principle, it would take more time to accomplish this change; and the change, once made, would again require more time to again alter the fixed condition. This is essentially the foundation of the law of heredity, and under its operation we could not reasonably look for a change in the coloring power of these European trees although light were an active agent, under even more than five or ten inherited generations.

At any rate we have in these salt-marsh plants the evidence that the plants of one country, in that country colorless, can be made to take the most brilliant colors when growing in ours. That these plants had one primary origin is certain, though the ancestry may have been separated by thousands of years. We know that plants introduced at once do not change at once—heredity forbids it. We may assume therefore that it was only after some generations on the American coast, under the influence perhaps of American light. that these European plants showed their American colors. We can see in these annual plants, with a new generation every year, the results in numerous generations, as we cannot see in the slower reproducing tree.

Mr. Meehan thought that though we could not say we had yet reached an unchallengeable solution of the cause of autumn color in American foliage, considerations like these brought us nearer to the end.

NOVEMBER 8.

The President, Dr. RUSCHENBERGER, in the chair.

Twenty-six persons present.

On Movements and Paralysis in the Leaves of Robinia.—Mr. THOMAS MEEHAN said that an inquiry of Prof. Sargent for a trunk of *Robinia viscosa* for the National Forestry Census, had led him to look closely into the history of *Robinia* in general, with some interesting results.

Though our text-books gave "Virginia and Southwards" as the native location of the tree, no one seems to have collected it of late years. Indeed herbarium specimens generally seemed to be from cultivated plants, and he could find nowhere direct evidence that it had ever been found wild by any botanist since its original discovery by Wm. Bartram, as we learn from his "Travels," and Michaux, as recorded by Venténat in his "Plants of the Garden of Cels," towards the end of the last century. In northeastern Pennsylvania and contiguous parts of New Jersey he had seen it the past season, in a number of places in gardens, and in most cases it was stated that the plants had originally been obtained from almost inaccessible places on the high hills of that part of the country. The fact that in these remote places trees from the distant nurseries are seldom obtained, together with the fact that the plant is not now nor probably has been for many years cultivated in American nurseries, makes it possible that the reports are true, and the plant may be found in the spurs of the higher Allegheny range. The highly viscose character of this species is interesting. The excretory glands are low and broad, with a crater-like mouth, from which the sticky matter flows, and soon covers the stem as with a thick coat of varnish. The viscid strength was such that in some instances the mere contact with a lead-pencil was sufficient to draw a branch towards the person pulling it. So many plants with viscid secretions have insects found adhering to the sticky matter, that it has been shrewdly suspected the secretion in such cases is a design for entrapping insects, from which the plant perhaps obtains a better supply of nitrogen than in the ordinary manner through the atmosphere. In the case of this clammy locust no insect was found adhering, though it would seem probable that some few, by blind accident, at least, ought to have been found there. For what purpose in the economy of the plant this secretion is formed, cannot be conjectured. From this view of individual benefit alone to the plant, or to the race, the secretion seemed an enormous waste of nutritive power. This waste seemed even more conspicuous in the inflorescence. It was too early to judge of the amount of seed the plants would produce; but many flowers had fallen, leaving no ovarium behind in a single instance. There were no indications that a solitary seed-vessel would result from all the flowers which had expanded up to that time; and if any seed perfected, they would have to be from a few of the later flowers. In any event, the amount of waste material in the barren flowers was enormous.

Here it was remembered that a belief widely prevails which regards flowers and insects as having been interadapted to each other. It is believed not only that flowers are often to be cross-fertilized by insects before they can perfect seed, but that special insects are adapted to certain plants, which in the absence of these special insects remained barren. An ally of this clammy Robinia, *Robinia hispida*, has been under culture in America and Europe for a great many years; but the speaker said he had never seen nor knew of any one who had seen a single seed-vessel from any garden plant. He had come to believe it probable that some special insect, adapted to the pollinization of this plant, existed in the native place of growth of this species, but which insect had not followed the plant in its artificial distribution over the earth. This season he had found the plant, for the first time in his botanical explorations, on the top of Lookout Mountain in Tennessee; but there, as under cultivation, he failed to see a single seed-vessel. He had been asked since, by a distinguished Belgian scientific gentleman, whether he noted any plants among the others which indicated a possibility of being recent seedlings. It had not occurred to him to look especially for these; but they would in all probability have been noticed if they had been present. He said it was not to be inferred that because neither he nor others had found seed, the plant never produced them. Experience with many other plants showed that they might be barren for years, and then become suddenly fertile. It was more than probable that long in the past these species were seminally fertile, perhaps capable of self-fertilization, and that the infertility of the flowers is a modern imbecility, which, as indicated in his Detroit paper before the American Association for the Advancement of Science, is the general concomitant of a species which has almost run its race. That these two species rarely produced seeds in modern times might be inferred from the fact, that though both were very fertile in suckers, they were certainly limited to very few locations. If with the power of producing seed to any considerable extent, they would soon spread over wide areas. If they had been deprived of the power of producing seed in very far away ages, by the power of suckering alone they would have been more widespread than they are. There seems to be no other logical conclusion than that the plants once seeded freely; but that this power must have been long lost, to account for the comparative limited areas to which the species are now confined.

Perhaps the most interesting new facts noted are those connected with the motion of the leaves in the two species named, as well as in *Robinia pseudacacia*, though the most strongly marked in *Robinia hispida*. There is a diurnal as well as a nocturnal motion, each in a separate direction. At a few hours before sundown, each pair of pinnæ are perfectly horizontal. The entire leaf is perfectly flat. With sundown the leaflets begin to droop, till, by dark, they are perfectly pendent, the under surface of each leaflet almost touching the under surface of the leaflet opposite to it. With the advent of morning, the leaflets arise; and soon after sunrise, the whole leaf is flat, as just before sundown, but they continue to rise, till, by noon, the opposite leaflets have met above the common petiole, almost touching each other by their upper surfaces at midday, as they nearly touch by their lower surfaces by night. In other words, instead of traveling ninety degrees, as do other plants the leaves of which "sleep" at night, these leaflets make a daily circuit of one hundred and eighty degrees.

Besides these novel facts, Mr. Meehan noticed what he could not but regard as a case of paralysis. About the middle of September, he noticed a sucker from one of his plants, which had finished its growth for the season after having made about a dozen nodes. While at midday the leaflets were erect, three leaves had all their leaflets drooping as at night. How long they may have been in this condition before being noticed is not known, but they continued in that "sleeping" condition till this date (November 7), the others having gone through their motions daily till now. During the last few days, however, the thermometer having once been nearly down to freezing point, only the two or three upper pinnules on the leaves have retained the power to move. The paralyzed leaves were in every respect as healthy looking as the others, but they were, all three, somewhat smaller. If these had been all together at the lower or upper end of the branch, the peculiarity might have been referred to some cause connected with maturity; but the first paralyzed leaf was the third from the top, the next the fifth, and the other the sixth; that is to say, there were leaves with perfect motile functions above and below these, as well as one among the three. Though for the six weeks, at least, they had lost the power of motion, the color and general healthy appearance of the leaves were precisely the same as the others. There was no difference whatever except in the length of the common petiole and size of the leaves. They were about three-fourths the ordinary size. The upward movement of the pinnules in this species is confined to those exposed to the sunlight; those shaded by even their own foliage have not the power.

Mr. Meehan had previously called the attention of the Academy to the fact that a large number of plants draw the upper surface of the leaf together in bright light, as illustrations of which he mentioned now: *Halesia tetraptera*, *Cornus florida*, *Cornus mas* and *Magnolia acuminata*.

November 15.

The President, Dr. Ruschenberger, in the chair.

Thirty-one persons present.

November 22.

The President, Dr. Ruschenberger, in the chair.

Twenty-nine persons present.

A paper entitled "On a fœtal Kangaroo and its Membranes," by Henry C. Chapman, M. D., was presented for publication.

The death of the Rev. Z. M. Humphrey, a correspondent, was announced.

November 29.

Dr. R. S. Kenderdine in the chair.

Thirty-one persons present.

The special business of the meeting being the nomination of officers, councillors and members of the Finance Committee, a letter from Dr. W. S. W. Ruschenberger was read, declining to be a candidate for re-election to the office of President, whereupon a committee, consisting of Messrs. Isaac C. Martindale, S. R. Roberts and J. H. Redfield, was appointed to prepare a suitable expression of the Academy's appreciation of Dr. Ruschenberger's services to the society.

December 6.

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

Thirty-six persons present.

The genus Carterella vs. *Spongiophaga Pottsi.*—Mr. Edward Potts referred to a paper (On *Spongiophaga Pottsi* n. sp., Ann. and Mag. of Nat. Hist., Nov., 1881) by H. J. Carter, F. R. S., etc., in which that eminent scientist gives an interpretation, differing from his own, of the statosphere tendrils which form the characteristic feature of the new genus of fresh-water sponges to which Mr. Carter's name had been attached in recognition of his very distinguished services. He wished to consider the subject entirely apart from its personal relation to themselves; and only as it concerned the stability of a genus, in which, as he claimed. for the first time in the history of fresh-water sponges, these tendrils had been noticed as distinctive features.

He then, at some length, gave his reasons why we should not accept Mr. Carter's theory of the parasitic nature of these tendrils or filaments; saying, that of the two points in the paper most likely to impress a student who had not seen specimens of the genus referred to, or one unfamiliar with the general subject, the *first* was founded upon certain appearances represented in figure 2 of Mr. Carter's plate. This figure shows an "axial canal" through the centre of the filament, widening into the "tubular prolongation from the process of the chitinous coat" of the statosphere and representing the supposable digestive tract of the animal parasite.

As after repeated and very careful examination of numerous specimens, both in a fresh condition and after being subjected to different methods of preparation, he had failed entirely to meet with an instance showing similar appearances, he referred specimens of all three species of the genus to Prof. Jos. Leidy, whose fame as an accurate observer is world-wide ; to Mr. Jno. A. Ryder, and to Prof. Kellicott and Mr. Henry Mills of Buffalo, the discoverers of one of the above species. The efforts of these gentlemen were equally unsuccessful, their opinion being well expressed in Prof. Leidy's words, "In my mind there can be no question as to the tendrils being part of the structure of the statoblast, and their parasitic nature would never have occurred to me." "The tendrils are homogeneous extensions of the inner capsule of the statoblast and I see no trace of the appearance to which you refer in Carter's figure 2." A paragraph from the letter of Prof. Kellicott makes a further point. These processes "are not found on the statoblasts of any other species in the Niagara River; I have examined hundreds of the statoblasts of *Carterella tubisperma*, and have not found one without said tube. I brought some of these, having wintered in the river, to my room last May; after a few days, there was sponge growth; so this form if a parasite did not destroy the life, etc."

The *second* point made by Mr. Carter was that the species marked *C. tubisperma* from Buffalo, was identical, as shown by its spiculation, with one marked *Heteromeyenia repens* from Lehigh Gap, Pa. That one of these identical species should exhibit the tubular prolongation and accompanying tendrils, while the other did not, was considered presumptive evidence that the former was affected in some abnormal way. To this Mr. Potts answered, that while there was unquestionably much similarity in shape of the birotulate spicules of the two sponges, covering the "seed bodies" in the ordinary fashion as a second or outer coat, the Lehigh Gap species alone exhibited the second class of long birotulates, interspersed with the others, which had induced him to place it in the genus *Heteromeyenia*. For this reason he believed the species were not identical, and this argument fails.

In continuation he reasoned that it should not be considered a matter of surprise that the statospheres of some genera pertaining to the family of fresh-water sponges, should present tentative features of this character. In a paper published so long ago as 1859, Mr. Carter called attention to the resemblance in appearance and function between the statoblasts of the Polyzoa and the so-called "seed bodies" of *Spongilla*. The parallelism is rendered more complete when we observe that in those forms of Polyzoa possessing a comparatively rigid octocyst, the statoblasts are circular or lenticular with smooth margins. Some of these are no doubt washed out from the tubular body from time to time during the winter, to extend the species to other places; while enough are retained by it to renew the growth in the original locality. On the other hand, where the body mass is simply gelatinous, as in *Pectinatella*, *Cristatella*, *etc.*, decaying away and releasing the statoblasts on the first approach of winter, these are provided with either a single row or a more complicated series of marginal tentacular hooks, by which they become matted together, entangled with roots, stems, etc., or held to rough places on planks or stones.

The same relation to the permanency of their skeleton structure we find existing amongst these genera and species of fresh-water sponges. The statospheres of nearly all species are provided with some arrangement for protection and retention. These vary greatly in kind and degree, inversely according to the protection afforded them by the surrounding skeleton. Perhaps the lowest in the series in this regard is *Meyenia Leidyi*. This is a thin encrusting sponge; the skeleton spiculæ stout and firmly matted together; maintaining the position and form of the mass throughout the year. The statospheres are formed in the autumn in the lowest parts of the sponge, within special capsules formed by interlacing spiculæ. It is hardly possible these should wash away, and accordingly we find no means provided peculiar to themselves for detaining them. Their armor consists of a closely laid series of birotulate spiculæ with entire margins, excellent as a shield but hopelessly useless as a means of retention. On the other hand no apparent means of diffusion are provided, and as a consequence the species seems to be extremely local; none having been noticed except in the stream where the first specimen was gathered, and within a few yards of the probable spot.

Spongilla fragilis of Leidy, when seen during the summer-time, nearly resembles in form the above-mentioned species; its skeleton structure, however, is much more fragile and is frequently detached and washed away, leaving a uniform series of statoblasts standing side by side, with no special coating of spicules for each, as in most other species, but grouped and held together by a common coating of cellular or granular matter, covered by and imbedding a great number of cylindrical spined spicules. A variety of this is often observed (whether it differs specifically in other respects he could not be certain) in which the statospheres are segregated into groups of four or more, spherically enclosed in a similar coating, thus appearing like one large seed. While the statoblasts of the former arrangement retain their positions during the winter and germinate there in the spring, it may be that *this* is a character assumed for diffusive propagation.

In *Spongilla lacustris* and similar branching sponges, the apparently conflicting ends of retention and diffusion are attained in a different way. The " seed " are formed in the interstices of both the sessile and the branching portions. In the former they are retained during the winter, partially by the agency of recurved spines upon the acerates projecting from the seed coat; while the fragile branches soon break off and float their contained statospheres to distant parts.

The massive sessile character of many sponges, repeated through various forms of *Spongilla* and *Meyenia*, partially protects their statospheres from the accidents of the winter season, and when that protection fails them, the rays of the birotulate spicules of the latter and the curved acerates of the former, come in play to retain a sufficient number until the time of germination in the spring.

Three species of American sponges have been grouped under the generic name *Heteromeyenia*, characterized by the presence of a *second* form of birotulate spicules interspersed amongst the more familiar series. These are about double the length of the former and are terminated by long recurved hooks. The framework of two of these species is altogether filmy and fugitive; the statospheres are not held within the interspaces of the skeleton or retained in any other way, and are therefore dependent upon the above hooks for their attachment to proper bases for future growth.

Completing the series of retentive agencies we find the statospheres of the three species of the disputed genus *Carterella* provided, in addition to their birotulate spicules, with long curling or twisting tendrils, extensions, as we have heard, of the tough chitinous coat. These are required to meet the emergency occasioned by the looseness of their skeleton texture, from which the sarcode flesh dying early washes away, most of the spicules soon following in the winter floods. The eggs are thus left to the protection of the above tendrils which lap them together, bind them to the remaining spicules or the roots of water weeds or shore plants; or, assuming the role of the hair the plasterer uses, bind the deposited silt about them and both to the stones, where they await the appointed time for a new growth. This function is very clearly shown in the collection in Mr. Potts' possession, and the resemblance in material structure of these tendrils to that of the specialized hooks of the forms of Polyzoa referred to, is very striking. He hopes therefore, that as both analogy and observed facts seem to indicate the correctness of his position, Mr. Carter will be willing to accept the compliment intended and which is so well deserved.

December 13.

The President, Dr. Ruschenberger, in the chair.

Twenty-three persons present.

The death of Ami Boué, a correspondent, was announced.

Pilobolus crystallinus.—Mr. Thomas Meehan remarked that this small fungus had proved this season to be an expensive annoyance to florists engaged in winter forcing flowers. Rose-growers especially had found it to interfere seriously with their profits. The injury was caused by the projection of the sporangia which covered the flowers and leaves of the roses as if profusely dusted with black pepper. The flowers were almost unsaleable as the first impression was that the black dots were Aphides.

Mr. J. B. Ellis, of Newfield, N. J., to whom he was indebted for the identification of the species, had informed him that it was somewhat rare in that vicinity. In the greenhouses referred to they were in immense profusion, the conditions of growth being probably more favorable. Mr. Meehan described the growth of the plant and the behavior of the asci in the generation and expulsion of the sporangia, which corroborated the facts detailed in the memoir of Eugene Coemans, published in 1859 in the *Bulletin of the Royal Academy of Sciences of Brussels.* M. Coemans found the plant on half-dried cow-droppings, in August, and in these greenhouse cases it was also growing in half-rotten cow-manure used for enriching the soil. Mr. Ellis reports that it is sometimes found on other manures, and so may be less rare than supposed. The projection of the sporangia has been noted by European observers, and originated Fore's name *Pilobolus*, literally the hat- or cap-thrower. The sporangia appear as small black caps on the top of the crystal-like asci, and are expelled with great force. By careful measurements they were found to be thrown when the direction was perpendicular, to a height of four feet. Coemans does not seem satisfied that the exact process has been made clear by which this remarkable projection is effected. It has been supposed that carbonic acid gas is generated, which, distending the cysts, causes them at length to burst at the thinnest part, which is the apex, and the sporangia are then blown out by the gas, as would be a cork from a bottle of champagne. Again Coemans finds a double membrane to the asci, and believes that by the agency of light the inner membrane contracts in a different manner to the outer, and that the projection is the result of this peculiar contraction. Mr. Meehan observed that the sporangia were expelled from the interior of the asci before they were finally discharged, and that they were always projected in a direct line from the centre, which would hardly be the case if a mere explosion of gas directed the movement. One large rose-grower had found, that sprinkling the surface of the earth under the rose plants with about the eighth of an inch of dry earth, effectually allayed the projectile annoyance.

DECEMBER 20.

The President, Dr. RUSCHENBERGER, in the chair.

Twenty-five persons present.

The deaths of Edw. Taylor and Dr. Isaac I. Hayes, members, were announced.

The Committee, appointed Nov. 29th, to prepare an expression of the Academy's appreciation of Dr. Ruschenberger's services to the society, presented the following report which, together with the resolutions proposed, was unanimously adopted :—

To the Academy of Natural Sciences of Philadelphia:

Your Committee, appointed November 29th, 1881, to prepare and report at a future meeting, an expression of the Academy's appreciation of the services of Dr. W. S. W. Ruschenberger, who declines a re-election to the office of President, respectfully reports :

Dr. W. S. W. Ruschenberger was elected a member of the Academy of Natural Sciences of Philadelphia, May, 1832, and became its President, December, 1869, succeeding Dr. Isaac Hays. He has been re-elected at each succeeding annual election, hence he has occupied this position for an unbroken period of twelve years, which, with one exception, is the longest term of service of any President of the Academy.

When the project for the erection of a new building was first proposed, Dr. Ruschenberger manifested so much interest therein, that when on the 14th of November, 1865, a committee was appointed, "to devise methods for advancing the prosperity and efficiency of the Academy by the erection of a building of a size suitable to contain the collections," he was by unanimous consent chosen its Chairman. He was likewise Chairman of the Committee of Forty, appointed December 26th, 1865, for the purpose of obtaining the funds necessary for the erection of a new building, and also was, and still is, Chairman of the Board of Trustees of the Building Fund, organized January 11th, 1867.

From the inception of the enterprise to its consummation in the occupancy of the new building by the Academy in 1876, Dr. Ruschenberger constantly gave to it his best energies, and to him more than to any other man the Academy owes the commodious building which it now occupies.

There were times when many members of the Committee doubted and even despaired of the completion of their service, but in the darkest hours Dr. Ruschenberger never faltered either in faith or works, but with his quiet persistent force, pushed forward the enterprise, and sustained the courage of his associates. His untiring interest in the welfare of the Academy, led him personally to supervise the contracts for building, and to inspect the progress of the work almost daily. He was thus able to save thousands of dollars to the Trustees, and to see the present building completed at a cost greatly within the original estimate. Those only who were associated with him in this the great achievement of his life, can rightly value the courage, patience, devotion, indomitable perseverance and ceaseless activity displayed by him throughout the entire period.

As a presiding officer, both at the meetings of the Academy and in the Council, his extreme punctuality, dignity of manner, unfailing courtesy and accurate acquaintance with parliamentary usage leading to prompt decisions, which seldom or never failed to command support, have increased in no small degree the debt of gratitude due him by the institution which he has served so faithfully and well.

Of his services to the scientific world this is not the time nor the occasion to speak in detail, but suffice it to say, they are such as have been long and widely recognized.

In view of the foregoing recital of facts, we deem it every way fitting that the Academy should suitably express and place upon record, its grateful sense of the long and faithful services of its retiring President, and we accordingly propose the following resolutions for its adoption:

Resolved, That the thanks of this Academy be, and they are hereby tendered to Dr. W. S. W. RUSCHENBERGER for the eminent services he has rendered both before and since he has held its honored position of President.

Resolved, That this report, and these resolutions be entered in full upon the minutes, and published in the Proceedings, and that a copy thereof suitably engrossed, attested by the Vice-Presidents and Secretaries of the Academy be presented to him.

ISAAC C. MARTINDALE,
JOHN H. REDFIELD,
S. RAYMOND ROBERTS,
Committee.

PHILADELPHIA, *Dec. 20th*, 1881.

Varying Influence of Heat on Flower-buds and Leaf-buds.—Mr. THOMAS MEEHAN referred to specimens of *Cratægus*, sent by Mr. Case, of Indiana, on which the sender remarked that the buds were larger through the winter on alternate years—and that the plants flowered freely in the seasons corresponding with those following the large buds. Mr. Meehan said, that though it must be within the knowledge of most observers that on the recurrence of spring, flower-buds were much larger than leaf-buds in the same species, no use had been made of this fact in physiological teaching so far as he knew. At the fall of the leaf, as any one might see in the peach, cherry, apple, pear, maple, willows, poplars, alders and numerous others, the flower-buds could scarcely, if at all, be discerned from leaf-buds; but by spring the flower-buds had increased to double their autumn size, while the leaf-buds remained exactly the same. Whenever the thermometer was in ever so slight a degree above the freezing point, the flower-bud increased in size during the winter. The leaf-bud required a higher temperature to excite it. This difference in excitability ought to be of value in explaining some biological points.

DECEMBER 27.

The President, Dr. RUSCHENBERGER, in the chair.

Thirty-six persons present.

The death of Henry Morris, a member, was announced.

The following was ordered to be published :—

ON A FŒTAL KANGAROO AND ITS MEMBRANES.

BY HENRY C. CHAPMAN, M.D.

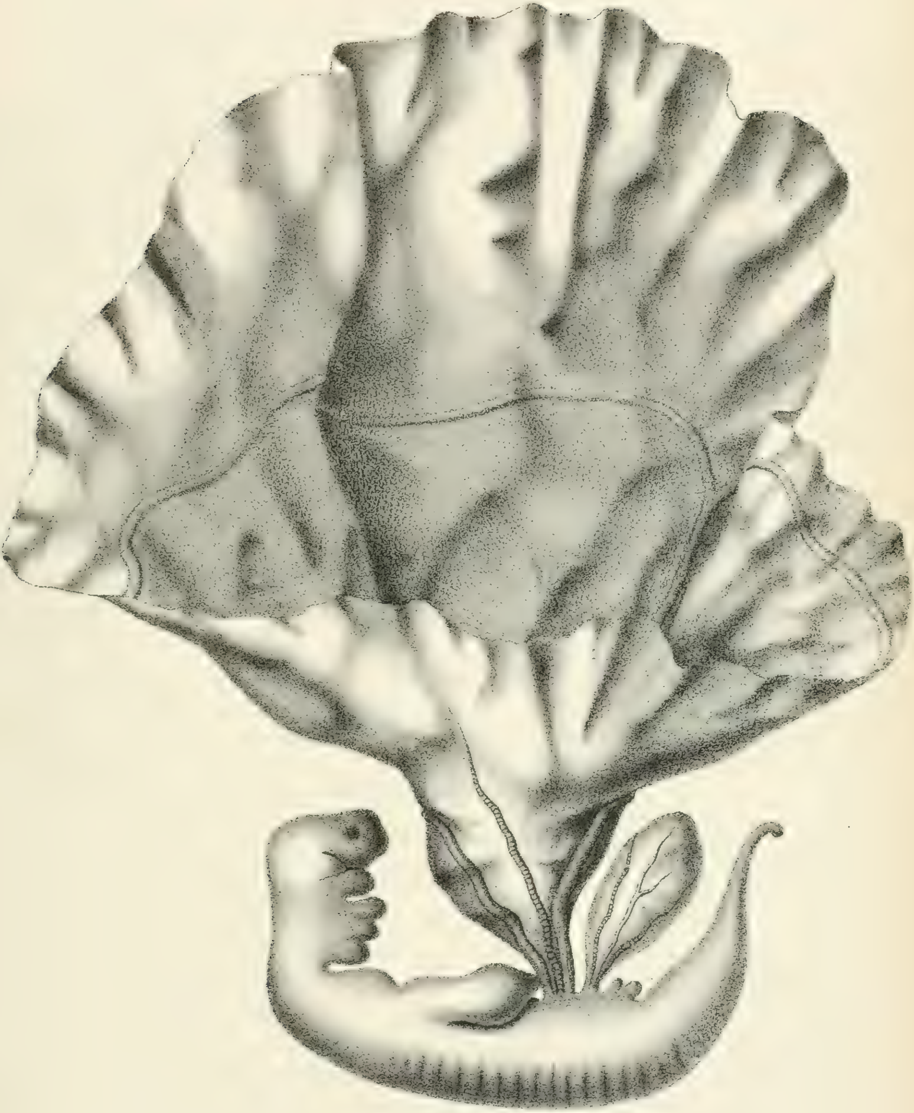
Since the publication, nearly fifty years ago, of Prof. Owen's invaluable paper[1] "On the Generation of the Marsupial Animals," in which the fœtal Kangaroo and membranes were first described, no further contribution has been made to our knowledge of this very important subject. Indeed some naturalists at the present day seem indisposed to accept Prof. Owen's statement that there is no connection in the Kangaroo between the fœtal membrane and the uterus, or, in other words, that no placenta is developed; and that, therefore, the division of the mammalia into non-placental and placental is not a valid one. Even though the present communication should not contain anything particularly new, I trust, however, that it will not be received without interest, if for no other reason than that it comfirms essentially Prof. Owen's descriptions.

One would have naturally supposed that, during the past half century, among all the Kangaroos killed in Australia and opened in various zoological gardens, at least one fœtal Kangaroo would have been found. As a matter of fact, however, this does not appear to have been the case, or, at least, if such was found, no record was made of it. Impressed with this fact, I never failed to examine the generative apparatus in the female Kangaroos which died from time to time in the Philadelphia Zoological Garden, with the hope that I might obtain an embryo. In September, 1879, I was successful, finding the specimen which forms the subject of the present communication, and to which I incidentally alluded in a previous communication to the Academy.[2]

The female Kangaroo, in which I found the embryo, was a fine example of the *Macropus giganteus*, and had taken the male about fourteen days before its death, which was caused by injuries inflicted upon itself, due to a fright incident to the boxing the animal for shipment. The embryo, Pl. XX, was, therefore, not more than fourteen days old. On opening the uterus of the left side, which was considerably swollen, the embryo Kangaroo was seen through the

[1] Philos. Transact., 1834.

[2] Placenta of the Elephant, Journal of Acad., vol. viii, p. 5.



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CHAPMAN ON FOETAL KANGAROO

transparent chorion. The chorion, which was thickened in places, insinuated itself between folds, into which the lining membrane of the uterus was thrown. The chorion was, however, entirely free from villi or villous processes of any kind, and was perfectly separable in its entire extent from the uterine surface. Indeed it was readily turned out of the uterus intact. On opening the chorion, the embryo Kangaroo was seen inclosed in a very delicate amnion, which was easily lacerated. What at once struck me, on opening the chorion, was the large size of the umbilical vesicle and the undeveloped condition of the allantois, which, though small, was undoubtedly present, consisting of a pear-shaped vesicle or diverticulum from the posterior part of the intestine. The umbilical vesicle adhered to the chorion by that part of its surface most remote from the umbilicus. The line of demarkation between chorion and umbilical vesicle being indicated by a circular blood-vessel. When in the fresh condition, the umbilical vesicle was seen to be highly vascular. The blood-vessels that ramified over its surface consisted of two veins and an artery. The veins began as one vessel from the under surface of the liver, which diverged at the umbilicus and united again on the umbilical vesicle as a terminal or marginal vein, *i. e.*, the circular vein just referred to, and which indicated the line of contact of the umbilical vesicle with the chorion. The third vessel was an artery, and through the mesenteric could be traced to the aorta. These vessels evidently correspond to the omphalo-mesenteric or vitelline veins and arteries of other vertebrate embryos as seen, for example, in the embryo chick. The disposition of the umbilical vesicle, with reference to the chorion (its large size and vascularity), reminded me also very much of the rabbit or rodent type of development. While, as we have just seen, the umbilical vesicle was in contact with the chorion, the rudimentary allantois, on the contrary, hung freely by its pedicle or urachus in the space between the amnion, the stem of the umbilical vesicle, and the chorion.

When the allantois was first examined, there could be distinctly seen three very fine vessels, two of which appeared to come from the aorta and corresponded therefore to the umbilical or hypogastric arteries of the placental mammals, while the remaining vessel I considered to represent the umbilical vein of the same. The small size of the allantois and the rudimentary condition of its blood-vessels taken in connection with the length of the embryo and the short time that the latter remains in the uterus, makes it impossible for me to think that in the Kangaroo a placenta is ever developed. I use the word placenta in the sense ordinarily accepted, meaning a structure which consists of the interlacing of the allantoic blood vessels with those of the decidua serotina of the uterus, that is, of that part of the hypertrophied mucous membrane of the uterus in contact with the ovum. Further, that while the umbilical vessel is fused through part of this surface with the chorion, the chorion is only in contact with the inner surface of the uterus, not adhering to it in any way. The disposition of these membranes in the Kangaroo embryo is therefore different from the so-called placenta of certain Sharks, which consists in the interlacing of the omphalo-mesenteric blood-vessels with those of the uterus. This structure in the Sharks, though called a placenta, is not homologous with the mammalian placenta, this consisting, as we have seen, of the allantoic vessels and those of the uterus. The Kangaroo cannot be said, therefore, to have a placenta in either sense in which that word is used. The small size of the embryo Kangaroo at birth, would lead me to suppose that it drew its nourishment from the umbilical vesicle like the reptile or bird, rather than from the uterine walls, as in the mammal. If the uterus does contribute to the nourishment of the fœtal Kangaroo, such nutriment must osmose through the omphalo-mesenteric vessels. The contact of the chorion with the uterus, however, is of a very adventitous character. The embryo Kangaroo itself measured six-eighths of an inch in length from the mouth to the root of the tail. The latter was one-eighth of an inch long. The mouth was open, and the tongue, though large, was not protruded. The palpebral folds were not developed. There was no sign of an auricle. Four branchial clefts could be distinguished. The anterior extremities were well developed, but the digits had not appeared. The posterior extremities, were represented only by small buds, not very apparent except with a lens. Indications of the ribs were distinctly visible. The membranous spinal cord could be seen; the elements of the vertebræ being as yet ununited. A penis was visible just in front of the anus. On the supposition that the theory of evolution is true, one would naturally expect to find forms intermediate in their structure and development between the reptiles and birds on the one hand and the placental mammalia on the other. As is well known, in the structure of its skeleton and generative apparatus, the *Ornithorynchus* resembles very closely the reptile and bird, while, as we have just seen, the fœtal membranes of the Kangaroo recall the corresponding parts in the reptilian-bird type and foreshadow those of the placental mammal. If the parts in question have been truthfully described and correctly interpreted as partly bridging over the gap between the non-placental and placental vertebrates, they supply exactly what the theory of evolution demands, and furnish, therefore, one more proof of the truth of that doctrine.

The following reports were read and referred to the Publication Committee:

REPORT OF THE PRESIDENT

For the Year ending November 30, 1881.

It is a pleasure to be able to repeat a statement made last year, that the Academy "remains free from debt," a very important statement, because the progress of the society is largely contingent on the condition of its financial affairs and the stability of its pecuniary resources.

The report of the Treasurer, William C. Henszey, whose prudent zeal in the discharge of the duties of his office entitles him to the full measure of our thanks, shows that the finances of the society are in a sound condition, and that the current receipts for the year somewhat exceed the expenditures.

The receipts from all sources amount to	$6959.20
And the total disbursements to	6952.16
Leaving a balance of	7.04

Even under this unusually favorable condition, observance of close economy in expenditures is still essential, as it ever should be under all circumstances, to keep the treasury always in a state to meet the current demands against it. They may possibly be greater on account of necessary repairs in the coming than in the past year. The exterior wood-work of the building may require painting in the course of the summer.

The treasurer's statements show that the Publication Fund, the Thomas B. Wilson Fund, the Elizabeth Phyle Stott Fund, the Isaac Barton Fund, the Charlotte M. Eckfeldt Fund, the Joshua T. Jeanes Fund, the Jessup Fund, the Life Membership Fund and the Maintenance Fund are in a satisfactory condition.

More than a thousand dollars of the income of the I. V. Williamson Library Fund have been necessarily diverted from library purposes to the payment of expenses to secure part of the property from which the income is derived. Now it is confidently believed that the whole of the receipts of the fund, which have been somewhat increased, may be appropriated to the purchase of books in accordance with the intention of its liberal and benevolent founder.

The manufacture of the Proceedings and Journal of the Academy has cost $1307.92. The return to the treasury on account of their sale is $1124.09. The works received into the library for them, in exchange, from 297 societies and 42 periodicals, at home and abroad, far exceed in value the difference between the cost of manufacture and the amount of money received on account of the sale of the Academy's publications.

The hope, entertained at the close of the last year, that the Maintenance Fund might be considerably increased by this time, has been disappointed. The circumstances which led to the effort to raise this fund have not changed. The enterprise has not yet been demonstrated to be hopeless, and until it is, should not be abandoned.

The aggregate of semi-annual contributions for the year reported by the treasurer, $1936, suggests that it is desirable to augment the number of members.

Fees for admission to the museum amount to $421.30, which is less than a janitor's salary.

Five students have been aided from the Jessup Fund in the course of the year. At this time two young men are its beneficiaries. The advantages of this fund are in demand. Many are indebted to it for a start on the course which led them to become naturalists and efficient investigators. An increase in the number of such scholarships is desirable. Every one who may give a sufficient sum to yield $250 annually, to aid in the support of one student, will contribute substantially to the advancement of knowledge, and at the same time erect for himself a continuously speaking memorial, more enduring, and conspicuous than can be formed of monumental marble.

To encourage the study of natural history among young persons, the Agassiz Association of Natural History, a juvenile society, was granted, Dec. 14, 1880, the use of the library room on alternate Wednesday afternoons, for its stated meetings.

The use of the library room was given to a board of examiners of Harvard University, from June 30 to July 2, inclusive, for the examination of candidates for admission into that institution.

Permission to visit the museum, given to the teachers and a limited number of pupils of the public schools in 1879, has been extended to them through the year 1882.

The Legislature of the State did not accept the proposition of the Academy to assume the custody of the collections of the Second Geological Survey of Pennsylvania and display them freely to the public, without any cost whatever to the treasury of the State. The proposition was approved in the Senate but not in the House. The result is not fortunate. It is believed that those collections cannot be held anywhere in the State more profitably to the public generally than in the Academy; because, located under the same roof with the collections of the First Geological Survey, with other extensive American and European collections, and also with a full and appropriate library of reference, they could be readily consulted and studied apart, or in connection comparatively with those of the First Geological Survey, as well as with other collections. No other place of deposit promises superior or equal facilities for their study.

The Curators report that the contents of the museum have been carefully inspected and that they are in good condition. Additions to the museum during the year not recorded in other reports are mentioned.

As long as the increase of the museum depends upon voluntary gifts alone, there is no reason to expect that it will ever be complete in any department, or as a whole represent the natural history of the day. Explorations of new regions and localities are continuously revealing objects, previously unknown, very few of which find their way into our cabinets.

To fill gaps which exist in many if not all the departments and make the museum perfect, money to purchase desiderata, when opportunity occurs, is necessary. A museum fund, yielding from twelve to fifteen hundred dollars a year, would enable the curators, in the course of a reasonably short time, to fill gaps in various departments and procure specimens of new objects whenever they may be discovered, and to furnish new materials for study and investigation. An endowment of this kind would do for the museum what the I. V. Williamson Library Fund has done for the library, which is regarded to be now the best and most extensive, though not yet complete, library of natural history of the United States.

The rate of growth of the library during the past year has been somewhat lessened, owing to a temporary diminution of the income applicable to it, as already mentioned. According to the report of the Librarian, 2719 additions to it from all sources have been made. Reckoning ten pamphlets to the volume, he estimates that the library now contains 29,485 volumes, exclusive of duplicates.

Many of the works consist almost entirely of dry technical descriptions of objects, and are, in one respect at least, analogous to dictionaries or encyclopædias, which are referred to, but not read from beginning to end. As a rule, circulating libraries do not lend their dictionaries, nor recent numbers of periodicals and serials.

After ample experience and mature consideration of the subject in all its relations, the Academy determined that its library, like that of the British Museum, should be maintained as a library of reference only, under a conviction that the interests of students and of the members far and near would be, on the whole, promoted by this policy. A large proportion of the books have been contributed on condition that they shall not be loaned for use outside of the building on any pretense whatever. Even if the Academy were now disposed to change it to a circulating library, it cannot annul the conditions upon which most of the books were given and accepted, without breach of trust. It is not likely that a majority of those entitled to vote here will ever consent that the Academy shall merit the just odium of such action merely for the sake of loaning its books.

The Recording Secretary reports that twenty papers from twelve authors have been accepted for publication in the Proceedings; and that the fourth or concluding part of the eighth quarto volume of the Journal has been printed, and distributed to subscribers and to those on the exchange list.

The volume of Proceedings of 1881 contains about 500 pages. The third volume of a "Manual of Conchology," by George W. Tryon, Jr., illustrated by 628 figures given in 87 plates, with 310 octavo pages of text, has been issued from the Academy by the author; and the Rev. Dr. Henry C. McCook has had published by J. B. Lippincott & Co., an octavo volume, fully illustrated, on "The Honey Ants of the Garden of the gods, and the Occident Ants of the American Plains," much of which he had presented at stated meetings of the Academy in the course of the year.

Several papers from the Conchological, Botanical, Mineralogical and Geological Sections have been accepted for publication in the Proceedings of the Academy. The Entomological Section has printed on the premises and issued about 230 octavo pages of its Proceedings and Transactions.

These publications constitute reliable evidence of the activity of the Society, as well as a measure of the extent of work done in connection with it by its members.

The average number of persons present at the stated meetings of the year is 30.44; the least number present at any meeting was 7, and the greatest, 363.

The scientific activity of the society may be estimated more accurately by what it publishes than by the numbers present at its stated meetings alone; provided its publication fund be equal to the demands made upon it. Original investigations are always pursued in the privacy of the study or laboratory. Discoveries, when made, are announced at a stated meeting, which is the avenue to publication, either in form of verbal communication or written statement carefully prepared for the Journal or the Proceedings. Such papers are read by title only: if read in full, technical or precise systematic descriptions of new species or genera would allure few not specially interested in their subjects, and a majority would find little or no pleasure in listening to them.

The progress of the society cannot be fairly inferred by comparing the average number present at stated meetings through a series of years. Careful examination of the minutes from 1850 to 1881, including both years, shows that the average number present at the stated meetings of each year does not increase regularly from year to year, but varies. The average attendance in 1850 was 12.28—little more than the average number present at the stated meetings of the Mineralogical and Geological Sections for 1881, namely, 11; for 1855, 19.26; for 1860, 35.55; for 1865, 18.28; for 1870, 22.34. Nor is there a uniform correspondence between the number of pages of Proceedings issued and the average number present at the stated meetings. A tabular statement of the average numbers in attendance at the stated meetings, the greatest and least number present at meetings in the year, the number of members and correspondents elected, and the number of pages of Proceedings published in the year, is herewith presented:

Year.	Average No. present at stated meetings.	No. present at any meeting.		Elected.		Proceedings published. Pages.
		Highest.	Lowest.	Members.	Corresp.	
1850	12.28	24	7	9	8	138
1855	19.26	33	6	21	13	200
1860	35.55	57	5	41	6	577
1865	18.26	34	6	25	11	310
1870	22.34	35	7	39	7	180
1871	20.15	36	8	35	6	370
1872	20.63	36	7	44	5	322
1873	24.73	41	6	48	9	470
1874	21.32	33	7	53	8	266
1875	25.94	50	11	52	10	552
1876	39.53	75	7	47	15	440
1877	31.55	78	9	43	66	403
1878	31.51	107	9	28	32	475
1879	36.71	190	13	23	8	490
1880	27.26	113	5	26	20	457
1881	29.80	363	7	15	6	

An estimate of the activity of the Academy from the numbers in attendance at its meetings alone, should include those in attendance at the meetings of the several sections. To specialize is the order of the day. All the great meetings of men interested in the advancement of the different departments of knowledge are splitting into sections and special societies. Many who habitually attend the meetings of the sections are seldom present at the stated meetings of the Academy, but their presence and work in the sections make part of the common or general activity of the society.

The Department of Recent Conchology now contains 139.592 specimens, mounted and arranged in 39,501 trays. The species are named throughout, and all, with rare exceptions, are accessible to students. The space allotted to this branch of natural history in the museum is insufficient. Lack of room for the Mineralogical and Geological Cabinets is also manifest.

Extension and completion of the building is very desirable. At this time, the building fund amounts to $3689.20. Attention of members and friends of the Academy is respectfully invited to this important matter. The finished part of the building is not now large enough to properly arrange all the materials in it in the most convenient manner for their study, and is certainly not sufficiently extensive to display them to the public in a way to render them attractive and instructive to visitors in general. The present rate of growth of the museum and library, and the already crowded condition of the cases, suggest that ways and means should be devised without delay to augment the building fund. It is obvious that a vast museum and a great library connected with it demand space for their accommodation commensurate with their extent; and that a structure to embrace such space cannot be erected in a day, at any time, nor without a large sum. To raise sufficient money to complete the edifice designed for the purposes of the Academy will be found an arduous and slowly progressive enterprise. Therefore no date will be too early for its commencement; its success will not be too soon. And for this the Academy must, as heretofore, rely upon the generosity of the intelligent and public-spirited who believe with us that the cultivation of the natural sciences is in many ways advantageous to the public; and that the project of completing the building and expanding the museum of the Academy, till it shall be in every sense a perfect museum of natural history, is worthy of favorable consideration and prompt encouragement.

Such an establishment would be an addition to the positive attractions of Philadelphia, and thus become indirectly of commercial value to the city; especially if admission to it during a part of every secular day were without fee, and monitors were always at hand ready to explain to visitors the nature of the objects displayed. It would be among the best of charities, for it would help all to knowledge who are disposed to help themselves. A leisurely promenade through a complete and well-arranged museum of natural history, where questions of curious and inquisitive visitors might be answered on the spot, would be almost in itself an education in this connection.

To hope for such a museum here is extravagant only in view of the great expense. The chief obstacle in the way of its realization is the cost, which would possibly far exceed that of a free public library of general literature, or a free public gallery of fine paintings. A museum of natural objects might not be as alluring to the masses as fictions told in prose or verse, or in different-colored pigments deftly mingled and displayed, all exciting admiration, and more likely to arouse romantic, even sensuous notions than to convey a ray of truth of any sort to the mind of the uncultured observer. But the influence of the museum in teaching untrained minds to think rightly and appreciate the beauties of truth, everywhere manifest in the works of the Creator, is likely to be as great, if not greater, and certainly not less salutary.

A complete standard museum, free to the public, is surely desirable in a locality which contains more than a million of inhabitants within a radius of ten or fifteen miles from this centre. The city contains many private special collections, and several small, good museums connected with colleges and schools, which are accessible to the few, but there is no great museum of natural history absolutely free to all. Without lessening the importance and value of private or collegiate collections, and without interfering with students in their use of it, the museum of the Academy, which has been formed at the cost of many years' labor and much money, can be made in a short time complete and entirely free to the public, provided that sufficient means for the purpose are supplied. Herein lies the difficulty of the problem to be solved before starting the enterprise suggested.

A newspaper has recently said that among our opulent citizens are those who might, without inconvenience, give a million to found a free public library. Assuming the conjecture to be true in part, at least, it might not be entirely in vain perhaps, to invite those very wealthy and intelligent persons to consider the claims of the Academy on their bounty.

The annual reports of the several sections or departments of the Academy show that their condition is satisfactory. They are:

1. The Biological and Microscopical Section, founded in 1858 by the absorption or junction of the Biological Society, then recently organized, and by adding to it, in July, 1868, the then newly formed Microscopical Society.

2. The Conchological Section, founded December 26, 1866.

3. The Entomological Section, founded November 1875, chiefly by annexation of the American Entomological Society.

4. The Botanical Section, founded in June, 1876.

5. The Mineralogical and Geological Section, founded April 24, 1877, under the title of Mineralogical Section. Its present title was authorized November, 1879.

The Biological and Microscopical Section reports that Professor J. Gibbons Hunt delivered seven lectures on histological subjects before the Section during the year, and that its annual exhibition was held on the evenings of November 16 and 17. It was largely attended by members of the Academy and their friends, and was satisfactory to all those who took part in it.

The sections afford greater facilities to specialists in their pursuits than they could obtain in newly organized and independent societies. They are in no sense detrimental to the interests of the Academy. They have the immediate care of those departments of the museum which are appropriate to them ; and in this connection their conservators relieve the Curators of considerable labor. There is no apparent reason why the formation of sections should not be encouraged. They tend to unite those engaged in separate but closely allied studies, advantageously to them as well as to scientific progress, and to centralize their interest in the general welfare of the society. A desire of membership in a section is often the only inducement to seek membership in the Academy.

The by-law, enacted May, 1876, which provides for the establishment of Professorships, had remained almost inoperative until December, 1880. In its partial observance it promises to be satisfactorily efficient, at least for the present.

The enactment was founded on an idea that "there are many men eminently qualified in all respects to engage in original research whose scientific work is greatly restricted because almost all their time is necessarily spent in gaining a livelihood, who, like the Davys, Faradays, Huxleys, and Tyndalls of the Royal Institution, would gladly accept a moderate support of assured continuance, and in return for it devote all their energies to scientific investigations and teaching."

Objection to the scheme, though commendable in itself, was that "to appoint professors before providing a laboratory in which they may pursue their investigations, or a lecture-room for the accommodation of those who would listen to their teachings ; or means for their permanent and entire support, would be merely to bestow complimentary titles, without advancing the interests of original research in any manner or degree. Gentlemen elected to professorships without income would not find in the title of professor alone the means of living. Such title would not relieve them from the necessity of giving their time and labor to some exacting vocation for daily bread, nor afford them more leisure than they may possess without it. Those devoted to original investigation who are pecuniarily independent of secular employment do not need the assistance which hoped-for endowments are designed to give. As the library and museum are accessible to all for the purpose of study, they are in condition to pursue their scientific labors without acquiring the title of professor from the Academy."

If the enactment be founded as stated, the objection to the appointment of professors before making provision of facilities suitable to the work imposed upon them, and of sufficient means for their permanent support, has no less force now than when first made five years ago.

It has been considered expedient to inaugurate the scheme of professorships before providing the ways and means for their permanent support, in the hope that the effort may meet with substantantial encouragement.

Dr. J. Gibbons Hunt was duly elected Professor of Histology and Microscopic Technology, April 17, 1877, without compensation or authority to incur expense.

At a stated meeting of the Council, December 27, 1880, Mr. Angelo Heilprin was duly elected Professor of Invertebrate Palæontology; and January 24, 1881, Mr. Henry Carvill Lewis was appointed Professor of Mineralogy.

Knowing that the society has no means to defray any expense incidental to the professorships, and that the long wished-for endowments to support them have not yet been made, these gentlemen have generously volunteered to contribute their time and valuable services towards promoting the interests of the Academy and scientific advancement without pecuniary compensation.

The Committee on Instruction and Lectures made arrangements necessary to enable the professors to inaugurate the work of instruction. Professor Heilprin delivered a lecture introductory to his course on Invertebrate Palæontology before the Academy, March 6; and at the stated meeting of the 15th, Professor Lewis delivered an introductory lecture to his course on Mineralogy.

The average attendance at Professor Heilprin's course of twenty-six lectures was twenty-five, and at Professor Lewis' course of fourteen lectures, thirty-five.

The Rev. Dr. Henry C. McCook, Chairman of the Committee on Instruction and Lectures, said, in his report, May 31, 1881: "The committee feels pleasure in recognizing the valuable services rendered by the professors to the classes of last winter—service that has been none the less valuable and is all the more entitled to hearty acknowledgment because voluntarily given. It has not been possible to give them a pecuniary acknowledgment of their services worthy of any notice in a report. The hope is expressed, that the liberality and justice of those interested in this department of the Academy's work, will enable the committee to make a more favorable report in this respect upon the operations of next winter."[1]

The committee has announced that early in January, 1882, Professor Lewis will begin a course of 25 lectures on Mineralogy, and Professor Heilprin a course of from 25 to 30 lectures on Invertebrate Palæontology.

The institution of these lectures is based on a supposition, a conjecture that there are many persons in the community who desire to be systematically taught such branches as are not included in academic or college courses, or if included, not generally accessible to those who are interested only in subjects proposed to be taught here, and that those persons are in number sufficient to warrant and sustain the enterprise. Experience will be required to determine whether or not the conjecture is well-founded, because the nature and character of the instruction given here is not likely to be generally known or appreciated in the community in a trial of less than two or three years. If, at the end of a third course, it should be found that the number attracted to these courses is not large enough to compensate the professors, it is not reasonable to suppose that they will be willing to continue their labors, which are certainly very considerable, without adequate substantial remuneration. When it becomes manifest that the demand for systematic and practical instruction is not sufficient to warrant or encourage work of this kind, it will be suspended. Then the professors will be free to devote their time to original investigations exclusively, provided that means of livelihood are supplied by endowment or otherwise.

On the other hand, if the admission fees are sufficient to maintain the lectures and lecturers, other systematic courses of instruction will probably be undertaken and continued as long as they are supported, and thus the Academy, which has been heretofore mainly a repertory of means and resources for the use of those who seek to instruct themselves, may also become efficient in

[1] The total amount of fees for admission to the lectures was $151, and of the incidental expenses, $52.27

teaching all branches of natural history, both by lectures, appropriately illustrated by diagrams and by specimens from the museum as well as by personal, individual laboratory work under the supervision of the professors.

Whatever the result of the experiment in teaching may be, the appliances necessary to study possessed by the Academy, will be always accessible to those who may be gratified to have an opportunity to teach themselves—to be self-taught.

Although defective and deficient in some respects, there is no conclusive reason to suppose that the Academy is not now realizing the hope of its founders, as well and as surely as in any previous year of its history. That defects will be corrected and deficiencies supplied in the course of time may be confidently conjectured, because the needs of students of natural science, which is daily becoming more fully appreciated than ever before in the world, are better understood. A great library and extensive collections of natural objects, appropriately classified and labeled, are necessary to enable the student to become a master of natural history, and qualify him to be a successful investigator. The cost of such necessary appliances and facilities of study is so great that no one student is able to purchase them for himself alone. He can enjoy their use, therefore, only in common with others, in a society like the Academy, which has acquired them through the generosity of many individuals in the course of years. Every specimen, every book, every dollar given here is a contribution to the repertory of means to facilitate the labors of present and future students of natural science. And every contributor is regarded as a benefactor to them directly, and indirectly as a patron of scientific progress, in greater or less degree.

Since the Academy was in its embryo state, seventy years ago, public opinion of the character and influence of its pursuits has greatly changed. Then they interested comparatively few, and those few were supposed to be almost, if not entirely, free from the influence of belief in religious principles of any kind. Many pious but prejudiced persons imagined that a naturalist is necessarily an infidel. Those very good, ignorant people then, like multitudes of the same class of the present day, limited their study of animal creation almost exclusively to man and his actions, depicted in endless variety by prose-writers and poets. Assurance that there is equal pleasure and greater mental satisfaction in the study of organisms inferior to man, fell then as now, generally speaking, upon incredulous ears. They do not believe them worthy of serious attention.

The nameless author of "La Spectacle de la Nature," a work which has the censor's approval, dated Paris, March 20, 1732, speaking of insects, says: "If the Deity did not think it unworthy of Himself to create them, is it beneath us to consider them? * * * the minutest things in nature were appointed to some peculiar end and purpose, and the Deity is as conspicuous in the structure of the fly's paw as He is in the bright globe of the sun himself."

No one pretends now to impugn the truth of this ancient statement!

But the study of the natural sciences is no longer regarded among Christian theologians and laymen of intelligence to be antagonistic to the existence and growth of religious sentiment. Statesmen recognize in it economic value. Governments require naturalists to accompany all geographical explorations. United States and State Geologist, Botanist, Entomologist, etc., are familiar titles. Periodical publications devoted to the natural sciences are numerous. To this kind of evidence of the increasing popularity of scientific pursuits may be added the mulitiplication of societies for their promotion in different parts of the country. All of them have been formed since the Academy was founded. They are all welcome co-laborers in the vast field of work, and are not regarded in any sense as rivals or competitors. They serve to create a spirit of wholesome emulation.

It is pleasant to suppose that the Academy has had a salutary influence on the progress of the natural sciences to the degree of popular favor they now possess, and that its general conduct heretofore is approved. Its ways have been and are unpretentious, unobtrusive. Membership in itself is not significant of any degree of scientific acquirement, but only of friendliness to scientific pursuits. Candidates to be inscribed on the list of its members are not required to possess special qualifications. Those members who avail themselves of the opportunity and appliances afforded to study, gain knowledge and receive due credit for any good work they may do. The reputation they may thus acquire is reflected upon the Academy.

On its list of members are very many who manifest their interest in the society's welfare only by contributing to its funds or collections; many who are active and successful workers; many who are distinguished by their attainments, and some who have reached great eminence; and it is reasonably supposable that recruits are coming forward to fill vacancies as they occur in each of these different kinds or classes of members. It has many numerous and valuable collections in every department, some of them unsurpassed, which are continuously increasing; and an appropriate library, the best of the kind in the country, for the steady growth of which permanent provision has been made. It owns the building it occupies, with land enough on which to expand it to twice its present dimensions. It is free from debt, and its current income has been in the past year equal to its economical expenditure.

The condition of the society, attained at the end of seventy years' existence, without any pecuniary aid whatever from the government of the State, justifies the policy which has guided the management of its affairs. There is nothing in its past history to suggest that it should depart now from the general conservative policy which has characterized almost every step of its progress since 1812. Observance of this policy has brought it to its present condition, in which there is nothing to warrant foreboding of decadence, but much on which to found hope of continuous progress. This condition is satisfactory, because at this time the income is enough to meet all unavoidable expenses. Suggested improvements in several directions are very desirable and earnestly hoped for; but they are of such a character that they can wait until money is supplied for their realization without absolutely arresting the progress of the institution.

Respectfully submitted.

W. S. W. Ruschenberger.

REPORT OF THE RECORDING SECRETARY.

The Recording Secretary respectfully reports that during the year ending Nov. 30, 1881, fifteen members and six correspondents have been elected.

Resignations of membership have been received from Messrs. J. Ward Atwood, H. Dumont Wagner, E. Egglesfield Griffith, Henry Pemberton, Jr., and Wm. F. Sellers.

The records of the death of eleven members and six correspondents have been published in the Proceedings under dates of announcement, so that it is unnecessary to repeat the names here.

Twenty papers have been accepted for publication. Eighteen of these have been printed, and the remaining two will be included in the current volume of Proceedings. The communications have been received from the following: Angelo Heilprin, 6; Rev. Dr. Henry C. McCook, 3; S. B. Buckley, 3; Henry C. Chapman, 2; Harrison Allen, Rafael Arango, John H. Ryder, R. E. C. Stearns, W. N. Lockington, and Messrs. Wachsmuth and Springer, each one.

Sixty-four pages of the volume of Proceedings for 1880, and four hundred and thirty of the volume for 1881, have been printed during the year. The fourth or concluding number of Vol. VIII of the Journal was issued and distributed to subscribers and correspondents in March.

The interest of the weekly meetings has depended mainly on the verbal communications made from time to time by Messrs. McCook, Wood, Leidy, Ryder, Meehan, Chapman, Potts, Allen, Horn, Foote, Bassett, Kite, Heilprin, Lewis, Rand, Haines, Koenig, Anders and Pike. The greater number of these have been reported by the authors, and duly published in the Proceedings.

Mr. Edw. S. Whelen having resigned from the Council and the Finance Committee, the vacancies were filled by the election, on the 22d of January, of Chas. P. Perot to the former and Isaac C. Martindale to the latter position.

A vacancy in the Council, caused by the resignation of Dr. H. C. Chapman, was filled, June 5, by the election of Dr. Geo. A. Koenig.

Article 3, Chap. XV, of the By-Laws was amended October 25 by adding after the word "election" the words "and resignation."

All of which is respectfully submitted.

EDW. J. NOLAN,
Recording Secretary.

REPORT OF THE CORRESPONDING SECRETARY.

The Corresponding Secretary reports that the business of his office has not differed materially from that of preceding years, the correspondence having been of the usual routine character.

During the past year our membership has been increased by the addition of six Correspondents, who have been promptly notified of their election, and from nearly all of whom acceptances have been received.

To those who have favored the Academy with donations to the Museum, prompt acknowledgments have been sent; these, to the number of one hundred and sixty-one, represent for the most part not single specimens, but masses of valuable material, a record of which will appear in the Curators' report.

The letters received are in great part either notices of the transmission of the publications of Corresponding Societies, or acknowledgments of the reception of our own by them.

The summary is as follows:

Letters of transmission,	49
Letters of acknowledgment,	58
Responses from Correspondents,	6
Miscellaneous,	13

representing eighty Scientific Societies. Public Libraries, Institutions of original research, and other bodies organized for the increase and diffusion of knowledge. The number of Corresponding Societies shows an annual increase.

During the year notices of the death of several Correspondents have been received, and published in the current Proceedings.

Respectfully submitted.

George H. Horn, M. D.,
Corresponding Secretary.

REPORT OF THE LIBRARIAN.

The Librarian respectfully reports that during the year ending November 30, 1881, there have been 2719 additions made to the library of the Academy. As heretofore, the greater part of these have been the publications of scientific societies, received in exchange for those of the Academy. The increase has been composed of 396 volumes, 2273 pamphlets and separate parts of periodicals and 50 maps and plates.

The sources from which these were derived are as follows :—

Societies, ...	1075	Norwegian Government, . .	3
Editors, ...	697	Wm. S. Vaux, ...	3
I. V. Williamson Fund, . . .	278	Rev. Dr. Syle, ...	3
Authors, ...	252	Trustees of British Museum, .	3
Jos. Jeanes, ...	94	Geological Survey of Canada,	2
F. V. Hayden, ...	33	H. C. Lewis, ...	2
Wilson Fund, ...	29	C. F. Parker, ...	2
Department of the Interior, .	22	Geol. Survey of New Jersey, .	2
Geological Survey of Sweden, .	22	Mrs. S. S. Haldeman, ...	1
Geological Survey of Bohemia,	16	B. L. Hewit, ...	1
Robert Bridges, ...	14	H. C. Chapman, ...	1
Geol. Survey of Pennsylvania, .	12	G. W. Tryon, Jr., ...	1
Fish Com'rs of Massachusetts,	12	University of Minnesota, . .	1
Geological Survey of India, .	9	Yale College, ...	1
Department of Agriculture, .	9	U. S. Commissioner of Fisheries,	1
Smithsonian Institution, . .	9	Fish Com'r of Maryland, . .	1
Isaac Lea, ...	9	Wesleyan University, . . .	1
War Department, ...	7	Philadelphia Library Co., . .	1
Fish Commissioners of Maine,	7	University of California, . .	1
Treasury Department, . . .	6	Dept. Mines, Nova Scotia, . .	1
Geological Survey of Belgium,	5	Geological Survey of Italy, .	1
Minister of Works, Mexico, .	5	Mercantile Library, St. Louis,	1
Minister of Public Works, France,	5	Mercantile Library, San Francisco	1
Dept. of Mines, New South Wales,	5	N. J. State Agricultural Station,	1
East Indian Government, . .	5	Pennsylvania Museum, . . .	1
Fish Commission of Michigan,	4	Rutger's Scientific School, . .	1
Geol. Survey of New Zealand.	4	Library Com'rs, Nova Scotia,	1
Engineer Department, U. S. A.,	4	Astor Library, ...	1
Major Huguet Latour, . . .	4	American Museum of Nat. Hist.,	1
University of New York, . .	4	Second Presbyterian Church, .	1
Fish Commission of Iowa, . .	3		

In addition, 8 volumes were procured by exchange of duplicates. The additions were distributed to the various departments of the library as follows :—

Journals, ...	2021	Education, ...	11
Geology, ...	236	Voyages and Travels, . . .	11
General Natural History, .	64	Agriculture, ...	10
Botany, ... ,	64	Helminthology, ...	9
Conchology, ...	47	Ornithology, ...	9
Anatomy and Physiology, .	40	Chemistry, ...	9
Ichthyology, ...	4	Medicine, ...	6
Bibliography, ...	21	Biography, ...	5
Entomology, ...	21	Mammalogy, ...	2
Mineralogy, ... ,	20	Miscellaneous, (War, Finance, Literature, etc.,) .	45
Anthropology, ...	18		
Physical Science, ...	11		

Estimating that it requires an average of 10 pamphlets or parts of periodicals to make a volume, the number of volumes now in the library is about 29,485. The failure of some of the ground-rents constituting the I. V. Williamson Fund and the consequent necessity of obtaining possession of the property involved, has decreased the number of works obtained from that source, those received having been mainly continuations of periodicals and serial works previously subscribed for. It is hoped, however, that the embarrassment is merely temporary, as the income from the Fund will be hereafter materially increased by the rents of the properties thus acquired.

The Academy is indebted to Mr. Jos. Jeanes for a gift of $500.00 for the purchase of botanical, and $239.80 for geological works actually required by the workers in these departments. The books most urgently asked for, have been ordered, and those which have been received are noted in the accompanying list of additions to the library.

The revision of the catalogue of American journals has been completed. Applications have been made for deficiencies in every case where it was at all probable that the publishers could be reached, and proposals to exchange have been made to a few societies not yet in correspondence with us. The latter are mainly in South America, and judging by the experience of the past, the answers, which we have not yet had time to receive, will be favorable.

EDW. J. NOLAN,
Librarian.

REPORT OF THE CURATORS.

The Curators present the following report of the Museum prepared by Mr. Chas. F. Parker, in special charge of the same.

I would respectfully report, that during the year all the collections of the Museum have been carefully inspected and cared for, and that they are in good condition.

The specimens received during the year have been labeled and placed in their proper positions.

The contributions in the various departments during the year, excepting those reported on by some of the special sections, follows, and will be found included in the "List of additions to the Museum."

The Haldeman collection, noted in the list, has been partially arranged in forty drawers and nine horizontal cases. A large number of specimens had to be packed away for want of room, which, it is hoped, will soon be provided for their display.

JOSEPH LEIDY, M. D.,
Chairman of Curators.

REPORT OF THE BIOLOGICAL AND MICROSCOPICAL SECTION.

Fifteen stated meetings were held during the year.

The following new members and associates were elected:

Members.—Robert S. Davis, E. P. Borden, J. E. Mitchell, Dr. Crozier Griffiths, Dr. George A. Rex, Edward P. Starr, D. S. Newhall.

Associates.—W. T. Seal, Dr. J. R. McClurg, J. H. Fenton.

The death of but one member was noticed upon the minutes of the section, that of Thomas W. Starr.

Besides the usual material presented at the meetings, the following special subjects were of more than ordinary interest:—

Dec. 6, 1880.—The anatomy of the Sponges, by Mr. Ryder.

Dec. 20, 1880.—An exhibition with a new Projecting Lantern, by Queen & Co.

Jan. 3, 1881.—Lecture upon Living Units and the Growth of Vegetable and Animal Matter, from the Original Cells or Bioplasts, by Dr. J. G. Hunt.

Jan. 17, 1881.—Lecture upon Mosses, by Dr. Hunt.

Feb. 7, 1881.—Lecture upon the subject, "Some Problems Within and Some that are Beyond Microscopical Observation," by Dr. Hunt.

Feb. 21, 1881.—Extended remarks upon the Anatomy of the Mosses and the best methods of Mounting, by Mr. Jacob Binder.

March 7, 1881.—The Microscopical Mechanism of some parts of the Digestive Organs, by Dr. Hunt.

March 21, 1881.—Extended remarks by Mr. George Binder upon the Fungi and the best method of mounting them.

March 21, 1881.—Observations by Mr. J. O. Schimmell upon the common Red Spider or Mite.

March 21, 1881.—A new method of bleaching vegetable tissues, by Mr. Jacob Binder.

April 4, 1881.—Lecture by Dr. Hunt upon the Significance of some Customs in Living Things.

May 2, 1881.—Lecture by Dr. Hunt upon Some Comparative Illustrations of Breathing Organs.

May 17, 1881.—Observations upon the best methods of preparing Crystals of Hippuric Acid.

June 6, 1881.—Lecture by Dr. Hunt upon Growth in the Skin and in some Trees alike.

Nov. 16 and 17.—The Annual Exhibition was held, and was attended by a large and interested assembly.

Dec. 5, 1881.—At the annual election the following gentlemen were elected officers for the ensuing year:

Director, ...	Dr. R. S. Kenderdine.
Vice-Director, . . .	Dr. Charles Schaeffer.
Corresponding Secretary, .	Dr. L. Ashley Faught.
Conservator, . . .	Mr. Charles P. Perot.
Treasurer, ...	Dr. Isaac Norris.
Recorder, ...	Dr. Robert J. Hess.
Committee of Auditors, .	Mr. J. C. Wilson, Mr. S. L. Fox, Dr. A. G. Reed.
Committee of Curators, .	Mr. C. P. Perot, Mr. E. Pennock.
Committee on Business, .	Dr. C. Schaeffer, Dr. R. J. Hess, Mr. C. P. Perot, Dr. A. G. Reed, Mr. S. L. Fox.

Respectfully submitted,

ROBERT J. HESS, M. D.
Recorder.

REPORT OF THE CONCHOLOGICAL SECTION.

The Recorder of the Conchological Section respectfully reports that during 1881, Mr. Rafael Arango, Prof. Angelo Heilprin, Dr. R. E. C. Stearns and Mr. Henry Hemphill have prepared papers, which have been accepted and published in the Proceedings of the Academy. Besides these, verbal communications have been made at various times upon conchological subjects, at meetings of the Academy, by Dr. Leidy and Messrs. Heilprin, Ryder and Ford.

Our Conservator, Mr. Tryon, reports that

"During the year ending December 1, 1881, forty-four distinct donations of recent shells and mollusks have been received, aggregating 877 species, represented by 3205 specimens. With the assistance of Mr. Charles F. Parker these have all been labeled, mounted and displayed in the Museum. In addition to this work, the rearrangement of the entire collection, in accordance with the latest and best views of classification, which was commenced two years ago, is constantly progressing—the Turbinellidæ, Nassidæ and Mitridæ having been completely re-studied and partly re-labeled.

"The collection of Unionidæ having outgrown the limits originally assigned to it, a new arrangement thereof became necessary, and for this purpose ninety-six drawers were appropriated, at the west end of the Conchological gallery. The specimens are now uniformly mounted, with new labels, and classified in accordance with the latest edition of Dr. Lea's Synopsis of Naiades. Two reference-catalogues of the family have been prepared, one of which is for the use of strangers desirous of consulting the collection. The cabinet of Unionidæ contains over six hundred species, represented by several thousand selected specimens, and occupies two hundred and forty feet of surface space. To the above work Mr. Parker has, as usual, devoted much of his time, and with great advantage to the appearance of the specimens.

"Early in the year an opportunity occurred to secure a fine suite of fossil shells from the older formations of the West—hitherto very imperfectly represented in the Academy's Museum; the Section obtained these by purchase.

"Prof. Angelo Heilprin having assumed official charge of the cabinet of invertebrate palæontology, his annual report will contain the summary of donations of fossil shells, heretofore included in this report.

"Recently, a large and valuable selection of recent shells, all new to the Academy's collection, has been offered to us at a reasonable price, and by the kindness of several friends, a portion of it has already been secured. In this connection we would call attention to the manifest impossibility of maintaining unimpaired the usefulness to students of our Conchological collection by continuing to rely upon occasional donations and exchanges for the supply of newly-discovered species. A museum which does not ever reflect the current state of knowledge misses its highest aim, and may become as valueless for progress as a library composed of books written several generations ago.

"Authentic or carefully identified specimens of known species are much more necessary to the student than books. Figures and descriptions, however carefully drawn, can only convey to him a portion of the significance of the specimens. Books are, of course, necessary implements of study, but to derive our knowledge of zoological characters from them exclusively is to receive at second hand the impression which natural objects have made upon other minds, a condition which almost precludes safe progress in zoological discovery. Through several wise benefactions, the library of the Academy has become the most important library of natural science in America, and means have been provided for its continuous growth; but the Museum has always depended upon fitful generosity exclusively; no intelligent direction has been given to its increase, simply for want of money. In no other department of the Museum do we suffer more for the want of purchasing power than in that of Conchology. Ten years ago our collection had become, by a succession of favorable circumstances, so complete that it was consulted by students as a standard authority. Its reputation still exists, but with each succeeding year it is less deserved, for few of the rich collections constantly being made in regions new to zoological research find their way into our cases. A fund yielding a few hundred dollars per annum would suffice to maintain, perhaps to increase, the value of our Conchological Museum. A gift for this purpose would, it is believed, be a good investment, productive in the best sense.

The Museum of Recent Conchology now contains 139,592 specimens, mounted in 39,501 trays. The species are named throughout, with rare exceptions, and are all accessible to students."

There have been no changes made in the By-Laws of the Section, and the officers of last year have been re-elected.

Respectfully submitted by

S. Raymond Roberts,
Recorder.

REPORT OF THE BOTANICAL SECTION.

The Vice-Director has much pleasure in reporting the continued progress of the Section during the past year.

The officers-elect for 1882 are:

Director, . . .	Dr. W. S. W. Ruschenberger.
Vice-Director, . .	Thomas Meehan.
Recorder, . . .	F. Lamson Scribner.
Corresponding Secretary and Treasurer, .	Isaac C. Martindale.
Conservator, . .	John H. Redfield.

Meetings have been held every second Monday in the month, except in July and August, with a slightly increased attendance over the previous year. Many valuable verbal and written communications have been made to the meetings; some of the more important have been afterwards published in the Proceedings of the Academy.

All the valuable work done by the Section this year has been without drawing, except to a trifling extent, on the funds of the Academy.

The membership has increased slightly, and the Treasurer reports a balance on hand of $34.92.

It is but right that the Academy should bear in mind that its Botanical collection is one of the finest in the United States. Numbers of excellent botanists stand ready to supply deficiencies, if they can only be furnished with lists of what are needed. A very little financial aid, to supply what the voluntary labor of the zealous members of the Section would be overtasked to do, would place it in a condition to do great honor to the Academy. Though in the continued absence of this financial aid, the progress is much slower than is desirable, the marked advance, as evidenced by the Conservator's report, is so very gratifying that the Section has adopted it as part of its report to the Academy.

Respectfully submitted.

Thomas Meehan,
Vice-Director.

The Conservator reports a constant and encouraging growth of the botanical collections of the Academy during the past year. The usual detailed list of the accessions is appended. Among the most important of these, we may refer to the large and nearly complete series of sections of North American woods, collected under the direction of Prof. Chas. S. Sargent, Commissioner of the Forestry Department of the U. S. Census of 1880, and by him presented to the Academy. Mr. Canby has contributed during the year 527 species of plants, mostly European, but with many rare species from South Africa and Australia. To Mr. Martindale we are indebted for the 5th, 6th and 7th Centuries of Ellis' N. American Fungi, containing a series of carefully determined specimens illustrating that most difficult department of Cryptogams. From the Cambridge Herbarium we have received a small but interesting collection of plants from Afghanistan, collected by Dr. J. E. T. Aitcheson during the advance of the British army into that country in 1879.

The Conservator has continued to direct his main attention to the work of bringing into more orderly arrangement the somewhat chaotic mass of material in the Herbarium, believing that in this way he can best facilitate the labors of those who may come after him. During the year provisional alphabetical lists of species have been prepared for a considerable portion of the general Herbarium, to which the arrangement of the species in the genus covers has been made to conform. Those who have occasion to consult the Herbarium will appreciate the great saving of time which this arrangement will effect. It would be gratifying if this labor could be accompanied by a thorough study and working over of the material represented, but with the limited time at the Conservator's disposal, this is absolutely impossible, and will be better performed hereafter when the Academy shall be able to secure the constant services of an experienced botanist. Yet this end has not been altogether neglected, and in the mounting of the N. American Herbarium, which work is still continued, careful revision of names has been kept in view, and if error has not been altogether avoided, it has at least been greatly lessened. The mounting of that portion of the collection covered by the issued part of Gray's Synoptical Flora, is now complete, and some little progress has been made in other portions.

During the year Dr. Eckfeldt has carefully examined and catalogued the lichens of the collection, contributing also 100 species which were wanting, and Mr. Scribner has continued his labors upon our grasses, which he is critically studying and mounting.

Mr. Chas. F. Parker, the Academy's Curator-in-charge, has been of the most essential service to the Conservator in carrying out the work of poisoning all new additions, a large proportion of which he has also mounted; and his contributions to the N. American Herbarium have filled many gaps, and added choicer specimens of species already represented.

Respectfully submitted.

JOHN H. REDFIELD,
Conservator.

REPORT OF THE ENTOMOLOGICAL SECTION.

The Entomological Section during the year has been enabled to perform an amount of work that is quite gratifying to its members. In this work it has been generously aided by the American Entomological Society, which has allowed it a fair share of its own limited income. The cabinets have been remodeled, and several new cases added thereto. These have been paid for by the Society.

By the increase in cabinet room thus obtained the Section has found space to add to the collection, 175 species, comprising 300 specimens or more, of which 60 species entirely new to the collection have already been arranged. A complete rearrangement of all the species is now being made by Mr. Howard Parker. The aforementioned new specimens are such as have been added so far as this rearrangement has progressed, viz., from the Cicindellidæ to Anisodactylus of the Carabidæ, inclusive.

During the year the Section held its regular monthly meetings, excepting in August and September, the usual vacation period. At these meetings communications, both written and verbal were made. These have been published in the Proceedings of the Section, of which 28 pages have thus far appeared. In addition to these pages of entomological matter the American Entomological Society has published 212 pages of its Transactions; these make a total of 240 pages of printed matter during the year.

At the meeting of the Section held December 12, the following officers were elected for the year 1882:

Director,	J. L. Le Conte, M. D.
Vice-Director,	George H. Horn, M. D.
Treasurer,	E. T. Cresson, M. D.
Recorder,	J. H. Ridings.
Conservator,	Charles Wilt.

Respectfully submitted.

J. H. Ridings,
Recorder.

REPORT OF THE MINERALOGICAL SECTION.

The Director of the Mineralogical and Geological Section would respectfully report that regular meetings have been held monthly during the year, except in July and August. At these meetings the attendance of members and visitors has been larger than in any former year, averaging eleven. New discoveries have been from time to time announced, and many items of interest discussed. For the details of this work he would refer to the appended reports of the Professors of Invertebrate Palæontology and of Mineralogy, and to the papers herewith transmitted, and which will be published in the Proceedings for 1882. Specimens received through the section during the year, though not as large in number as in some prior years, have made a valuable addition to the cabinet.

A special meeting was held in March, in conjunction with the meeting of the Academy, at which the Professor of Mineralogy delivered his inaugural address. Two hundred members and visitors were present.

The success of this insured the unanimous approval by the Section of the proposition to combine the meetings of the Sections with those of the Academy.

The following officers have been elected for the ensuing year:

Director,	Theo. D. Rand.
Vice-Director,	W. W. Jefferis.
Secretary,	Chas. Schaeffer, M. D.
Treasurer,	John Ford.
Conservator,	H. Carvill Lewis.

Respectfully submitted.

Theo. D. Rand,
Director.

REPORT OF THE PROFESSOR OF INVERTEBRATE PALÆONTOLOGY.

The Professor of Invertebrate Palæontology respectfully reports, that during the year 1881, a course of 26 lectures on Invertebrate Palæontology was delivered in the class room of the Academy (commencing on March 8, and terminating June 4), which course was attended by an average of about 25 listeners, largely made up of teachers from some of the more prominent institutions of learning in the city.

The work of classifying and arranging the old collections in the Palæontological Department of the Academy has made some progress during the year. The determination of specimens embraces:

123 trays of (so-called) Cretaceous fossils from the Téjon group of California, originally described by W. M. Gabb for the Whitney Survey, and largely composed of type specimens; these last have been specially indicated.

312 trays of Tertiary (Miocene and Pliocene) fossils, largely composed of T. A. Conrad's types.

435

The specimens contained in 263 of these trays have been carefully mounted and labeled by Mr. Chas. F. Parker, Curator-in-charge; to the remaining 172 trays, only provisional labels have been attached.

The Palæontological collections of the Academy have thus far suffered greatly from want of room for their proper exposition; something toward remedying the evil, by the construction of additional drawers, has been done in the course of the year, but much more still remains to be accomplished. It is especially desirable that a suitable cabinet, or other fixture, be obtained for the exhibition of specimens typically representing the various geological formations, which would not only greatly facilitate the work of the Professor in teaching, but would very materially aid the students, special as well as general, in their studies.

All the additions to the Palæontological collection, made in the course of the year, have been labeled and mounted by Mr. Chas. F. Parker, Curator.

The Department of the Library pertaining to Geology and Palæontology has received many valuable accessions during the year, for a considerable portion of which the Academy is indebted to the liberality of Mr. Joseph Jeanes.

ANGELO HEILPRIN,
Professor of Invertebrate Palæontology.

REPORT OF THE PROFESSOR OF MINERALOGY FOR 1881.

In submitting to you this, my first annual report upon the condition and needs of the department under my charge, allow me to express my appreciation of the assistance which has been rendered through the active co-operation of your committee on instruction, in the discharge of my duties as Professor of Mineralogy.

Under their auspices a course of practical instruction in Mineralogy was given during the months of March and April. It consisted of thirteen lectures, and was attended by a class of about 35, being as large in number as could conveniently be accommodated in the room set apart for the purpose. The course opened with a review of the history of Mineralogy and of mineralogical classification. Succeeding lectures consisted of a detailed description of the characters of minerals and an exposition of the methods used in mineralogical determination, with experiments. Specimens from the valuable collection of the Academy were used in illustration. Practical work was successfully carried on by nearly all the class. It consisted of the determination of the characters of minerals, the application of chemical tests to detect their constituents, and the performance of the various operations of blowpipe analysis. This was supplemented by a day of practical work in the field.

The summer months were employed in discovering and tracing the line across Pennsylvania of the great terminal moraine of the North-American glacier; the work having been accomplished with the assistance of the Second Geological Survey of Pennsylvania, and of which a report will shortly be published.

The mineral collection of the Academy has been increased during the past year by valuable additions. The donations made by Mr. Bement and Mr. Vaux are especially worthy of note. A number of undetermined specimens and specimens wrongly labeled have been examined and properly placed in the collection. The labels have been written and the specimens arranged as heretofore by Mr. Chas. F. Parker, in his usual careful manner. It is hoped in time to form special collections, illustrating the various external characters of the minerals.

A very valuable acquisition has been the manuscript catalogue of the rock collection made by the First Geological Survey of Pennsylvania. This catalogue, consisting of 300 pages, is an exact copy of the original catalogue made by Prof. H. D. Rogers, which is now in the possession of the State Agricultural College at Bellefonte. It was copied under the direction of Prof. J. P. Lesley, who, at my request, has now deposited it with the Academy. This catalogue transforms a worthless collection of rocks into a most valuable one. The collection, which was given by Prof. Rogers to the Franklin Institute, and which is now boxed in the cellar of the Academy, awaiting arrangement, consists of 5725 specimens, illustrating the lithology of the greater portion of the State. The specimens are all numbered, and can be so arranged as to correspond with the pages in Prof. Rogers Final Geological Report, and thus to prove of great service to students. It is to be regretted that the limited space now at the command of the Academy precludes any satisfactory display of this collection.

In accordance with the by-law requesting the Professor to state the needs of the department under his charge, the following suggestions are here offered:

It is very desirable that a single row of drawers should be placed beneath the mineral cases. Specimens of less value than those in the cases, those valuable only for locality, and minerals for the use of students would properly be placed in such drawers. The systematic arrangement and good appearance of the collection would thus be permanently established. It is also recommended that some provision be made for the storage of duplicates. A series of wooden trays sliding in a rough frame would be the most compact and suitable arrangement, and could conveniently accommodate not only the duplicate specimens now scattered, but also others that may hereafter be received.

In the department of instruction much is needed. Before any systematic instruction in crystallography can be given, the Academy should have a set of the Siegen glass crystal models for instruction, and a collection of wooden models for practice. For advanced mineralogical instruction it is also necessary to have certain instruments, among which a reflecting goniometer, a polariscope, and a lithological microscope are the most important. A good balance is also desirable for accurate specific gravity determinations. These instruments would be used both for instruction to advanced students, and, under proper restrictions, for original investigations.

HENRY CARVILL LEWIS,
Professor of Mineralogy.

SUMMARY OF THE REPORT OF WM. C. HENSZEY,

Treasurer, for the year ending Nov. 30, 1881.

Dr.

To Balance from last account	$ 911 21	
" Initiation fees	120 00	
" Contributions (semi-annual contributions)	1936 45	
" Life Memberships	100 00	
" Voluntary Contributions from Life Members	5 00	
" Admissions to Museum	421 30	
" Sale of Guide to Museum	25 00	
" " Duplicate Books	5 00	
" Donation from Entomological Society	75 00	
" W. L. Mactier, for lectures, 1881 and 1882	25 00	
" Freight returned	1 00	
" Publication Committee	1124 09	
" " " Balance of Publication amount in their hands	800 54	
" Fees, Lectures on Palæontology	70 00	
" " " " Mineralogy	81 00	
" Interest from Mortgage Investment, Joshua T. Jeanes' Legacy	1000 00	
" Wilson Fund. Toward Salary Librarian	300 00	
" Publication Fund. Interest on Investments	320 00	
" Barton Fund. " " "	240 00	
" Life Member. Fund. " " "	60 00	
" Maintenance Fund. " " "	30 00	
" Interest on Deposits	220 28	
		$7870 87

Cr.

Salaries, Janitors, etc	$3394 97	
Freight	65 94	
Repairs	338 93	
Insurance	30 00	
Coal	615 45	
Gas	91 72	
Mounting Parrot	1 50	
Stationery and Postage Stamps	121 14	
Alcohol	42 75	
Newspaper Reports	60 00	
Water-rents	26 15	
Trays	50 50	
Binding	50 00	
Printing and Paper	1291 68	
Plates and Engravings	42 99	
Lecture Expenses	32 52	
Miscellaneous	447 20	
A. Heilprin. One-half Receipts, Committee of Instruction.	74 36	
H. C. Lewis. " " " " "	74 36	
Life Membership, transferred to Life Membership Fund.	100 00	
		6952 16
Balance, General Account		$918 71

LIFE MEMBERSHIP FUND. (For Maintenance.)

Balance per last Statement		$1000 00
Life Membership transferred to this account		100 00
Interest on Investments		60 00
Phila. and Erie Railroad Bonds paid off		2000 00
		$3160 00
Transferred to General Account	$60 00	
Investment in Bond and Mortgage, at five per cent. int	2000 00	
		2060 00
To Balance for Investment		$1100 00

BARTON FUND. (For Printing and Illustrating Publications.)

Balance per last Statement	$240 00
Interest	240 00
	$480 00
Transferred to General Account	240 00
Balance	$240 00

JESSUP FUND. (For Support of Students.)

Balance, last Statement	$521 67
Interest on Investments	560 00
	$1081 67
Disbursed	500 00
Balance	$581 67

MAINTENANCE FUND.

Balance per last Statement		$526 35
Interest on Investments		30 00
Phila. and Erie Railroad Bond paid off		1000 00
Stuart Wood. Subscription		100 00
		$1656 35
Transferred to General Account	$30 00	
Investment in Bond and Mortgage, at five per cent. int	1000 00	
		1030 00
To Balance for Investment		$626 35

PUBLICATION FUND.

Balance, last Statement	$408 25
Income from Investments	320 00
Phila. and Erie Railroad Bond paid off	1000 00
	$1728 25
Transferred to General Account	320 00
Balance	$1408 25

Of this Balance, $1300.00 is for Investment.

MRS. STOTT FUND. (For Publications.)

Spring Garden Railroad Bonds paid off		$2000 00
This amount is for Investment.		

I. V. WILLIAMSON LIBRARY FUND.

Balance, last Statement		$209 55
Rents Collected		444 75
Ground-rents Collected		1179 86
		$1834 16
For Books	$753 00	
Expenses, Sale of Four Properties for Arrearages of Ground-rents	331 00	
Taxes on Four Properties sold	341 31	
Repairs to Properties	191 10	
Taxes	22 40	
McFadden's Interest in 1451 Mt. Holly St	50 00	
Collecting	103 89	
		1792 70
Balance		$41 46

THOMAS B. WILSON LIBRARY FUND.

For Books		$456 90
Transferred to General Account toward Salary of Librarian		300 00
Barker Bros. & Co. Collecting U. S. Bonds		4 50
Investment in Bond and Mortgage, at five per cent. interest		4500 00
		$5261 40
Balance per last Statement	$108 02	
Income from Investments	540 00	
U. S. Bonds paid off	4500 00	
		5148 02
Balance Overdrawn		$113 38

ECKFELDT FUND.

Amount for Investment as per last Statement	$2466 86
Investment in Bond and Mortgage, at five per cent. interest	1500 00
Balance for Investment	$966 86

BOOK ACCOUNT. (Donations from Jos. Jeanes, Esq.)

Jos. Jeanes. Donations	$739 80
Less Cash paid for Books	214 00
Balance	$525 80

INSTRUCTION FUND.

Chas. Schaffer. Donation	$25 00
Thos. Meehan. "	10 00
	$35 00

The election of Officers for 1882 was held, with the following result:—

President, . . .	Joseph Leidy, M. D.
Vice-Presidents, . .	Wm. S. Vaux, Thomas Meehan.
Recording Secretary, .	Edward J. Nolan, M. D.
Corresponding Secretary,	George H. Horn, M. D.
Treasurer, . . .	Wm. C. Henszey.
Librarian, . . .	Edward J. Nolan, M. D.
Curators, . . .	Joseph Leidy, M. D., Wm. S. Vaux, Chas. F. Parker, R. S. Kenderdine, M. D.
Councillors, to serve three years,	Charles P. Perot, J. H. Redfield, S. Fisher Corlies, W. S. W. Ruschenberger, M. D.
Finance Committee, .	Isaac C. Martindale, Clarence S. Bement, Aubrey H. Smith, S. Fisher Corlies, George Y. Shoemaker.

ELECTIONS DURING 1881.

MEMBERS.

January 25.—Joseph J. Knox, Geo. A. Rex, M. D.

February 22.—Robt. P. Field.

April 26.—Henry Skinner, Jesse S. Walton.

May 31.—John G. Lee, M. D., Alexander Biddle, M. D., W. Norton Whitney, M. D.

June 28.—Jerome Gray.

July 26.—John C. Graham, E. C. Hine, M. D.

October 25.—W. N. Lockington.

November 29.—D. S. Newhall, Edwin P. Starr, W. H. Harned.

CORRESPONDENTS.

February 22.—John Brazier, of Sydney, N. S. W.; Rafael Arango, of Havana, Cuba; Chas. Mohr, of Mobile, Ala.

May 31.—Thomas T. Bouvé, of Boston.

June 28.—Chas. S. Sargent, of Brookline, Mass.; M. S. Bebb, of Rockford, Ill.

ADDITIONS TO THE MUSEUM.

December 1, 1880 to December 1, 1881.

Mammals.—Zoological Society of Philadelphia. *Hystrix cristata*, two *Myopotamus coypus*, portion of skin, eyes, tongue and viscera of young *Hippopotamus*; *Didelphys derbiana.*

Dr. H. C. Chapman. Stomach of *Hippopotamus*, stomach and generative organs of *Dicotyles.*

Dr. Jos. Leidy. Skeleton of *Hippopotamus amphibius* (young).

Birds.—Zoological Society of Philadelphia. *Rhamphastos toco*, *Brotogerys virescens*, *Astur Novæ-Hollandiæ*, *Melopsittacus undulatus*, *Aix galericulata*, *Scops asio*, *Chrysotis coccineifrons*, *Haliaster Indus*, *Numida vulturina.*

J. Kieff. *Dendrœca maculosa* and *D. cærulescens*, Montgomery County, Pa.

Theo. D. Rand. One egg each of swan and ostrich.

Colin F. Stam. Nest of *Trochilus colubris*, Chestertown, Md.

Chas. H. Townsend. Mounted specimen of *Numida vulturina.*

Crocodilia, *Ophidians* and *Fishes.*—J. C. Martindale. *Alligator mississippiensis* (young).

Zoological Society of Philadelphia. *Epicrates angulifer.*

U. S. National Museum. One hundred and sixteen species of fishes from the Pacific Coast of N. A.

R. M. Holbrook. *Coryphæna punctulata.*

Articulates.—Mr. Booth. *Streptocephalus* (sp.) Nevada.

T. R. Peale. *Bopyrus Manhattensis*, Red Bank, Monmouth Co., N. J.

Carlos J. Marsillan. Two species fire-flies, *Pyrophorus noctilucus* and *P. rusticus.*

J. A. Warder. *Camponotus Pennsylvanicus*, Ohio.

Dr. Edward Palmer. Thirty-two species of diurnal Lepidoptera, Mexico.

Dr. Jos. Wilson. Cocoons of *Ætias luna*, *Telea polyphemus*, *Platysamia cecropia*, etc.

H. F. Bassett. Sixty-two species of Galls.

G. Howard Parker. Four species of Galls, Phila.

Mollusks.—Rafael Arango. One species of marine, and sixteen of terrestrial shells of Cuba; four of the latter being types of new species described in the Academy's Proceedings. *Ctenopoma nodiferum*, Arango (type), Cuba

Thomas Bland Sixteen species of terrestrial shells from the West Indies; forty-one species of land shells, of which ten are author's types.

John Brazier. Forty-three specimens of shells, mostly marine, from Australia, New Caledonia, etc.; twenty-one species of Australian marine and terrestrial shells; twenty-two species of *Cypræa* and twelve speces of *Trivia*, mostly Australian; sixty-eight species of Australian marine shells.

J. J. Brown. *Cylindrella mabuja* and *C. Gruneri*, from Gonave, I. Haiti; *Corbula Caribæa*, d'Orb., from Port-au-Prince, Haiti; *Columbella mutabile*, from Salt Lake, Matlin's Isl., Bahamas. *Unio Canadensis* Lea, Lake Ellen, Sheboygan Co., Wis.

Mrs. A. E. Bush. *Helix Diabloensis*, Cooper, and *H. aspersa*, Müll., from San José, Cal.

W. W. Calkins. *Conulus Upsonii*, Calkins, Winnebago Co., Ill.

Dr. J. C. Cox. Thirty-eight species of Marine shells, from Port Stephens, New South Wales.

Dr. W. H. De Camp. *Bythinella attenuata*, Grand Rapids, Mich.

John Ford. Twenty-one sections of shells, prepared by him. Very fine suite of *Asaphis coccinea*, from Elbow Key, Fla; four species of Mollusca, and a fine section of *Turbinella scolymus*, remarkable series of *Cypræa annulus.*

The late W. M. Gabb. Seventeen species of land and marine shells collected by him in San Domingo.

Dr. W. D. Hartman. Sixteen species of *Partula*, new to our collection.

P. R. Hoy. *Amnicola lustrica* and *A. Cincinnatiensis*, from deep water, Lake Michigan.

Mrs. M. A. Haldeman. A collection of fresh-water shells, part of the cabinet of the late Prof. Haldeman.

A. A. Hinkley. Ten species of marine shells, Cedar Keys, Fla.

Joseph Jeanes. Sixty-four species and varieties of marine shells, collected by Henry Hemphill on the coast of California; eighty-six species and varieties of marine, land and fresh-water shells from the West Coast of America.

F. R. Latchford. Sixty-two species terrestial and fluviatile mollusks, from Ontario, Canada; seven species of fresh-water shells from Canada.

Isaac Lea. Twenty-five species of marine and terrestrial shells, new to the collection.

Dr. E. Palmer. *Unio fuscatus*, Lea, *U. Jayanus*, Lea, *U. nigrinus*, Lea, *U. Blandingianus*, *U. amygdalum* and *W. Buckleyi*, from near Cassina River, Fla.

C. F. Parker. Twenty-eight species of marine shells, new to the collection.

John A. Ryder. *Arca pexata*, Say, Wood's Holl, Mass. and Cherry Stone Inlet, E. Shore of Virginia; *Xylotrya fimbriata*, Jeffreys, from St. Jerome's Creek, St. Mary Co , Md.

John H. Redfield. Thirty-one species of marine bivalve and land shells, new to the collection.

S. R. Roberts. Four specimens of *Cypræa*, and three other marine species.

R. E. C. Stearns. *Helix circumcarinata* Sterns, Stanislaus Co., Cal.

John Jay Smith. Abalone, the animal of *Haliotis*, eaten by the Californian Chinese.

Geo. W. Tryon, Jr. Eighty-two species of shells, new to the collection.

Dr. J. W. Velie. *Veronicella Floridana*, *Bulimus multiradiatus*, from Florida.

W. S. Vaux. Fifty species of shells, new to the collection; three species of land shells from Tunis, and one from Peru.

Joseph Willcox. *Unio luteolus*, Lam., Rideau Lake, Ontario.

F. M. Witter. *Amnicola Cincinnatiensis*, Anth.; *Unio Mississippiensis*, *U. Anodontoides*, *U. lachrymosus*, from Muscatine, Iowa.

Fossil Invertebrata.—J. W. Vogdes, U. S. A. Sixteen specimens of Miocene fossils from Virginia (Yorktown).

Angelo Heilprin. Thirty species from the Eocene of Clarke Co., Ala., eleven of which are types; nine species from the Eocene of Alabama and Florida, two of which are types.

Conchological Section of the Academy of Natural Sciences. Eighty-six species from the Carboniferous of Illinois, etc.; two hundred and twelve species, mainly from the Palæozoic of Illinois and Indiana.

F. W. Payne. Annelid tracks in Hudson River Slate.

A. W. Bailey. Specimen of *Fulgur adversarius* washed ashore from a submarine (?) Miocene bed, Atlantic City, N. J.

J. W. Pike. Thirty-five species of Carboniferous fossils from Mazon Creek, Grundy Co., Ill.

Dr. J. W. Hess. Fossil (?) from the Carboniferous of Vermilion, Ill.

F. R. Latchford. *Leda glacialis*, Champlain clays, Ottawa River, Eardley, Quebec.

F. L. Hess. *Eurypterus*, from the Carboniferous of Streator, Ill.

Dr. Jos. Wilson. Eighteen species of Crinoids, and two species of Mollusca from the Lower Carboniferous of Burlington, Iowa.

Ethnological and Miscellaneous.—Mrs. M. A. Haldeman. The Haldeman collection, consisting of many thousand specimens, ancient and modern, of spears and arrow-heads, axes, hammers, pounders, chisels, gauges, scrapers, knives, awls, borers, morters and pestles, mullers, net-sinkers, plummets, discoidal stones, sharpeners, pierced tablets, ceremonial weapons, pendants, sculpture, pipes, pottery, beads and other ornaments, shell-money, basket-work, bows and arrows, etc.

Dr. J. B. Brinton. Pestle, Cooper's Creek, Camden, N. J.

Harriet M. Harned. Indian relic, Oxford, Adams Co., Pa.

Otto W. Lowe. Stone axe (serpentine), Rock Island, Ill.

Plants.—Wm. M. Canby. Five hundred and fifty-two species of plants from Europe, S. Africa, Australia, Madeira and N. America.

Isaac C. Martindale. *Turnera aphrodisiaca* Ward, Mexico. *Mentzelia crocea* Kell., Calif. Trunk of *Quercus heterophylla* Mx., from Mt. Holly, N. J. Ellis' N. American Fungi, centuries V, VI and VIII.

Hugh D. Vail, Los Angeles, Calif., through Benj. N. Marsh. *Echinocactus Wislizeni* Engelm., Arizona. Twigs and acorns of *Quercus Wislizeni* var. *frutescens* Engelm., Cal. Twigs and acorns of *Q. dumosa* Nutt., Cal. Twigs and acorns of *Q. oblongifolia* Torr., Cal. Twigs and acorns of *Q. agrifolia* Nees, Cal. Flowering specimens of *Eucalyptus obliqua* (?), cult. in Cal.

Dr. J. H. Eckfeldt. One hundred species of Lichens from Northern U. States, mostly new to the collection, with catalogue; pod of *Hymenæa Courbaril*, from West Indies.

Thos. Meehan. *Corallorhiza Mertensiana* Bong., Washington Terr.; *Pachystima Canbyi* Gr., cult. from plants found at Wytheville, Va.; *Salisburia adiantifolia*, in fruit, from Wistar's garden, Germantown; *Arceuthobium occidentale* var. *abietinum* Engelm., Washoe Valley, Nevada.; *Phoradendron juniperinum* var. *Libocedri* Engelm., Washoe Valley, Nevada.

Isaac Burk. Fruit of *Chrysobalanus oblongifolius*, raised from seed by Mrs. Caroline Pennock, Delaware Co., Pa.; stem and root of *Aristolochia tomentosa* Sims, cultivated.

R. P. Smith and J. Jay Smith, of Germantown, Phila.; specimens of *Eucalyptus globulus* Lab., cult. in Cal.; *E. amygdalina*, cult, in Cal.; *E. rostrata*, cult. in Cal.

Chas. F. Parker. One hundred and seventy-five species of N. American plants from his herbarium, many of them new to the collection.

Two ladies, unknown. Collection of Marine Algæ, mostly from N. York Harbor, beautifully mounted and superbly bound; prepared for Charles M. Wheatley, by Saml. Lounsbury, of N. Y.

M. S. Bebb, Rockford, Ill. *Herbarium Salicum, Fasciculus primus*, being the first instalment of what is intended to be a full suite of the North American Willows, with such European forms as may aid in the understanding of their affinities With full printed tickets and manuscript notes, accompanied often with magnified drawings of the floral organs.

Dr. S. B. Buckley, Austin, Texas. *Clematis coccinea*, Englm.; *Berberis Swayzei* Buckl.; *Ampelopsis quinquefolia* Mx., var. *heptaphylla* Buckl.; *Styrax platinifolia* Engelm.; *Quercus Durandi* Buckl., series of specimens showing variations of foliage; *Quercus rubra L.*, var. *Texensis* Buckl.; all from Texas.

Prof. C. S. Sargent, Commissioner of Forestry Department of Tenth Census of U. S. Series of specimens of N. American woods, showing transverse and longitudinal sections and bark, all named at the Arnold Arboretum, Cambridge, and numbered to correspond with Prof. Sargent's Catalogue of Trees and Shrubs of N. America.

M. Carey Lea. A large collection of plants, consisting, first, of species collected by him in vicinity of Philadelphia; second, of species collected by Dr. Engelmann, Prof. Tuomey, and others, in Western and Southern States; third, of species of European plants, collected by Prof. Balfour, of Edinburgh.

Harriet M. Harned. Fungus (?).

J. P. H. Fruit of the great flowering Mimosa, Bombay.

Dr. Geo. Vasey, Agricultural Department, Washington, D. C. Twenty species of grasses, collected by the Wilkes Exploring Expedition, years 1838 to 1842.

C. Mohr, Mobile, Ala. Specimen of the rare *Darbya umbellata* Gray, staminate plant, near Cullmann, Ala.

Geo. E. Davenport, Boston, Mass. *Tænitis lanceolata* R. Br., a fern new to the U. S., from Old Rhodes Key, Florida.

Wm. P. Fodell. Double pear, preserved in alcohol, from garden in Kensington, Phila.

T. R. Peale, *Broussonetia papyrifera* Vant., in fruit, cultivated at Red Bank, N. J.; leaves of *Quercus heterophylla* Mx., different forms, Swedesboro, N. J.

F. W. Price. *Linaria vulgaris* Mœnch., peloric form and form without spur, West Chester, Pa.

F. L. Scribner. *Calamagrostis Howellii* Vasey, new species from Oregon; *Panicum capillare* L., variety from Phila.; *Eulalia Japonica* Trin., cultivated, native of Jamaica

Prof. Asa Gray, Cambridge, Mass. A collection of one hundred and two species of plants, collected by Dr. J. E. T. Aitcheson, in the Kurum Valley, Afghanistan, in 1879.

J. M. Hutchings, Yosemite, Cal. Cone of *Pinus Lambertiana,* framed in wood of the *Sequoia gigantea.*

John H. Redfield. Forty-six species of plants from N. Mexico, Colorado and California, many of them new to the collection. Eleven species of ferns from California, Arizona and N. Mexico, new to the collection. Seventeen species of ferns and lycopods, collected in New Zealand by A. Craig.

Minerals.—C. S. Bement. Corundum, Mineral Hill, Del. Co., Pa.; Hydrohematite, Chestnut Hill, Lanc. Co., Pa.; Rutile and quartz, Graubünden; Pyrolusite, Ilmen, Thuringia; Pyrolusite (polianite), Bohemia; Ouvarovite, Wakefield, Can., Oxford, Can.; Pyrosmalite, Nordmarken, Sweden; Stilbite and apophyllite, Cape d'or, N. S.; Samarskite, Mitchell Co., N. C.; Apatite, Renfrew, Can.; Autunite, Cornwall, Eng.; Ankerite, Erzberg, Styria; Aragonite, colored by cobalt, Schwartz, Tyrol; Meteoric iron, Aug. Co., Va.; Blende, Ulster Co., N. Y.; Greenockite, Friedenville, Pa.; Arsenopyrite, Cornwall, Eng.; Magnetite, Binnenthal; Rutile in pericline, Pfitsch, Tyrol; Limonite on quartz, Schneeberg, Sax.; Wollastonite, Lewis Co., N. Y.; Garnets, Phila., Jefferson Co., N. Y., and Kremnitz, Hungary; Axinite, near Bethlehem, Pa.; Felspar, Silesia, Austria; Datholite, Isle Royal, L. S.; Serpentine, Grand Cal. Is., Can.; Serpentine pseud., after Monticellite, Monzoni, Tyrol; Titanite, Renfrew, Can.; Wolframite pseud., after Scheelite, Trumbull, Conn.; Barite (cawk), Derbyshire, Eng.; Blue Calcite, Rossie, N. Y.; Azurite, Moldaira; Orpiment, Felsöbánya, Hungary; Petzite, Col.; Spinel and Idocrase, Vesuvius; Manganite, Sweden; Limonite, Chestnut Hill, Lanc. Co., Pa., and Superior Mine, Mich.; Cookeite, Mt. Mica, Me.; Wollastonite, Vesuvius; Pyroxene, Renfrew, Can.; Tourmaline (nine crystals), Pierpont, St. Lawrence Co., N. Y.; Titanite, Medels, Surry and Ontario, Can.; Pinite, Schwartzenbach, Bavaria; Pyromorphite, Cumberland, Eng.; Brochantite, Sonnenberg; Calcite, St. Louis, Mo.; Concretions of Siliceous carb. of lime, Easton, Pa.; Concretions (very beautiful), head of Conn. River, N. Y.; Thenardite, Tarapaca, S. A.; Zircon (twin crystal), Renfrew, Can.; Apatite, Renfrew, Can.; Scapolite, St. Lawrence Co., N. Y.; Sphene and wollastonite, Lewis Co., N. Y.; Millerite, Antwerp, N. Y.; Pyroxene, Can.; Zircon, Grenoble, Can.; Muscovite, Portland, Conn.; Zircon with apatite, Renfrew, Can.; Columbite, Middletown, Conn., and Portland, Conn.; Campylite, Cumberland, Eng.; Specific gravity apparatus of Jolly.

Wm. S. Vaux. Fine specimens of Danburite, Russell, St. Lawrence Co., N. Y.; Fine specimen of apatite in calcite, Canada; Twin Zircon, Renfrew, Canada; Native gold in quartz, Gaston Co., N. C.; Native copper, Australia; Native sulphur, Napa Co., Cal.; Byssolite, Chester Co.; Chrysocolla, Berks Co. Pa.; Prehinite, Charleston, Mass.; Haüynite, Laacher See, Prussia; Andalusite, Tyrol; Stilbite, Reading, Pa.; Dolomite (gurhofite), Sussex Co., N. J.; Siderite, Scranton, Pa.; Aragonite with Chalcopyrite and magnetite, Berks Co., Pa.; Cerussite, Chester Co., Pa.; Malachite, Berks Co., Pa.; Azurite and Chrysocolla, Lebanon Co., Pa.; Galenite, coated with Pyromorphite, Stolzite with Wulfenite, Pyromorphite and galenite, all from Wheatley Mine, Chester Co., Pa.; Pebble of anthracite, Tamaqua, Pa.

Mrs. Hugh Davids Octahedrite (Wiserine), Binnenthal, Switzerland; Wolframite, Germany.

J. B. Gicker. Actinolite, washed from decomposed rock, Chestnut Hill, Delaware.

Jos. P. Hazard. Anthracite, Wales; Metallic tin, Cornwall; Limestone, Himalaya Mts.

A. Meyer. Twenty-nine specimens of fossil iron ores and associated rocks, Lycoming Co., Pa.

Mr. Fiss. Beryl (very large crystal), Amelia Co., Va.

S. Tyson. Bastnäsite and Tysonite, Colorado.

Jos. Willcox. Corundum; ditto, coated with damourite; ditto, coated with margarite, Iredell Co., N. C.

Geo. Woener. Impure limonite; bituminous shale, Pa.

E. S. Reinhold. Alunogen, Mahanoy City, Pa.

A. H. Smith. Flattened garnet in muscovite, Del. Co., Pa.; Boulders dredged from bed of Del. River, below Chester, Pa.; Gneiss, Schooner Ledge, Del. River.

Peter Walker. Dendritic manganese in sandstone, conglomerate, etc., Wayne Co., Pa.

J. W. Pike. Limonite nodule, Newfield, N. J.

S. Ball. Hematite in green quartz; siderite; rhodonite; all from near Windsor, Me.

G. Howard Parker. Aquacreptite; autunite; menaccanite; apatite; all from vicinity of Phila.; Native tellurium, Boulder Co., Col.

Theo. D. Rand. Nine specimens of rocks, vicinity of Phila.; Gypsum (artificial), from a salt-pan; Quartz in mica, Amelia Co., Va.; Stalactite, mountain cork, and nine specimens of rocks, Del. Co., Pa.

W. P. Adams. Dolomite, Harford Co., Md.

E. M. Bye. Magnetite, enstatite, talc with altered actinolite, serpentine, picrolite; all from Harford Co., Md.

H. C. Lewis. Halotrichite, East Park, Phila.; Halotrichite, melanterite and sulphatite (efflorescence on marl), West Jersey marl pits; Fahlunite, Germantown, Phila.; Recent rain prints, marl pits, Pemberton, N. J.

W. W. Jefferis. Aragonite, pyrite, Chester Co., Pa.; Garnet, Del. Co., Pa.; Epidote, Baltimore, Md.; Calcite, Wisconsin; Quartz, Mill Creek Hundred, Del.

C. M. Wheatley. Chalcocite, pseudomorph after wood, Little Whitia River, Archer Co., Tex.

W. H. H. Bates. Pyrrhotite, China, Me.

J. M. Hartmann. "Salamander," or slag, from blast furnace, Oxford, N. J.

Mrs. M. A. Haldeman. Spinel ruby, Ceylon.

Dr. Kreizer. Black marble, Myerstown, Lebanon Co., Pa.

In exchange. Vesuvianite, Templeton, Can.; White Garnet, Hull, Can.; Apatite (twin crystal), Renfrew, Can.; Smithsonite, Sultanella, Spain; Aragonite, Fort Collins, Col.

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Beadle, Rev. E. R., memorials of. 2d Presbyterian Church.

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Berg, Carlos. Apuntes lepidopterológicos. The Author.

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Espèce nouvelle du genre Trichillum. Note sur le genre Macroderes Wstw.

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Boucard, A. Coleoptera of the genus Plusiotis. The Author.

Bouvé, T. T. Historical Sketch of the Boston Society of Natural History. The Author.

Bowditch, H. I., M. D. Public hygiene in America. The Author.

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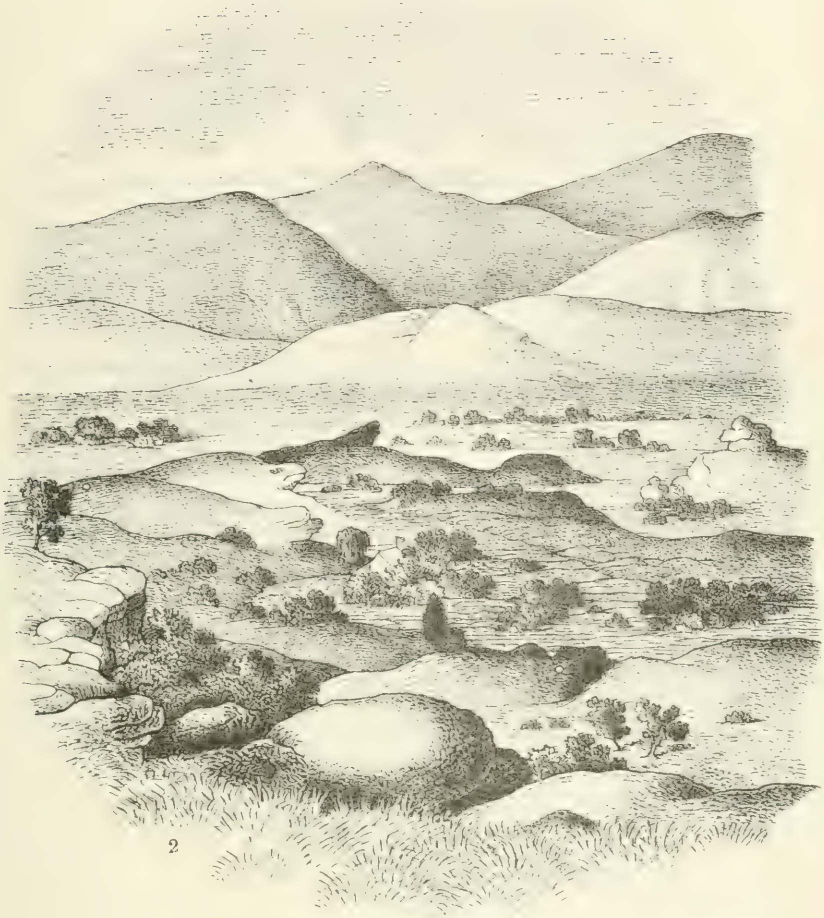
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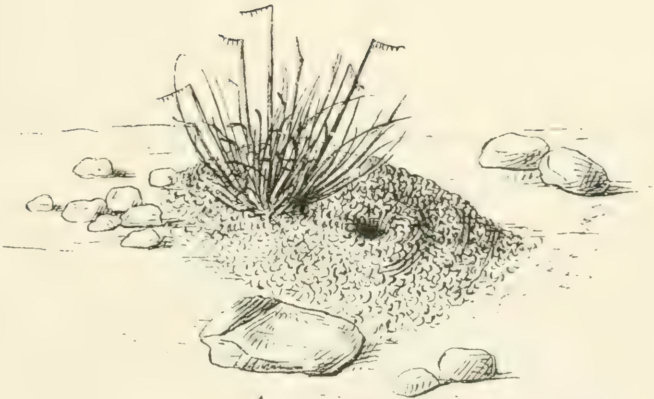

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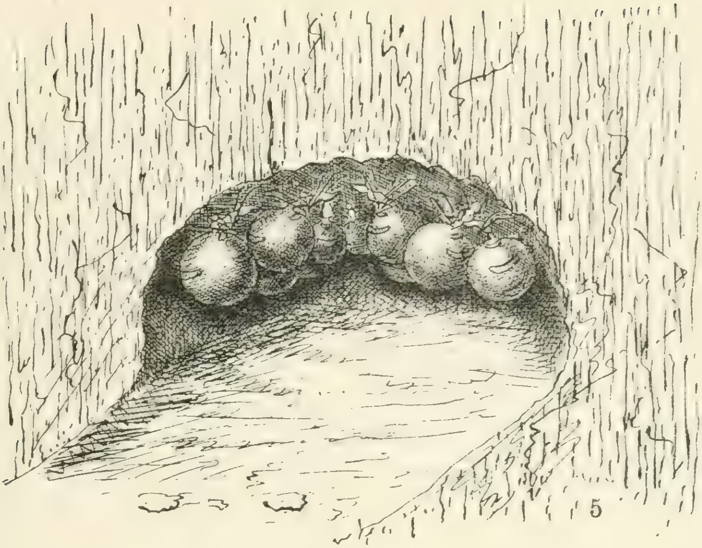

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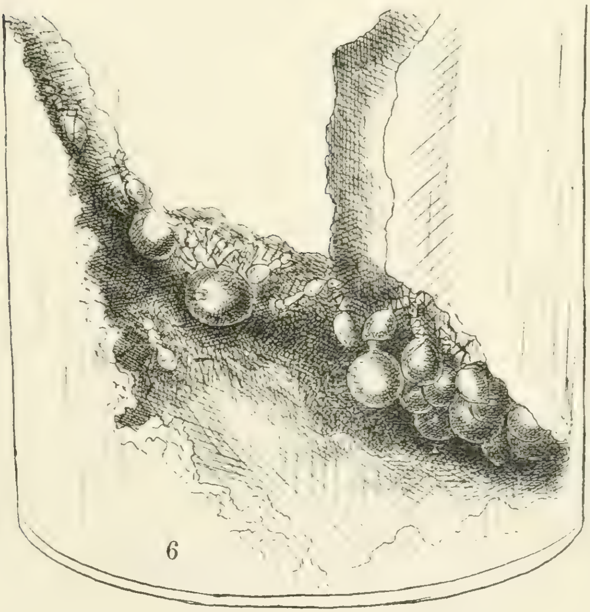

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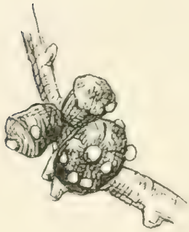

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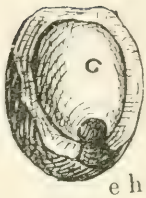

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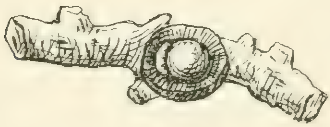

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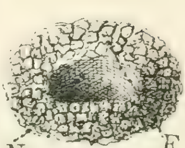

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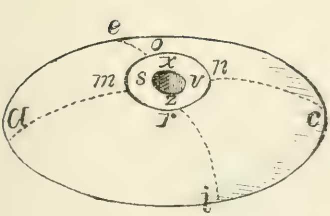

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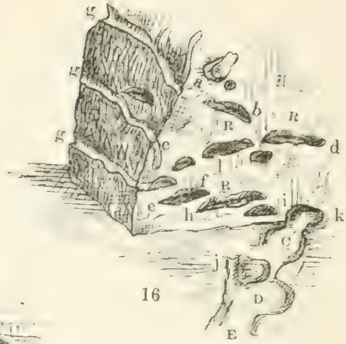

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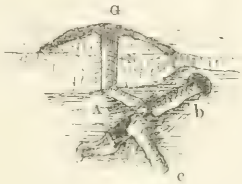

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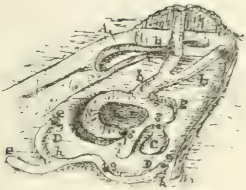

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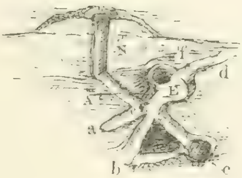

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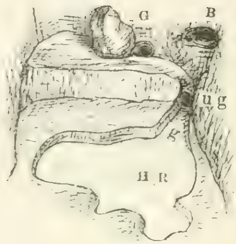

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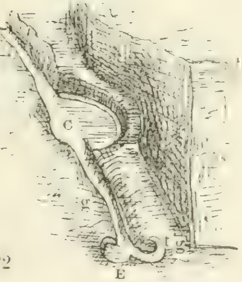

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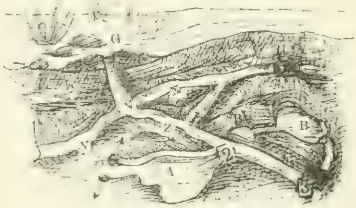

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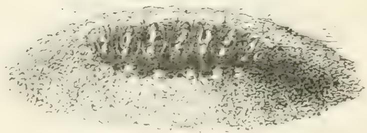

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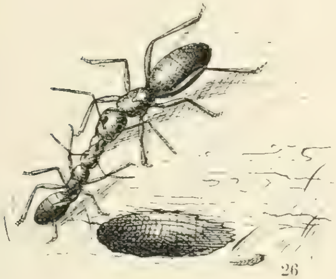

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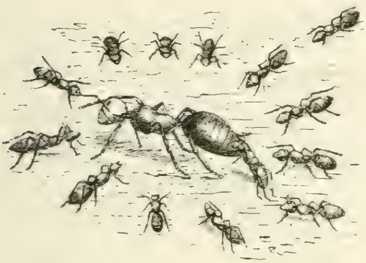

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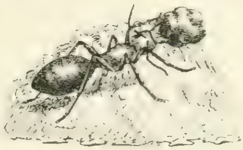

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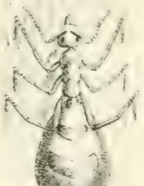

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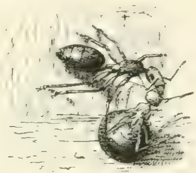

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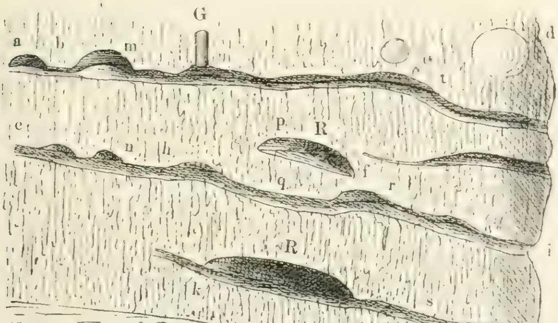

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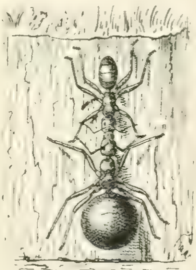

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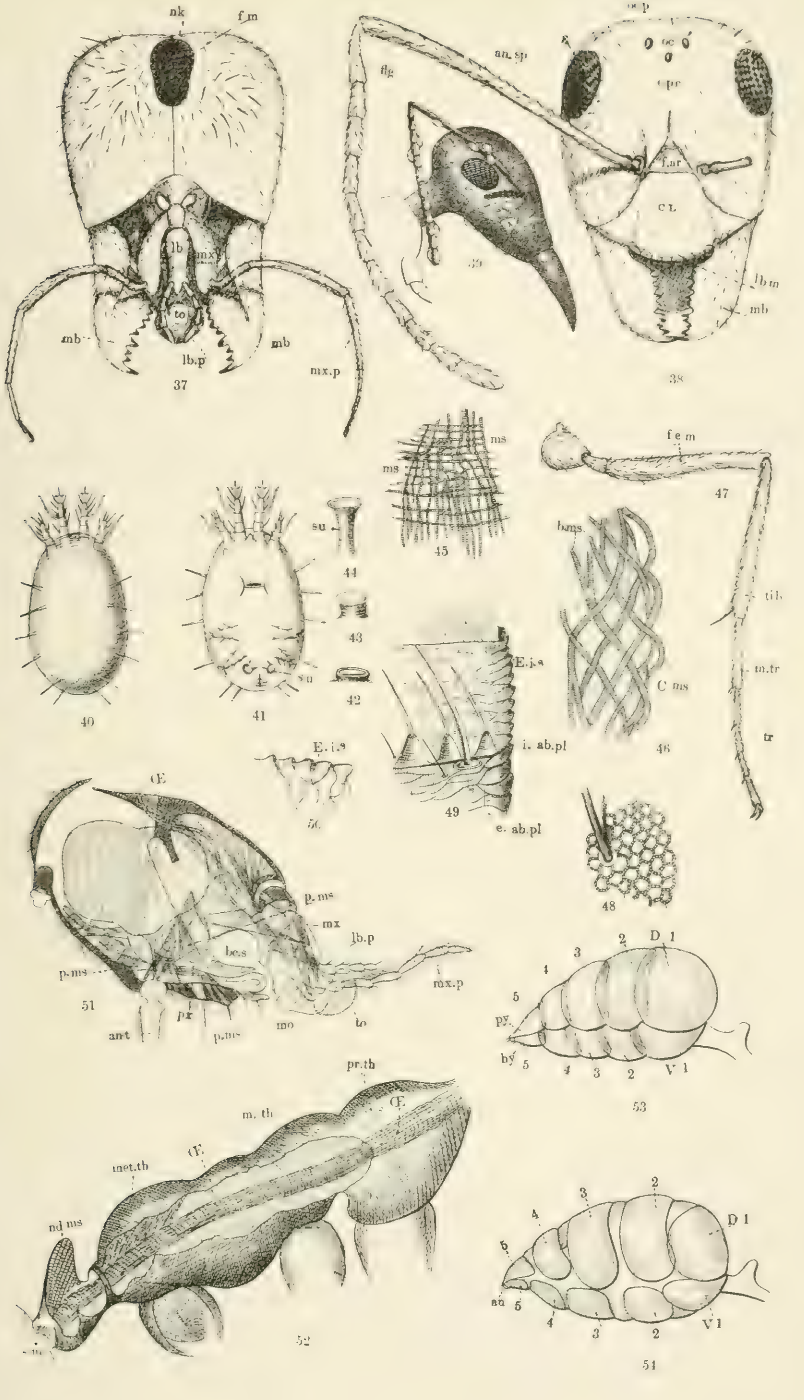
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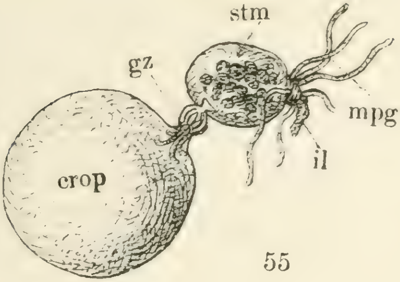

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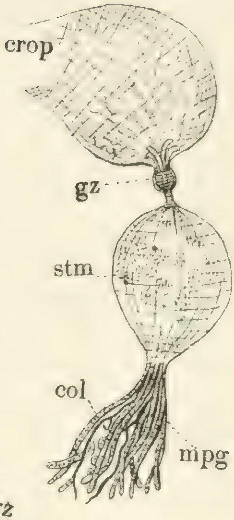

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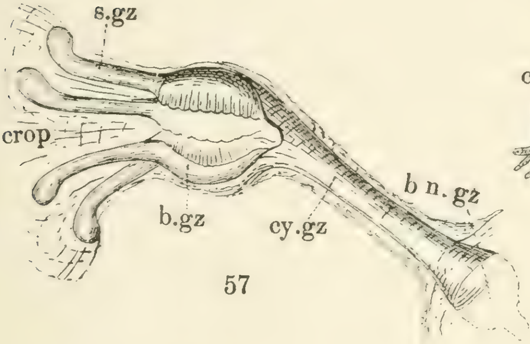

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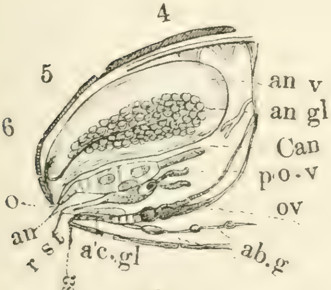

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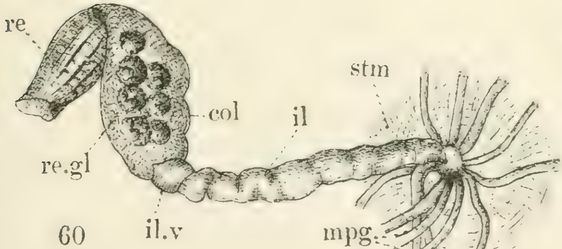

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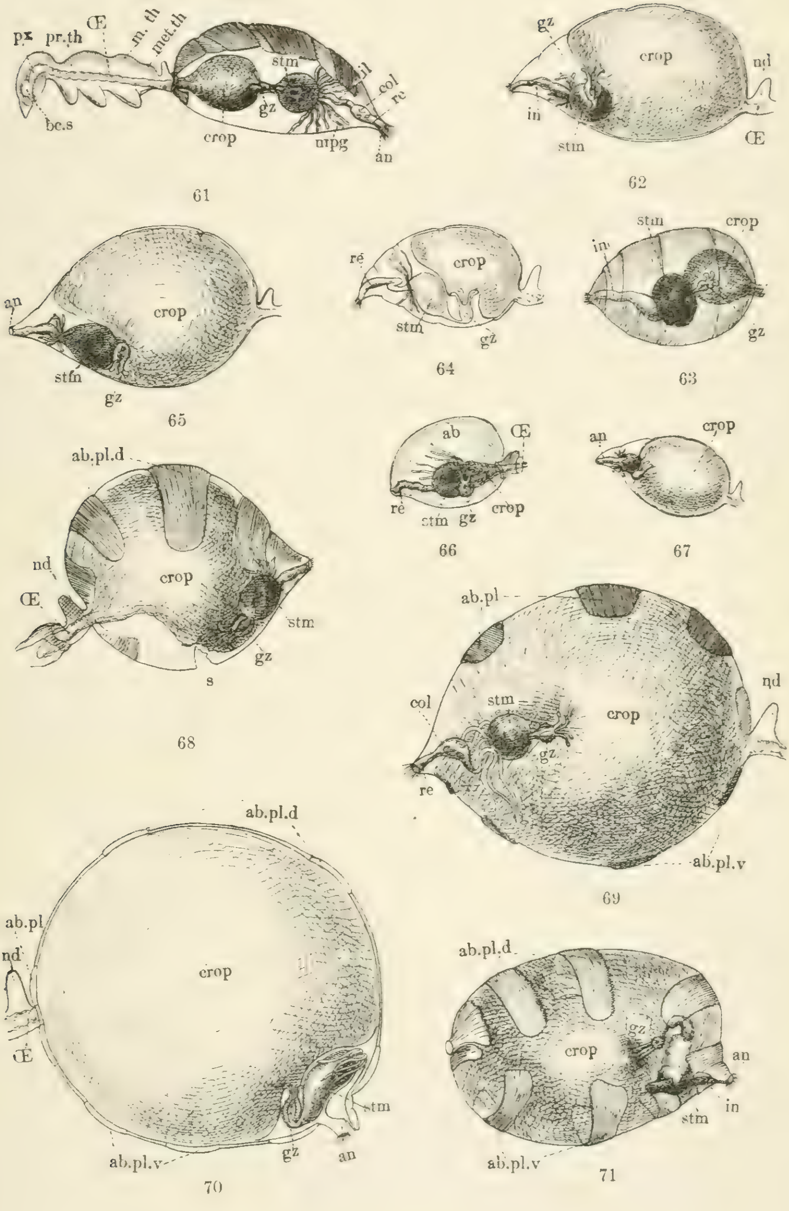
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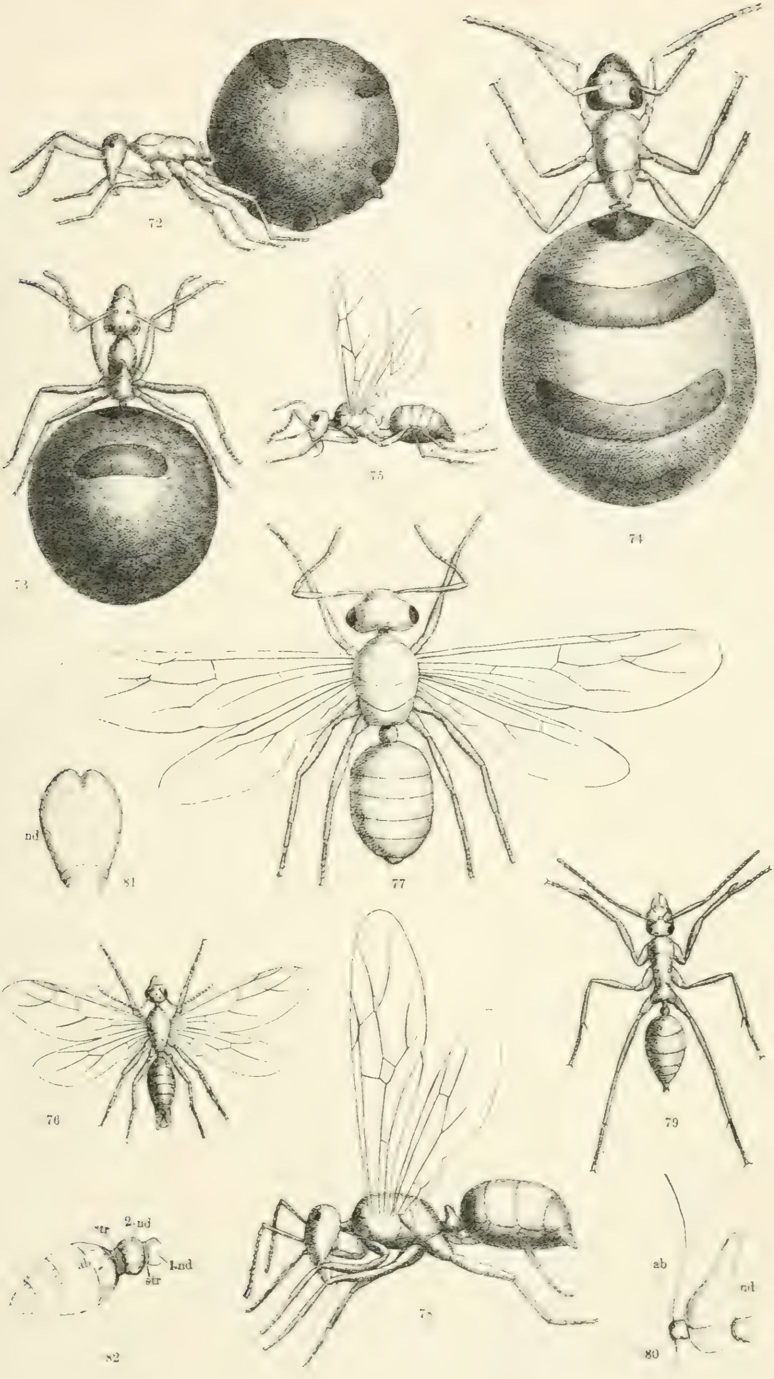
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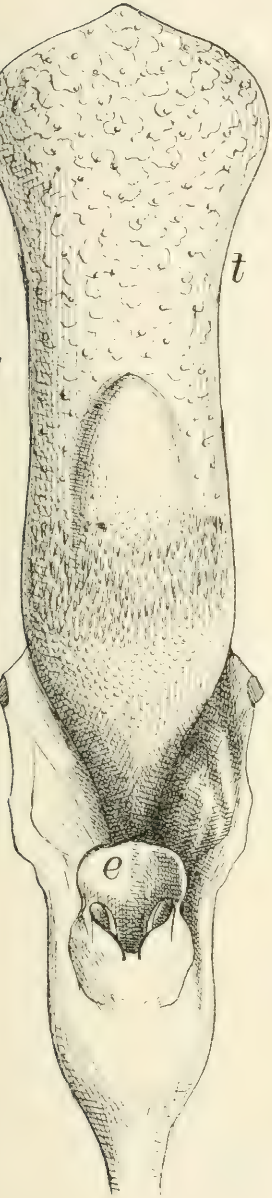

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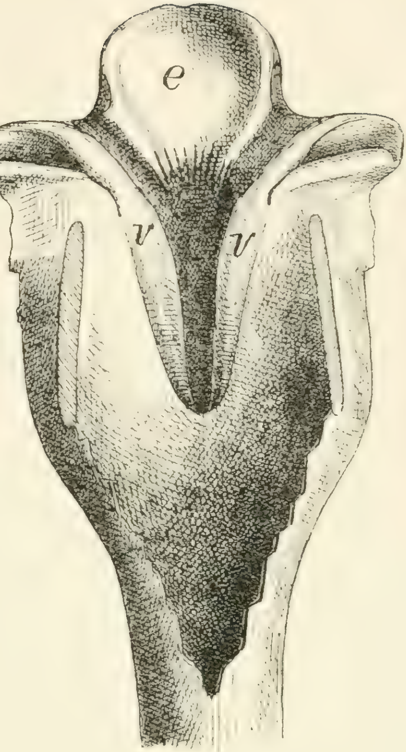

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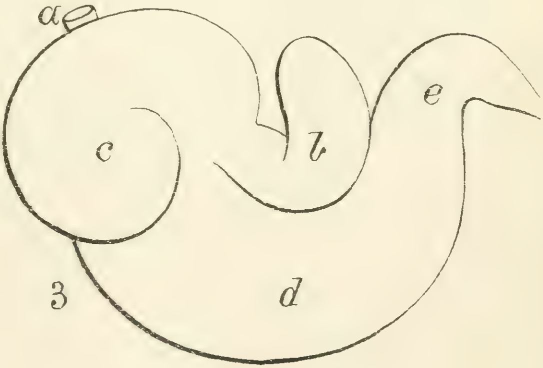

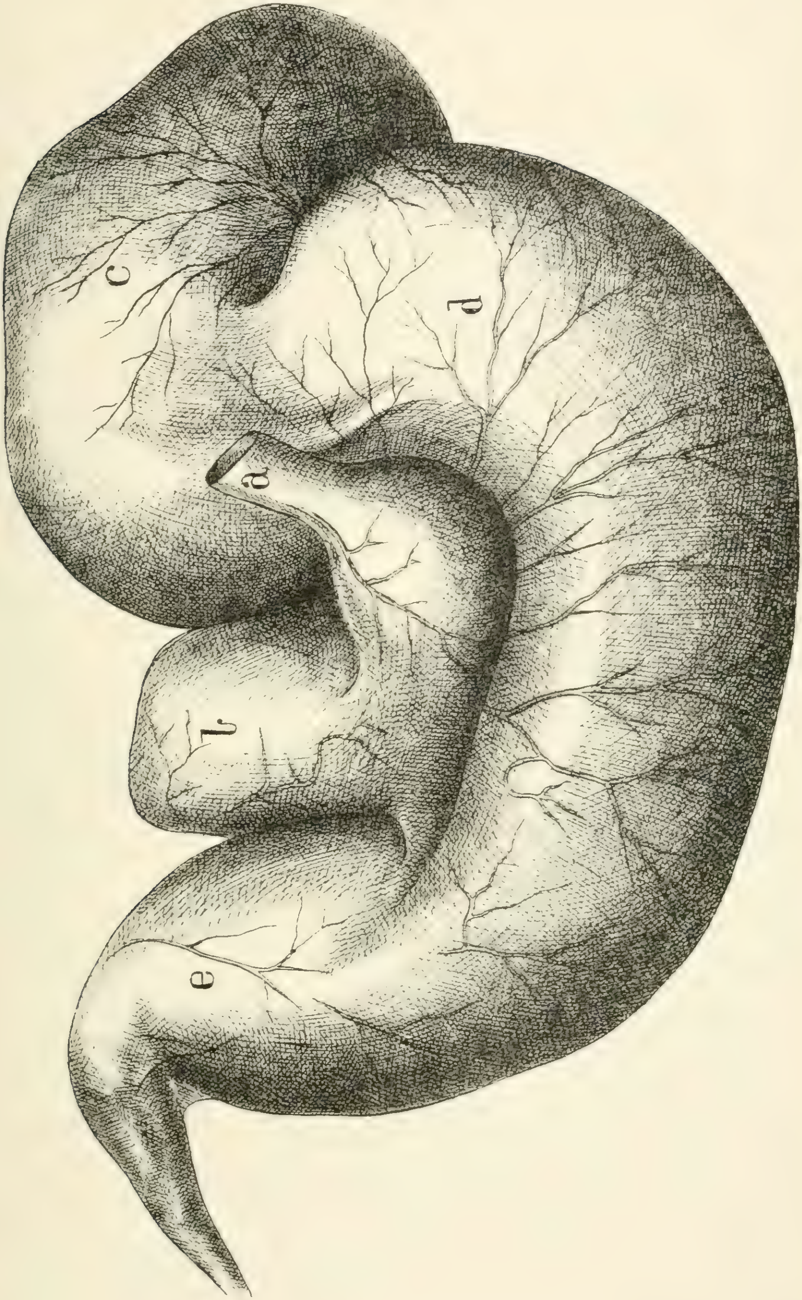
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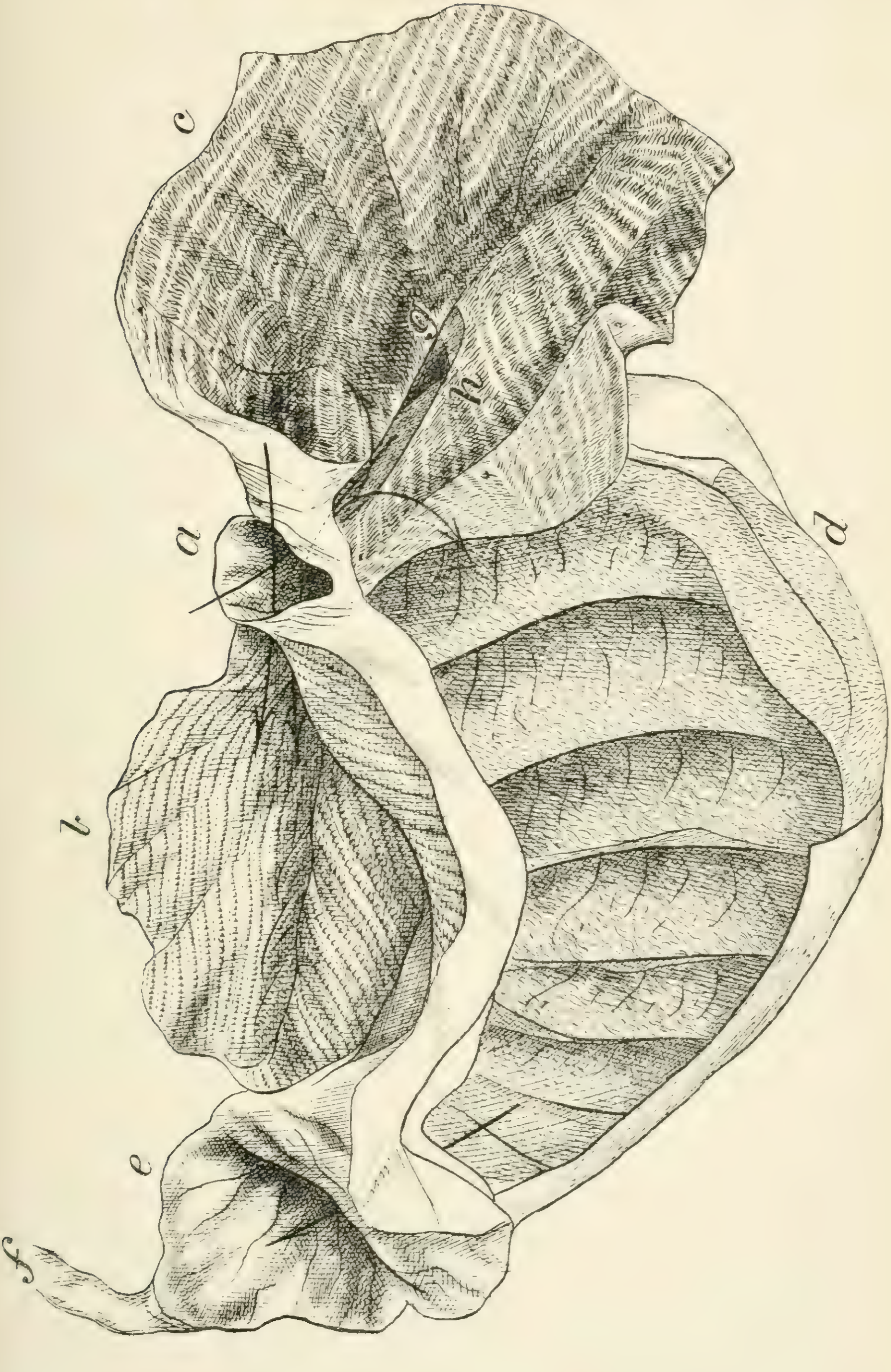
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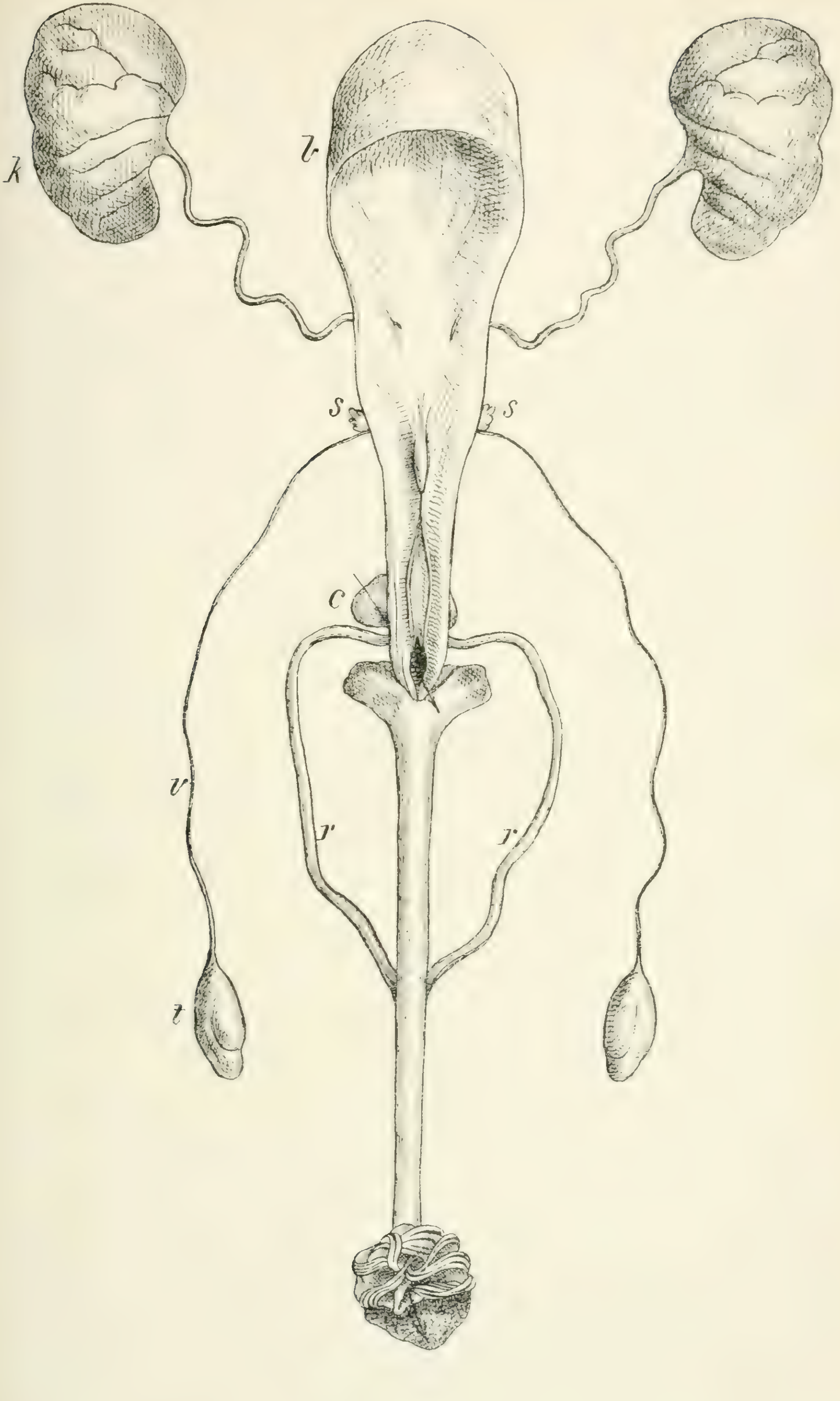
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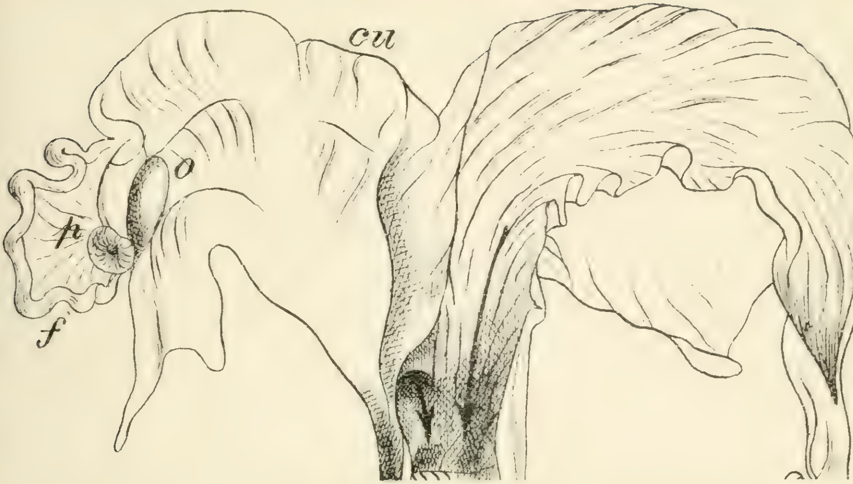
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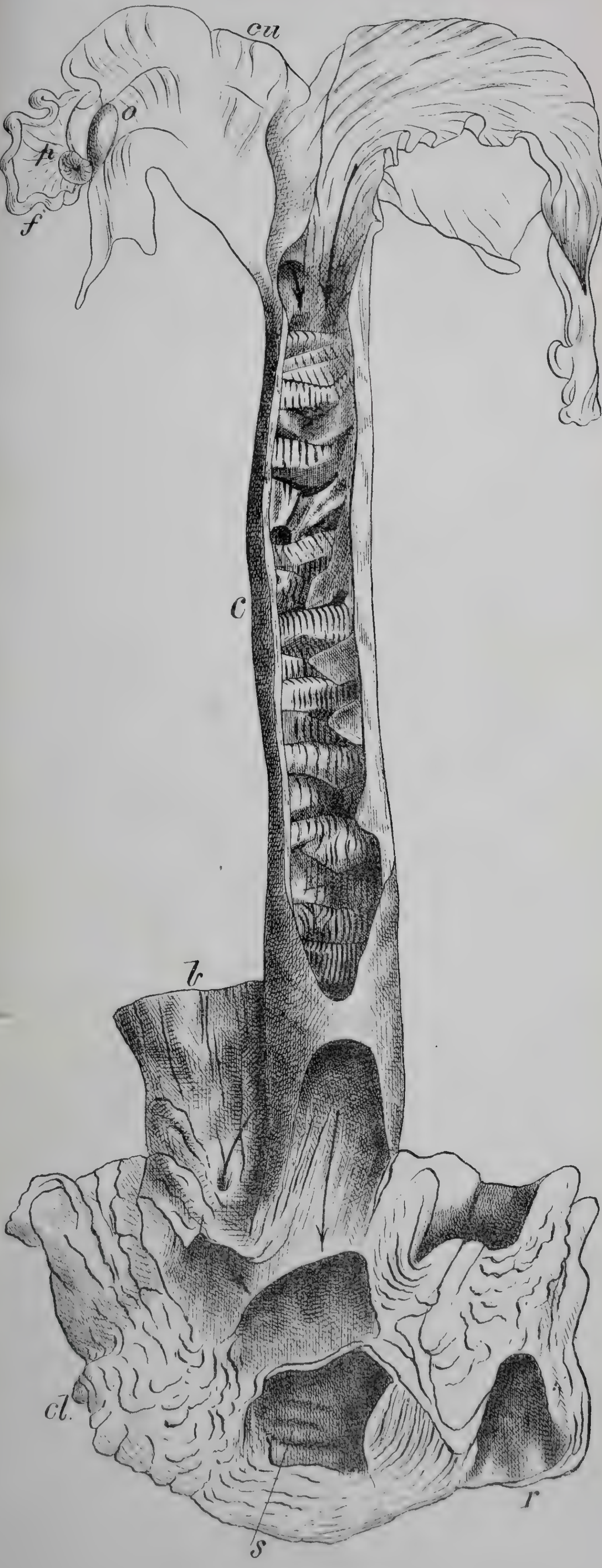
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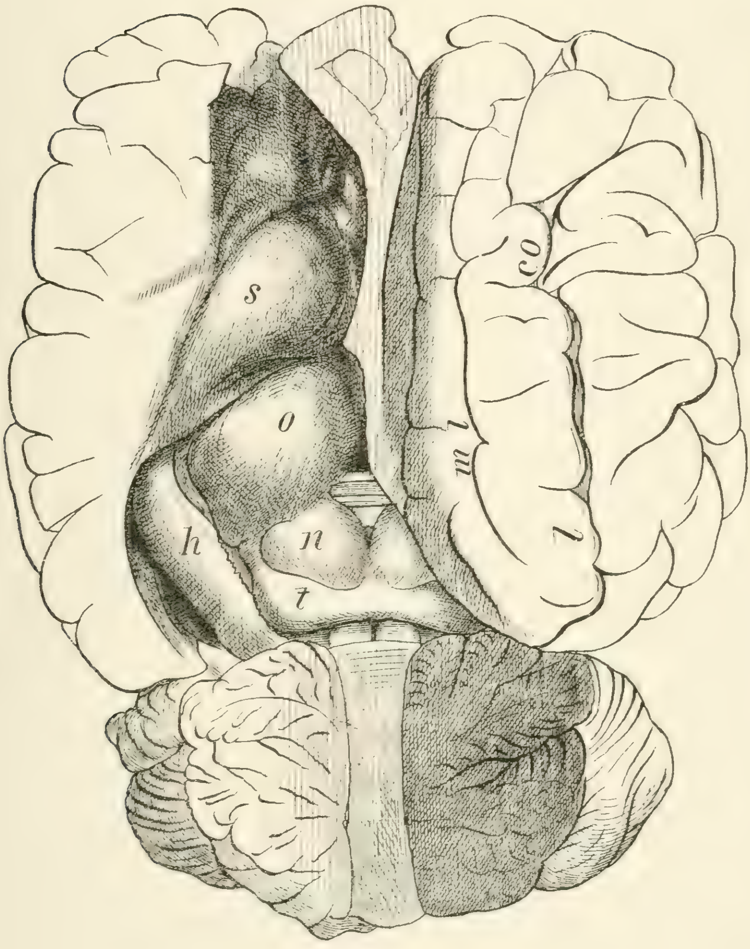
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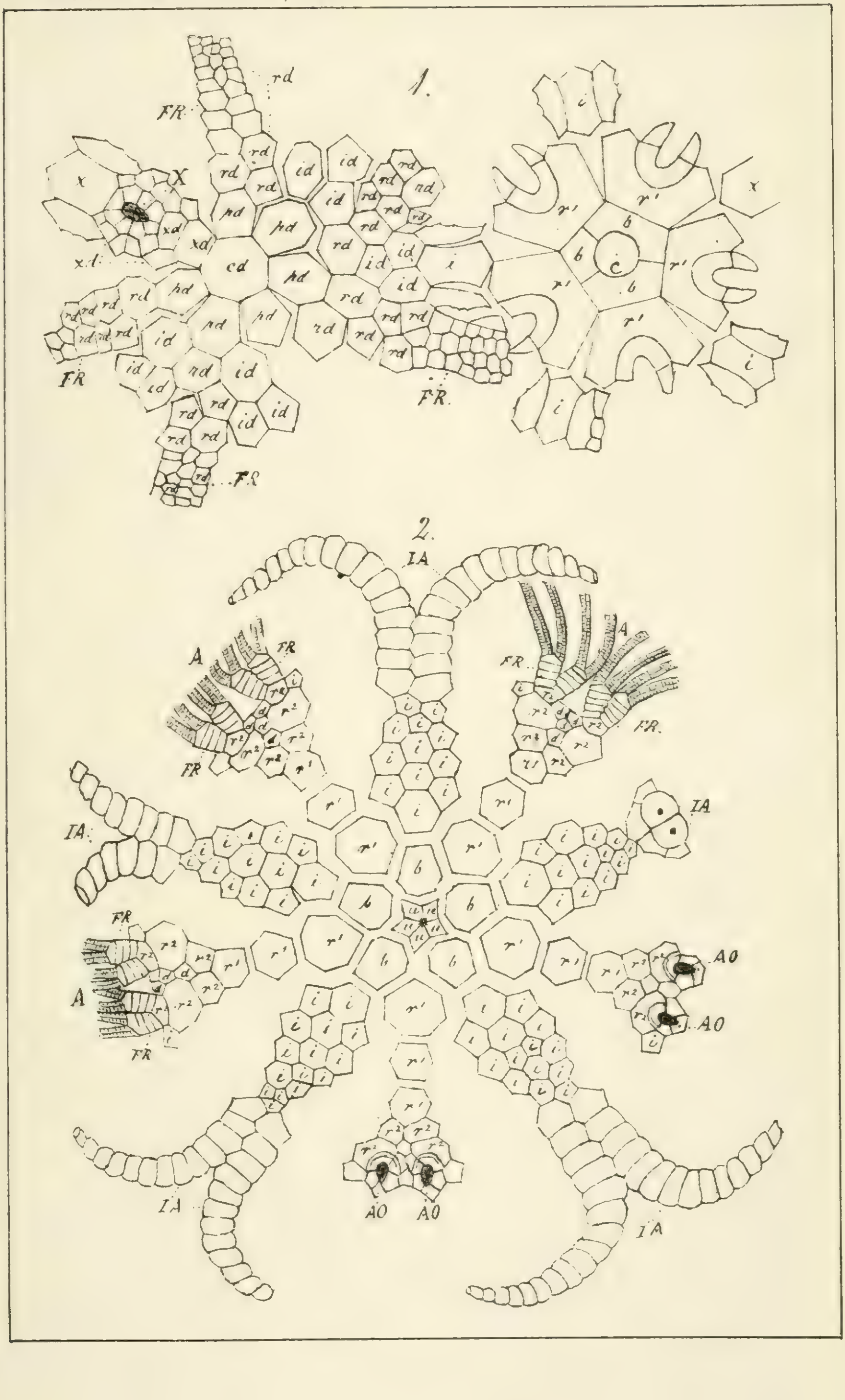
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