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REVISION OF THE NEW YORK HELDERBERGIAN CRINOIDS.

By Mignon Talbot.

Art. IV. — *Revision of the New York Helderbergian Crinoids;** by Mignon Talbot. (With Plates I–IV.)

This paper treats of the Crinoidea of the Helderbergian rocks of New York, and is a continuation of Dr. George H. Girty's thesis, "A Revision of the Sponges and Coelenterates of the Lower Helderberg Group of New York." In Dr. Girty's paper, the term "Lower Helderberg" included the Tentaculite, or Manlius, limestone; but here "Helderbergian," as proposed by Clarke and Schuchert,† is used to include only the Coeymans, or Lower Pentamerus; the New Scotland, or Delthyris Shaly; and the Becraft, or Upper Pentamerus.

With the exception of the work done by Wachsmuth and Springer, who probably used specimens that Hall had studied, the crinoids of the Helderbergian rocks of New York have not received much attention since Hall's descriptions were published, in 1859. Very little subsequent collecting has been done, and for the most part the forms secured have been specimens of *Homocrinus scoparius* and *Edriocrinus pocilliformis* or simply stem fragments, the work of gathering being done in the New Scotland.

A reopening of the old locality at Jerusalem Hill was made, however, in 1901, by Professors Beecher and Schuchert; and a new locality was discovered at North Litchfield, both of these being in the Coeymans limestone. The majority of fossils found were crinoids, but there were also cystids in appreciable numbers and five ophiuroids representing two genera. In the fall of 1903, these collections were increased by more material collected at the same locality by Mr. C. J. Sarle; so that in the Yale University Museum there are now three collections—one from Jerusalem Hill and two from North Litchfield.

The first of these consists mainly of *Homocrinus scoparius*, though it contains uncompressed forms of *Cordylocrinus plumosus* and several good specimens of *Melocrinus pachydactylus*. In the region of Litchfield, the Coeymans limestone attains a thickness of one hundred and fifty feet and *Homo-*

* This paper is part of a thesis presented to the Graduate Faculty of Yale University for the degree of Doctor of Philosophy, in June, 1904. The larger part of the work was done under the supervision of the late Professor Charles Emerson Beecher, for whose help and inspiration the writer wishes to make the most grateful acknowledgment. Type specimens have been studied in the Yale University Museum, the New York State Museum and the American Museum of Natural History; and the thanks of the writer are here expressed to Professor R. P. Whitfield, Dr. J. M. Clarke, Dr. E. O. Hovey and Mr. H. H. Hindshaw, for courtesies in connection with the study, and to Professor Charles Schuchert, who took up the direction of the work after Professor Beecher's death.

† Science, New Series, vol. x, p. 876, 1899.

crinus scoparius is said to range from the Manlius almost to the top of the Coeymans. Most of the specimens in the Yale collection were found about forty-six feet from the top of the section in a twelve-inch layer containing slabs rich in *Homocrinus scoparius* and also specimens of *Melocrinus pachydactylus*, *Anomalocystites cornutus*, *Lepocrinites gebhardi* and the ophiuroids. *Cordylocrinus plumosus* is abundant in the lower bed mentioned later.

The collection from North Litchfield is chiefly from two horizons and is extremely rich. One of these beds is a limestone four inches thick in which are specimens of *Melocrinus nobilissimus* with very large crowns and very stout, long stems and a large form of *Cordylocrinus plumosus* in comparative abundance, the majority of the individuals showing many long cirri crowding around the calyx. The material from this zone has one specimen of *Lepocrinites gebhardi* and several of *Homocrinus scoparius.* Although all the fossils in this bed are of large size, especially is this true of *Melocrinus nobilissimus*, whose columns are very thick and, though only fragments, measure from fifty to seventy centimeters in length. This is long for Paleozoic crinoids. Wachsmuth and Springer state that no columns over three feet in length have been seen from the Paleozoic and that generally they are not over one foot long.* Here there are numbers over two feet in length.

The other horizon, a few inches higher in the section, has furnished slabs covering a floor space of some sixty-five square feet, slabs that are literally covered with crinoid stems and crowns. Here, too, as in the lower bed, are stems over two feet long. The forms represented are *Mariacrinus beecheri*, *Melocrinus nobilissimus*, *M. pachydactylus*, *Thysanocrinus arborescens* and *Cordylocrinus plumosus.* To show the relative abundance of these species, an enumeration of the individuals on the slabs was taken and by actual count there were found, of *Mariacrinus beecheri* thirty-one specimens, of *Melocrinus nobilissimus* six, of *M. pachydactylus* one, of *Thysanocrinus arborescens* ten, and of *Cordylocrinus plumosus* eight hundred and seventy-three, making a total of nine hundred and twenty-one specimens. In addition to these are numerous crinoid columns, several gastropods and brachiopods and one cephalopod. On a small surface of six square feet there are three hundred and twenty crinoids.

The cover of this bed is also in the collection and it is estimated that two-thirds as many more crinoids are on its lower surface. This enumeration was made before anything was done toward developing the slabs and such preparation may

*North American Crinoidea Camerata, vol. i, p. 39; Mem. Mus. Comp. Zool., Harvard College, vol. xx, Cambridge, Mass., May, 1897.

double the number now visible; hence in this one collection, there are undoubtedly more crinoids than in all other collections from New York combined.

The following species, listed by Hall from the Coeymans limestone at North Litchfield, have not been recognized in the Yale material: *Mariacrinus paucidactylus* (probably *Melocrinus pachydactylus*), *M. ramosus*, *M. plumosus*, *Platycrinus parvus* (probably *Cordylocrinus plumosus*), *P. ramulosus* (seems to be restricted to the Cobleskill zone of the Manlius) and *P. tentaculatus*. This is not to be wondered at, however, as a slight change of position, horizontally or vertically, often reveals a different fauna; and as Hall's collections represented gatherings not only from the quarries but also from the stone walls about the town of Litchfield, the fossils undoubtedly came from different horizons and localities.

In the classification, nomenclature and terminology of the crinoids, Wachsmuth and Springer have been followed and the reader is referred to their works, "The North American Crinoidea Camerata"* and "The Revision of the Palæocrinoidea."†

Order, INADUNATA Wachsmuth and Springer.

Suborder, FISTULATA, Wachsmuth and Springer.

Family, *Cyathocrinidæ* Roemer.

Genus, *Homocrinus* Hall.

Homocrinus scoparius Hall. Plate III, figure 3.

Homocrinus scoparius Hall, Nat. Hist. N. Y., Pal., vol. iii, 1859, p. 102, pl. 1, figs. 1–9.—Wachsmuth and Springer, Rev. Palæocr., Pt. I, 1879, p. 79; Proc. Phila. Acad. Nat. Sci., vol. xxxi, 1880, p. 302.—Bather, Kongl. Svenska Vet. Akad., Handl. xxv, 1893, p. 105.

In the collection of crinoids from Jerusalem Hill, N. Y., now in the Yale University Museum, there is a considerable number of slabs showing *Homocrinus scoparius* in abundance. These slabs vary in size from a few centimeters to over half a meter in length and the surfaces are virtually covered with these beautiful fossils. One slab, thirty centimeters long and twenty-three wide, has eighteen specimens, three of which are complete, that is, have the crown and the whole length of the column, including the distal end. Aside from these, there are four other stems and two (possibly three) specimens of *Anomalocystites cornutus* on the same slab. On other slabs from the same horizon are *Melocrinus pachydactylus*, *Anomalocystites cornutus*, *Protaster forbesi*, and *Dalmanites sp. (?)*. Many

* Memoirs of the Museum of Comparative Zoology at Harvard College, vols. xx and xxi, with Atlas, Cambridge, Massachusetts, May, 1897.

† Proceedings of the Philadelphia Academy of Natural Sciences, vols. xxxi, xxxiii, xxxvii and xxxviii.

of the specimens of *Homocrinus* are in almost perfect condition, and where the fine cirri are visible on the stem the grace and delicacy of this species are well shown (pl. III, fig. 3).

The following additions are made to Hall's description :—

Ventral sac strong, elongated, sometimes three-fourths as long as the arms, the upper part composed of vertical rows of small hexagonal plates. The upper end of the sac probably has five large plates, which are drawn out into spines, something like those in *Scaphiocrinus unicus*. Three of these spines and traces of a fourth can be seen in one specimen, and their position shows that a fifth was probably present originally. These spines are not scattered irregularly over the upper surface, as is indicated in Hall's figure. Column long and slender, consisting of irregularly alternating larger and smaller joints, round below and becoming obtusely angular and enlarged above. Canal small and round. Shortest column observed 4^{cm} in length ; longest, which is still incomplete, 15^{cm} long. Very delicate cirri are preserved, but in no specimen are they found above the middle of the stem. Wherever the distal end of the column is present, there is a coil or loop, as if the stem twined around some support (pl. III, fig. 3). No indications of the clustering of columns mentioned by Hall were seen in the Yale collection.

Horizon and locality.—Common in the thinly laminated or shaly layers of the Coeymans or Lower Pentamerus, at Schoharie, Jerusalem Hill and North Litchfield. Hall reports the species from the Manlius, or Tentaculite, limestone,* but no such specimens have come under the writer's observation.

Cotypes (used by Wachsmuth and Springer for the revised genus) in the American Museum of Natural History, from Litchfield, N. Y.

Family, *Edriocrinidæ* n. fam.

In the specimens of *Edriocrinus* under observation, there are differences that at first seemed to have specific, if not generic value. There are two quite common forms—one (No. 1 and No. 2)† the small hemispherical cups, so well known to collectors in the Helderberg Mountains; and another (No. 3) like the preceding only that the cup has a prominent band or ring around the upper margin. There are other forms that are not so common, however; and they can be divided into two groups, or even three. One specimen (No. 4) about twice as high as the common ones has the hemispherical cup, above which and fused to which is a solid band ; and above this still another band of six fused plates, twice as high as the lower

* Nat. Hist. N. Y., Pal., vol. iii, p. 103, 1859.

† Numbers refer to those on pl. IV, figs. 1–6.

band. Another individual (No. 5) does not show the first band, and the second is broken up by weathering into five comparatively broad plates and one narrow one. The next specimen to attract attention (No. 6) resembles the one just described only that on one side the plates succeeding the cup have the appearance of a row of three short plates, instead of one high one.

It was not until these forms, seemingly so different, had been most carefully compared that any conclusion concerning them could be reached. The difficulty was due, mainly, to the fact that in most cases the suture lines are wholly obliterated; but, with a trace of a suture here and another there, there was something on which to base an interpretation. The following solution is offered:

The genus *Agassizocrinus* is said to be dicyclic because young specimens have infrabasals, although the latter are obliterated before maturity is attained. The question has arisen, Why may not the same be true of *Edriocrinus?* By following out this idea, these seemingly distinct forms were reduced to two whose difference is simply in the development of the basals, which in one group are inconspicuous and in the other are enlarged to form the prominent ring or band mentioned above.

The explanation of these varying specimens is as follows: No. 2 and No. 5, instead of being monocylic, are dicyclic, the infrabasals, which are the largest, being fused with the basals. No. 3 shows infrabasals and basals, the latter being very prominently developed. No. 6 has infrabasals and fractured radials, but no brachials. This conclusion has been reached by comparing opposite sides of the same specimen. Though on one side there seems to be a short radial followed by two short brachials in each ray, the other side shows no such division; and it is evident that the apparent brachials are due to the transverse breaking of the radials. This view is supported by the fact that the anal plate is as high as the radials and the apparent brachials combined. No. 4 shows all the plates of the calyx and furnishes the clue to the others. The prominence of the basals is hardly a specific characteristic and these specimens are all left in the original species, *E. pocilliformis.* In the Yale collection, there is one example of *E. sacculus* which gives faint indications of the presence of infrabasals, though none of the specimens show any thickening of the basal ring.

In regard to classification, these forms certainly cannot belong with the genus *Agassizocrinus* in the family Astylocrinidæ, where *Edriocrinus* was placed provisionally by Wachs-

muth and Springer,* because there are no supplementary anal plates in the calyx, as is the case in *Agassizocrinus*. Bather lists the genus provisionally under the order *Flexibilia*,† an order with no anal plate in the cup; but, as *Edriocrinus* has such a plate, the genus cannot be so referred. The calyx structure is that of the Cyathocrinidæ but there are differences that prevent the reference of *Edriocrinus* to this family. The absence of a column is one of these differences and the manner in which the rays divide is another. In *Cyathocrinus*, which is the most representative genus of the family, the arms in branching spread out irregularly, and the joints are generally higher than wide; while in *Edriocrinus* the joints are very short, and the arms branch as do those of *Ichthyocrinus*, the divisions remaining in contact and curling inward. The arms, however, do not form a part of the calyx as in the last named genus.

Family description.—Calyx elongate. Base dicyclic, probably five fused plates in each order. Radials with facets for the insertion of the brachials extending across the whole width. Arms incurved, seemingly without pinnules, divisions remaining in contact; joints much wider than long. Column wanting, the attachment being by the infrabasals in the young stages; mature forms unattached.

Genus, *Edriocrinus* Hall.

Edriocrinus Hall.

Edriocrinus Hall, Nat. Hist. N. Y., Pal., vol. iii, 1859, p. 119; 15th Rept. N. Y. St. Cab. Nat. Hist., 1862, p. 115.—Meek and Worthen, Geol. Rept. Ill., vol. iii, 1868, p. 119.—Wachsmuth and Springer, Rev. Palæocr., Pt. I, 1879, p. 21, Pt. III, 1885, p. 10, and 1886, pp. 192, 265, 286; Proc. Phila. Acad. Nat. Sci., vol. xxxi, 1880, p. 244, vol. xxxvii, 1886, p. 232, and vol. xxxviii, 1887, pp. 116, 189, 210; N. Am. Cri. Cam., vol. i, 1897, pp. 59 and 145.—Zittel, Handb. d. Palæontol., I Band, 1880, p. 350.—P. H. Carpenter, Ann. Mag. Nat. Hist., May, 1883, p. 333.—Bather, Rept. Brit. Assoc. Adv. Sci. for 1898, p. 923; A Treatise on Zoology, 1900, Pt. III. The Echinoderma, p. 191.

Amended generic description.—Caylx directly cemented, either throughout life or only in the young stages, the attachment being by the large infrabasals. The cicatrix very large in some specimens and in others obliterated, by the accumulation of calcareous matter on the outer surface of the calyx plates. Infrabasals large, their height being from one-half to two-thirds that of the cup as ordinarily found, completely fused so as to destroy suture lines and to make the number of plates uncertain. Basals five, height varying in proportion to that of

* Rev. Palæocr., Pt. III, p. 192, 1885, or Proc. Phila. Acad. Nat. Sci., vol. xxxviii, p. 116.

† Rept. Brit. Assoc. Adv. Sci. for 1898, p. 923; also The Echinoderma, p. 191, 1900.

the infrabasals, generally so fused as to show no suture lines on the outer surface, although they are often seen on the inner side. Upper margin scalloped for the attachment of the radials and the anal plate. Radials five, large, rectangular, the upper margin excavated slightly for the attachment of the brachials and the lower curved to fit into the concave upper margin of the basals. An anal plate half as wide as the radials and a small plate above it furnish all that is known of the anal area. Ventral surface unknown. Arms known in only one species, *E. sacculus*, where they consist of very short transverse plates and bifurcate several times, but show no trace of pinnules.

Genotype, E. pocilliformis Hall.

Edriocrinus pocilliformis Hall. Plate IV, figures 1–6.

Edriocrinus pocilliformis Hall, Nat. Hist. N. Y., Pal., vol. iii, 1859, p. 121, pl. v, figs. 8–12.—Meek and Worthen, Geol. Rept. Ill., vol. iii, 1868, p. 370, pl. 7, figs. 5a and 5b.—Wachsmuth and Springer, Rev. Palæocr., Pt. III, 1886, p. 266; Proc. Phila. Acad. Nat. Sci., vol. xxxviii, 1887, p. 190.—Keyes, Geol. Surv. Mo., vol. iv, 1894, p. 221, pl. xxx, fig. 7.

Amended specific description.—Infrabasals present but so fused that their number is uncertain. Height from one-half to two-thirds that of the cup as ordinarily found. Basals five, completely fused with each other and with the infrabasals or distinguished from the latter as a narrow protruding band. Suture lines sometimes apparent on the interior. Upper margin scalloped for the attachment of the radials and the anal plate. Height about half that of the infrabasals. Radials five, often as high as the infrabasals and basals combined, and, like them, fused to form a part of the cup. In most instances, however, the suture lines between the radials are plainly discernible. As a rule, the union between the radials and basals is not so strong as that of basals with infrabasals; and the cup is generally broken off at the top of the basals. Since in no specimens are brachials preserved, the union of brachials with radials must have been still weaker. Anal plate as high as the radials, but only half as wide. Radials and anal gently convex, sloping in all directions from the center of the plate. Arms and ventral disk unknown. The attachment scar is visible on a number of specimens, and in some is a short distance up on the side of the cup, rather than on the bottom.

Horizon and locality.—Throughout the New Scotland limestone in Helderberg Mountains.

Cotypes in the American Museum of Natural History.

Order, CAMERATA Wachsmuth and Springer.

Family, *Thysanocrinidæ* Wachsmuth and Springer.

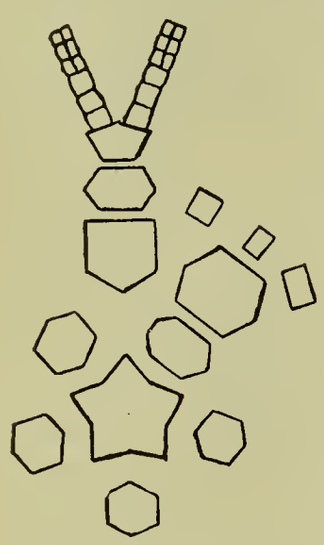
Genus, *Thysanocrinus* Hall.

Thysanocrinus arborescens n. sp. Plate I, figure 2; text-figure 1.

Although, in America, no members of this genus have been reported above the Niagara, a number of crinoids that must

be referred to this genus is found in one of the beds of the Coeymans limestone at North Litchfield. The generic features, as given by Wachsmuth and Springer,* are well marked—the subglobose calyx, urn or bell-shaped; infrabasals five, small, barely protruding beyond the column; basals five, the posterior one truncated by a large anal plate; radials five, considerably larger than the costals; costals two; arms ten or twenty, rather strong and biserial; pinnules long; first interbrachial large, followed by smaller ones; anal side wider, first anal plate followed by three in the next row.

The specimens under examination lack the ridges which are so conspicuous in marking the rays in most of the species of *Thysanocrinus;* their plates are smooth, instead of being sculptured as is generally the case in this genus, and the column is pentangular, while in most of the species it is round. The specimens resemble *T. liliiformis* more closely than any other species, but differ from it in the pentangular column and the absence of the ridges on the radial series of plates. Not enough is known about the bifurcation of the arms in *T. liliiformis* to make comparison.



Text-figure 1.—Diagram of *Thysanocrinus arborescens* showing position of the anal plates and first bifurcation of the arms.

Specific description.—Calyx subglobose. Surface of plates smooth. Infrabasals five, small, projecting slightly beyond the column. Basals five, large, hexagonal, the posterior one heptagonal and truncated above to receive the anal plate. Radials five, somewhat larger than the basals, pentagonal. Costals two, half as large as the radials, hexagonal, the second smaller than the first and supporting on its sloping upper margins the two rows of distichals, the lower three of which are larger than the succeeding ones and are embodied in the calyx. Interbrachials, two ranges of large plates followed by smaller ones. Anal plate large, followed by three much smaller ones in the next row. Arms biserial. Each ray bifurcates on the second costal and again on the fourteenth distichal. A third bifurcation occurs, seemingly only on the inner branches and at different intervals in the different arms, varying from the fourteenth to the twenty-third palmar. Pinnules found on the fifth distichal and continuing to the tips of the arms. Column pentagonal. Near the calyx, the joints alternate in size; but farther down the stem every fourth joint is larger. In a specimen in which the crown is 29^{mm} in length, the column, though incomplete, is 40^{cm} long.

* N. Am. Cri. Cam., vol. i, p. 190, 1897.

This species is associated with *Melocrinus nobilissimus*, *M. pachydactylus*, *Mariacrinus beecheri*, and *Cordylocrinus plumosus*.

Horizon and locality.—Upper third of the Coeymans limestone at North Litchfield.

Holotype in the Yale University Museum.

Family, *Melocrinidæ* Roemer.
Subfamily, *Melocrininæ*.
Genus, *Mariacrinus* Hall.

In re-diagnosing the genera *Mariacrinus* and *Melocrinus*, Wachsmuth and Springer recognized the fact that the arms of the former remain apart and do not form the tubular appendage which is so conspicuous in *Melocrinus*. The only species in the Yale collection that shows this characteristic of *Mariacrinus* is a new species, *M. beecheri*, in which the proximal end of the ray forms a tube while the distal end is divided, the arms diverging conspicuously. The species is thus seen to hold a position intermediate between *Mariacrinus* and *Melocrinus*. As the features of the former are more strongly developed, this species is referred to that genus.

Genotype, *M. plumosus* Hall.

Mariacrinus beecheri n. sp. Plate I, figure 3 ; text-figure 2.

This species bears a resemblance to *Melocrinus nobilissimus* but differs from it in features other than the division of the rays. The auxiliary arm, instead of being comparatively inconspicuous, as in *Melocrinus*, is strong and prominent and lies alongside the tube.

The joints of the rays are longer than those of *M. nobilissimus*, so that, although the arms are given off more frequently than in the last named species, they seem to take origin at greater intervals. As in *M. nobilissimus*, the stem joints alternate in size, but they are so very thin in all parts of the stem, and especially so near the crown, that there is no difficulty in determining this form by the column alone. The column is also much larger in proportion to the size of the calyx.

Text-figure 2.—Anal sac of *Melocrinus beecheri* with *a*, *b* and *c* as the last of the anal series of plates in the cup. × 4½.

Specific description.—Calyx small, elongate, once and a half as long as wide, the increase in width being very gradual. Basals wider than long, pentagonal, not forming a projecting cup, but continuing the width of the column. Radials five, four heptagonal and one hexagonal. Costals two, the first hexagonal, more than half as large as the radials, and the second smaller, pentagonal, and support-

ing two rows of distichals, three in each row. The last distichal supports two rows of palmars, whose first two plates are connected. Above this point, the palmars separate, those on the outside of the ray forming an auxiliary arm which lies alongside the ray but is not connected with it. The inner row of palmars joins corresponding plates from the other row of distichals to form a tubular appendage which extends for a short distance only, when the divisions separate and remain apart to the end of the ray. On the outer side of the ray, arms arise from every fourth or fifth joint; but, on account of the length of the joints, the arms are quite far apart. The arms are biserial to the end. The first interbrachial is large, hexagonal, followed by a double row of alternating hexagonal plates. Anal interradius wider and ending in a short thick tube or sac, composed of numerous plates which seem to have been hexagonal originally. This sac is seen in but one specimen, where the plates are very poorly preserved (text-fig. 2). Column circular, with diameter large in proportion to the size of the calyx. Distally the joints alternate in size, but near the calyx they are very thin and of uniform thickness.

Horizon and locality.—Upper third of the Coeymans limestone at North Litchfield.

Cotypes in the Yale University Museum.

Genus, *Melocrinus* Goldfuss.

Genotype, *Mariacrinus nobilissimus* Hall.

Melocrinus nobilissimus (Hall). Plate II.

Mariacrinus nobilissimus Hall, Nat. Hist. N. Y., Pal., vol. iii, 1859, p. 105, pl. 2, figs. 1-5; pl. 2A, fig. 1.

Melocrinus nobilissimus Wachsmuth and Springer, Rev. Palaeocr., Pt. II, 1881, p. 122; Proc. Phila. Acad. Nat. Sci., vol. xxxiii, 1882, p. 296; N. Am. Cri. Cam., vol. i, 1897, p. 295; Atlas, pl. xxiii, figs. la, 2 and 3.—Bather, A Treatise on Zoology, 1900, Pt. III. The Echinoderma, p. 161, text-fig. lxxiv, 2.

Sixteen individuals of this species have been added recently to the Yale collections; yet, since the type specimen is so nearly perfect, very little additional knowledge has been gained from this new material. Attention, however, may be called to a few points. One specimen shows a row of three or four small plates between the auxiliary arm and the tubular appendage. These plates appear in the figures given by Wachsmuth and Springer, but no mention is made of them in the descriptions. They seem to be interpalmars, though it is possible that they belong to the ventral disk. The domelike extension of the anal series of plates, which is also figured by Hall, is seen indistinctly in one specimen. One crown has a column attached, over 21^{cm} in length; while another column on the same slab, and to all appearances of the same species, is over 69^{cm} long and gives no indication of proximity to either calyx or distal end.

At North Litchfield, this species was found associated with *Mariacrinus beecheri*, *Melocrinus pachydactylus*, *Cordylocrinus plumosus*, *Thysanocrinus arborescens*, *Homocrinus scoparius*, *Lepocrinites gebhardi*, and *Dalmanites* sp. The crowns are not numerous, but judging from the associated fragments of stems this spot must have been very favorable to the growth of *Melocrinus nobilissimus*. On one slab about fourteen inches long (pl. II), four crowns were found with columns belonging to forty-six more. The only other fossils on this slab are one *Conularia* and two Bryozoan fragments.

Horizon and locality.—Coeymans limestone at Litchfield and North Litchfield.

Cotypes in the American Museum of Natural History.

Melocrinus pachydactylus (Conrad). Plate I, figure 1.

Astrocrinites pachydactylus Conrad, Ann. Rept. Pal. N. Y., 1841, p. 34.—Mather, Geol. Rept. N. Y., 1843, p. 347; text-fig. 6 on p. 345.

Mariacrinus pachydactylus Hall, Nat. Hist. N. Y., Pal., vol. iii, 1859, p. 107, pl. 3, figs. 1–4.

Mariacrinus paucidactylus Hall, ibid., p. 109, pl. 3, fig. 5.

Melocrinus pachydactylus Wachsmuth and Springer, Rev. Palæocr., Pt. II, 1881, p. 122; Proc. Phila. Acad. Nat. Sci., vol. xxxiii, 1882, p. 296; N. A. Cri. Cam., vol. i, 1897, p. 296, pl. xxiii, figs. 4 and 5; pl. xxiv, figs. 4a and 4b.

Melocrinus paucidactylus Wachsmuth and Springer, Rev. Palæocr., Pt. II, 1881, p. 122; Proc. Phila. Acad. Nat. Sci., vol. xxxiii, 1882, p. 296; N. A. Cri. Cam., vol. i, 1897, p. 296.

Actinocrinus polydactylus Bonny, Schenectady Reflector, 1835.

Although this species heretofore has been considered a rare fossil, it is now represented in the Yale University Museum by thirteen specimens. Little additional knowledge of the calyx, however, has been gained. In all cases where the distichals can be distingushed from the other plates, their number is two, instead of three. The former number agrees with all previous figures; yet, in their description, Wachsmuth and Springer make the distichals three in number.*

One of the rays, though incomplete, shows nineteen arms, which are plainly seen to be uniserial, not biserial as previously described and figured.† The actinal side of the rays and arms shows the ambulacral groove. As to the number of brachials in the successive orders of the plates of the rays, careful examination of the specimens at Yale yields results different from those reached by Wachsmuth and Springer.‡ Brachials of the fourth, fifth and sixth orders have seven plates, and the subsequent orders seem to alternate with six and seven to the

* N. Am. Cri. Cam., vol. i, p. 296, 1897.

† Nat. Hist. N. Y., Pal., vol. iii, 1859, p. 108, pl. 3, figs. 1–3 and 4a; N. Am. Cri. Cam., Atlas, pl. xxiii, figs. 4 and 5; pl. xxiv, figs. 4a and 4b, 1897.

‡ Ibid., vol. i, p. 297.

end of the ray. In one specimen, small dome-like interpalmars show between the auxiliary arm and the tubular appendage, occupying the same position as in *M. nobilissimus*, but differing in form. Stem joints alternate in size near the calyx, but farther down the column every fourth one is larger. One individual has a stem 19^{cm} long, which makes a loop at the distal end about $2{\cdot}5^{cm}$ in diameter. Another loop not more than 1^{cm} in diameter has two complete whorls.

M. pachydactylus is found at Jerusalem Hill with *Lepocrinites gebhardi* and many specimens of *Homocrinus scoparius;* at North Litchfield with *Mariacrinus beecheri*, *Melocrinus nobilissimus*, *Thysanocrinus arborescens*, and *Cordylocrinus plumosus.*

Wachsmuth and Springer regard *M. paucidactylus* and *M. pachydactylus* as synonyms, but give no reasons therefor. Hall's distinctions are the narrower calyx and the fewer and more distant arms of the former. The specimen figured on pl. I, fig. 1, is very narrow, proving the width of the calyx to be variable. The greater distance between the branches of the arms cannot, in itself, be considered a specific difference; and there seems to be no reason for referring these narrow specimens to another species.

Horizon and locality.—Near the base of the Coeymans limestone at Schoharie;* in the upper third of the same limestone at Jerusalem Hill and North Litchfield.

Family, *Platycrinidæ.*

Genus, *Cordylocrinus* Angelin.

Cordylocrinus plumosus (Hall). Plate III, figures 2 and 4; text-figure 3.

Platycrinus plumosus Hall, Nat. Hist. N. Y., Pal., vol. iii, 1859, pp. 113 and 148, pl. 4, figs. 1–5.

Platycrinus parvus Hall, Nat. Hist. N. Y., Pal., vol. iii, 1859, p. 114, pl. 4, figs. 6–9.

Cordylocrinus plumosus Wachsmuth and Springer, Rev. Palaeocr., Pt. II. 1881, p. 61; Proc. Phila. Acad. Nat. Sci., vol. xxxiii, 1882, p. 235; N. Am. Cri. Cam., vol. ii, 1897, p. 737; Atlas, pl. lxxv, fig. 20.

Cordylocrinus parvus Wachsmuth and Springer. Rev. Palaeocr., Pt. II, 1881, p. 60; Proc. Phila. Acad. Nat. Sci., vol. xxxiii, 1882, p. 234; N. Am. Cri. Cam., vol. ii, 1897, p. 737.

Clematocrinus plumosus Jaekel, Zeit. d. deutsch. Geol. Gesell., Band xlix, 1897, Verhandl., p. 47.

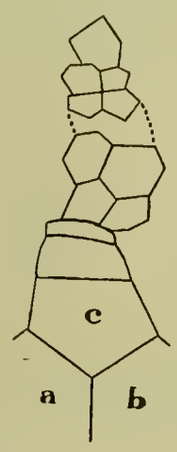
Clematocrinus parvus Jaekel, Zeit. d. deutsch. Geol. Gesell., Band xlix, 1897, Verhandl., p. 737.

In the Yale Museum, there are many hundreds of specimens of this species; and at first glance it seemed that substantial additions could be made to the descriptions already given. Closer examination, however, revealed the fact that in only a

* Nat. Hist. N. Y., Pal., vol. iii, p. 109, 1859.

few specimens could the plates be distinguished. It also seemed that there were two species, the fossils differing so much in size, gibbosity and general appearance; but further study failed to reveal any real differences. Some of the forms have a hemispherical calyx, and arms only three or four times as long as the cup, while others have a flat cup and arms five or six times as long; and yet the plates of the calyx, the joints of the arms, the pinnules and the cirri seem to be the same in the two varieties.

In the material from North Litchfield, the lower bed has much the larger forms, all of which are compressed. The upper bed has an abundance of the smaller ones, a few of which have the calyx gibbous, not flattened. The specimens from Jerusalem Hill are uncompressed and small. Wachsmuth and Springer consider *C. parvus* the young of *C. plumosus;* and it may be that it was these small, uncompressed specimens from the upper crinoid bed that Hall had under observation when he described the former species. If this assumption can be proved, it may be well to regard *C. parvus* as a variety of *C. plumosus*, as these small forms occur at a slightly higher geological horizon.



Text-figure 3.—Anal sac of *Cordylocrinus plumosus*. *a*, right postero-lateral radial; *b*, left postero-lateral radial; *c*, first of anal series of plates. ×4.

From a study of the specimens in the Yale University Museum, the following new data may be given: In no case does the length of the column exceed once and a quarter that of the crown, which varies from 5^{mm} to 32^{mm}. A large majority of those specimens which retain the column have very many unusually long cirri.

Several of the specimens have a feature which Bather states is found in some of the Camerata, and which he explains as being due to the fusing of the joints of the arms.* In these forms the arms are composed of long joints, seemingly single, with the upper and lower surfaces parallel and horizontal. In parts of the arm, every other joint bears two pinnules on the same side of the ray. This alternation of one- and two-pinnuled joints does not extend throughout the whole length of the ray, but in places it is every third joint that has this peculiarity. Toward the base the joints are normal, that is, one-pinnuled. In his description, Hall mentions the fact that some of the joints have two pinnules; but in his figure,† he represents most

* A Treatise on Zoology, Pt. III. The Echinoderma, p. 116, 1900.
† Nat. Hist. N. Y., Pal., vol. iii, pl. 4, fig. 4, 1859.

of such joints as made of two, in this agreeing with Bather's explanation. The specimens under examination, although one is very well preserved, do not give the faintest trace of the separate joints; yet this explanation for the presence of the additional pinnules seems to be the most rational one yet offered.

Of the whole number of specimens examined, only one shows the anal tube mentioned by Hall. This tube is seen indistinctly in the photograph (pl. III, fig. 4; also text-fig. 3). The length of the tube is a little over half that of the crown.

Horizon and locality.—Upper third of the Coeymans limestone at Jerusalem Hill and at North Litchfield.

Cotypes in the American Museum of Natural History.

Order, ARTICULATA Wachsmuth and Springer.

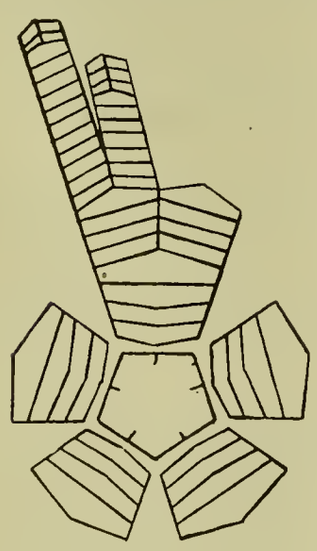
Suborder, IMPINNATA Wachsmuth and Springer.

Family, *Ichthyocrinidae* Wachsmuth and Springer.

Genus, *Ichthyocrinus* Conrad.

Ichthyocrinus schucherti n. sp. Plate III, figure 1; text-figure 4.

Specific description.—Crown, including the incurved arms, an inverted, truncated cone with straight sides. Length and breadth equal, 19^{mm}, the greatest breadth being at the point where the arms become free. Infrabasals not shown. Basals five, pentagonal. Radials five, hexagonal, wider than long. Costals three in each ray, wider than long, one hexagonal, the other two pentagonal, the upper supporting two rows of distichals, the first three ranges of which are quadrangular and the last pentangular and followed by two rows of palmars. The palmars are of different numbers in the different rays and even in different parts of the same ray. Two or three of the palmars are included in the cup. Each costal and each distichal is wider than the plate of the same order below it, but in the palmars there is a decrease in the size of the successive plates. Anal area not shown. Arms free from the second or third palmar, incurved. Each row of palmars divides at least once, making the number of branches forty. Column spreading slightly at the point of union with the crown. Joints of the column thin and equal near the calyx, alternating below, the larger ones about three times as high as the smaller. Length of column unknown.



Text-figure 4.—Diagram of *Ichthyocrinus schucherti.*

A single individual of this species was found by Professor Schuchert and was presented by him to the Yale University Museum. It differs from other species of the genus, principally in the shape of the crown, the straight sides of the cup being very characteristic. It resembles *I. lævis* more closely than any other, but differs from that species in the divisions of the rays and in the fact that the suture lines are not wavy.

Horizon and locality.—Lower third of the New Scotland limestone near Clarksville.

Holotype in the Yale University Museum.

Too little is known of the following Helderbergian crinoids to make definite statements in regard to their classification :—

Genus, *Aspidocrinus* Hall.

Aspidocrinus callosus Hall.

Aspidocrinus callosus Hall, Nat. Hist. N. Y., Pal., vol. iii, 1859, p. 123, pl. 5, figs. 13 and 14.—Wachsmuth and Springer, Rev. Palæocr., Pt. II, 1881, p. 228 ; Proc. Phila. Acad. Nat. Sci., vol. xxxiii, 1882, p. 402.

Aspidocrinus digitatus Hall.

Aspidocrinus digitatus Hall, Nat. Hist. N. Y., Pal., vol iii, 1859, p. 123, pl. 5, figs 19 and 20.—Wachsmuth and Springer, Rev. Palæocr., Pt. II, 1881, p. 228 ; Proc. Phila. Acad. Nat. Sci., vol. xxxiii, 1882, p. 402.

Aspidocrinus scutelliformis Hall.

Aspidocrinus scutelliformis Hall, Nat. Hist. N. Y., Pal., vol. iii, 1859, p. 122, pl. 5, figs. 15–18.—Wachsmuth and Springer, Rev. Palæocr., Pt. II, 1881, p. 228 ; Proc. Phila. Acad. Nat. Sci., vol. xxxiii, 1882, p. 402.

These species of *Aspidocrinus* present difficulties that are as yet unsolved. Hall described the forms as bases of crinoid cups, but Wachsmuth and Springer listed them doubtfully as crinoid roots. There are two reasons, at least, for thinking that they cannot be crinoid roots or basal expansions of columns. If they are basal expansions, the concave side must be the under side and this must have rested on the mud of the sea floor. One specimen of *A. scutelliformis* in the Yale University Museum has a bryozoan attached to this concave surface, proving that this surface could not have rested on the mud. If, on the other hand, these specimens represent the base of a cup, the presence of the bryozoan might be explained by supposing that its growth took place after the upper part of the dead calyx had been broken off but while the lower part still remained attached to the column.

Again, in undisputed examples of basal expansions, the lower or distal joints of the column enlarge and the segmentation of the column is continued into the upper part of the enlarged base. No such segments are visible in any of the specimens in question. In every good specimen, there is a clear-cut cir-

cular spot, generally dark-colored, which looks like the point of attachment of the column to the crown. With the exception of this spot, the cleavage lines of the calcite have obliterated all traces of organic structure.

Horizon and locality.—At the base of the Becraft limestone, or what was called the "Scutella limestone," at Clarksville, Countryman Hill and Schoharie.

Genus, *Brachiocrinus* Hall.

Brachiocrinus (*Herpetocrinus ?*) *nodosarius* Hall. Plate IV, figures 7 and 8.

Brachiocrinus nodosarius Hall, Nat. Hist. N. Y., Pal., vol. iii, 1859, p. 118, pl. 5, figs. 5–7, pl. 6, figs. 1–3. - Wachsmuth and Springer, Rev. Palæocr., Pt. II, 1881, p. 229 ; Proc. Phila. Acad. Nat. Sci., vol. xxxiii, 1882, p. 413.
Herpetocrinus nodosarius Bather, Am. Geol., vol. xvi, 1895, p. 217.

In Hall's description, these fragments of crinoids are considered as arms or parts of arms ; and this opinion was also held by Wachsmuth and Springer, in 1881. In 1895, Bather brought arguments to prove that they belong to columns, not arms,* and even gave a revised diagnosis of these New York forms as *Herpetocrinus nodosarius.* That he is not so certain of this classification as the earlier paper would indicate, may be gathered from the fact that in a later reference to the fossil, he lists *Brachiocrinus* as doubtfully synonymous with *Herpetocrinus.*†

Among other points in support of his first view, he remarks that "cirri composed of thick, beadlike joints which increase in size from the base to the middle and thence diminish to the extremities," characteristic of this species, are also found in *Herpetocrinus flabelliformis*, which occurs in the uppermost beds of the Silurian of Gotland.‡

Most of the specimens in the Yale collection are so encrusted with silica that it is very difficult to get anything but general outlines ; but one specimen is in fairly good condition and clearly shows the joints of the column and the cirri. The joints are slightly wedge-form and quite thin, giving to the fossil an irregular appearance, which is still further increased by the difference in the size of the joints of the cirri. The diameter of the cirri is so great that only every third or fourth joint is cirrus-bearing. The bulb-like process, varying in size and shape, is shown in several specimens at the end of the column. The question has arisen whether this bulb is at the base of the stem, or whether it is simply a thickening somewhere between the proximal and distal ends. If the latter were the case, the central canal should show at both ends of

* Am. Geol., vol. xvi, p. 213, 1895.
† A Treatise on Zoology, Pt. III. The Echinoderma, p. 146, 1900.
‡ Am. Geol., vol. xvi, pp. 215 and 216, 1895.

the specimens. Although one individual shows the canal very well at the distal end of the cirri and the proximal end of the stem fragment, this canal is not visible at the distal end of the bulb on any individual under observation. A small depression on one specimen looks like a cicatrix of attachment. Several individuals have the crescentic form of the joints of the column, as in *Herpetocrinus*.

Horizon and locality.—Lower part of the New Scotland limestone in the Helderberg Mountains.

Cotypes in the American Museum of Natural History and the New York State Museum.

EXPLANATIONS OF PLATES.

Plate I.

Figure 1.—*Melocrinus pachydactylus.* About natural size.

Figure 2.—*Thysanocrinus arborescens* showing the hexagonal column and the branching of the arms. About natural size.

Figure 3.—*Mariacrinus beecheri* showing the thin stem joints near the crown and the separation of the two parts of the rays toward the distal end. About natural size.

Plate II.

Slab containing stems and crowns of *Melocrinus nobilissimus.* Reduced a little more than one-half.

Plate III.

Figure 1.—*Ichthyocrinus schucherti* showing the characteristic straight sides of the crown and the straight suture lines. ×2.

Figure 2.—*Cordylocrinus plumosus* showing the long, crowding cirri and the one- and two-pinnuled joints of the arms. ×2.

Figure 3.—Distal end of the stem of *Homocrinus scoparius* showing the coiling and the delicate cirri. ×2.

Figure 4.—*Cordylocrinus plumosus.* The upper specimen on the plate shows the anal sac. ×2.

Plate IV.

Figures 1–6.—*Edriocrinus pocilliformis.* ×2.

Figures 1 and 2.—Simple ordinary forms, basals and infrabasals fused.

Figure 3.—Cup showing fused basals as a prominent ring, also cicatrix of attachment.

Figure 4.—Cup showing ring of basals, not protruding, and high narrow radials.

Figure 5.—Cup showing radials, but basals indistinguishable from infrabasals.

Figure 6.—Cup showing basals and infrabasals fused and radials fractured transversely.

Figures 7 and 8.—*Brachiocrinus nodosarius.* ×2.

Figure 7.—Portion of the column showing the bulb at the distal end and the beadlike cirri.

Figure 8.—A larger bulb with the first joints of two cirri attached.

Table of Helderbergian Crinoids.

Species with * also in the Siluric. Numbers refer to localities given below.	Coeymans.	New Scotland.	Becraft.	Location of the Type.
Aspidocrinus callosus Hall		1, 2		Holotype, Am. Mus. Nat. Hist.
" *digitatus* Hall		2		" N. Y. St. Mus.
" *scutelliformis* Hall			2, 3, 4	Cotypes, Am. Mus. Nat. Hist.
Brachiocrinus (*Herpetocrinus?*) *nodosarius* Hall		1, 2		" Am. Mus. Nat. Hist. and N. Y. St. Mus.
Cordylocrinus plumosus (Hall)	5, 7			" Am. Mus. Nat. Hist.
Coronocrinus polydactylus Hall		2		Holotype, N. Y. St. Mus.
Edriocrinus pocilliformis Hall		3, 4		Cotypes, Am. Mus. Nat. Hist.
**Homocrinus scoparius* Hall	2, 5, 6, 7			" Am. Mus. Nat. Hist.
Ichthyocrinus schucherti n. sp.		3		Holotype, Yale Univ. Mus.
Mariacrinus beecheri n. sp.	6			Cotypes, Yale Univ. Mus.
" (?) *macropetalus* (Hall), referred provisionally to *Cordylocrinus* by Wachsmuth and Springer				Cotypes, Am. Mus. Nat. Hist.
Mariacrinus plumosus Hall	7			Holotype, N. Y. St. Mus.
" *ramosus* Hall	7			" N. Y. St. Mus.
" (?) *stoloniferus* Hall		1, 2		Cotypes, Am. Mus. Nat. Hist.
Marsupiocrinus tentaculatus (Hall)		7		Holotype, Am. Mus. Nat. Hist.
Melocrinus nobilissimus (Hall)	6, 7			Cotypes, Am. Mus. Nat. Hist.
" *pachydactylus* (Conrad)	2, 5, 6			?
Platycrinus ramulosus Hall	5			? Probably occurs in Cobleskill zone of the Manlius.
Thysanocrinus arborescens n. sp.	6			Holotype, Yale Univ. Mus.

1. The Helderberg Mountains.
2. Schoharie.
3. Clarksville.
4. Countryman Hill.
5. Jerusalem Hill.
6. North Litchfield.
7. Wheelock's Hill.

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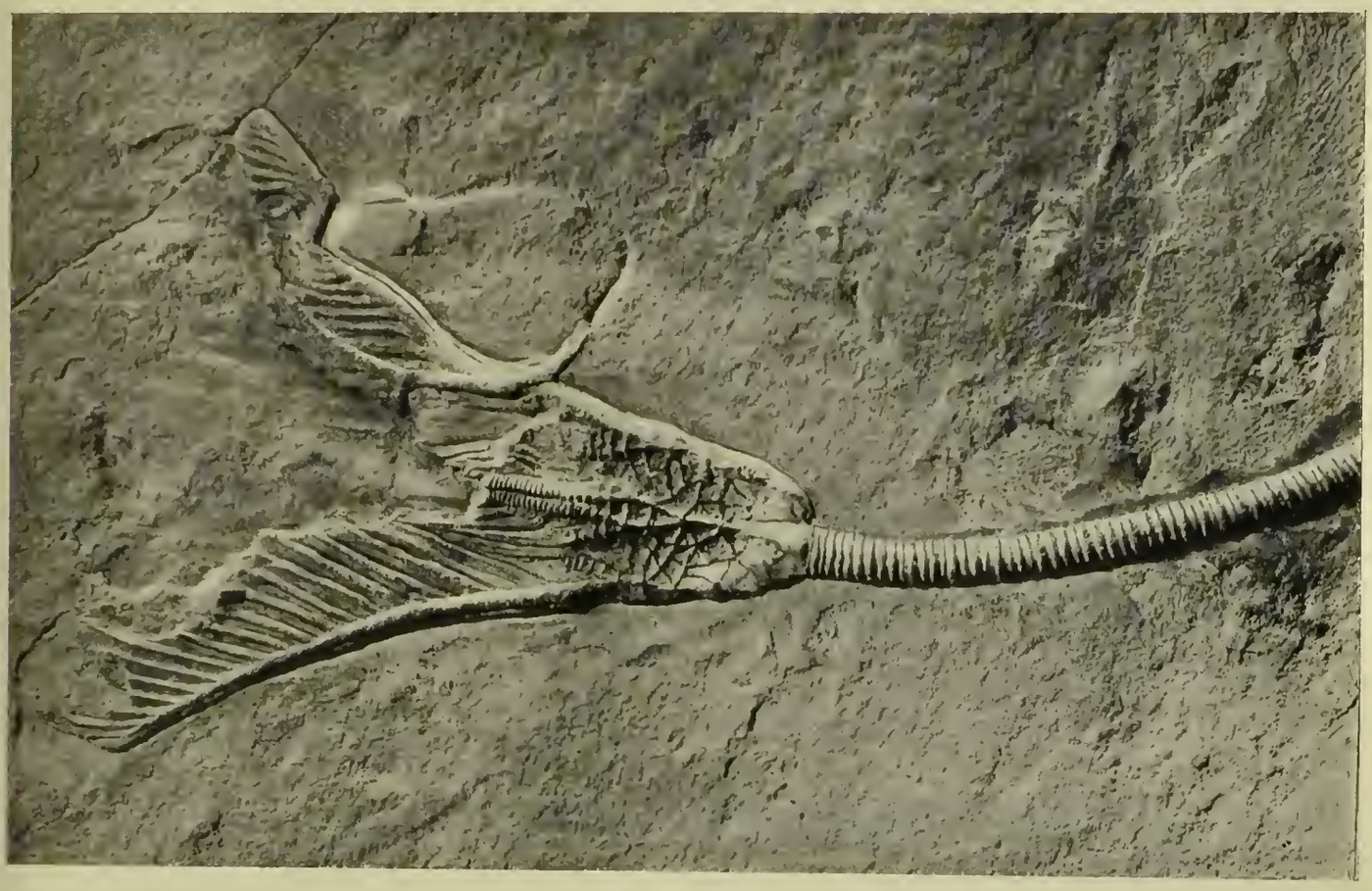

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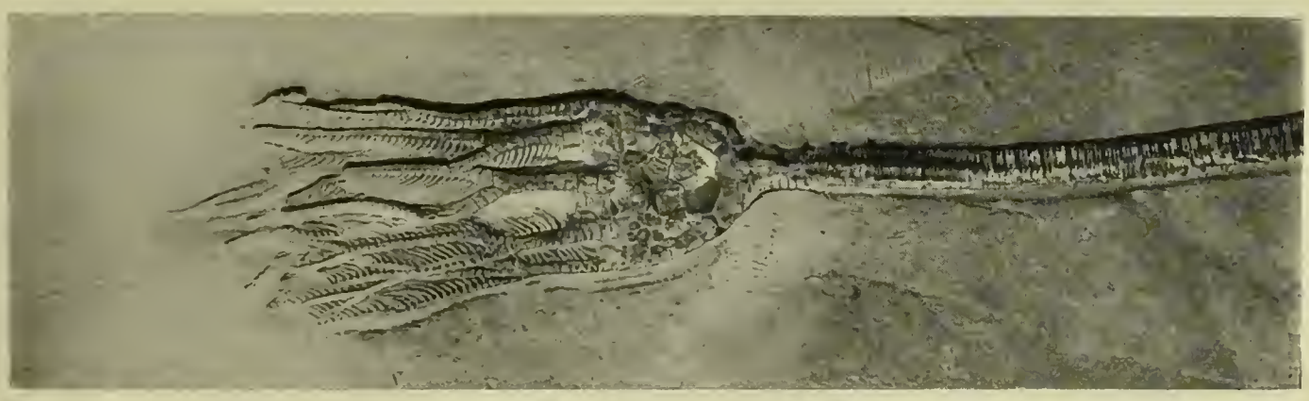

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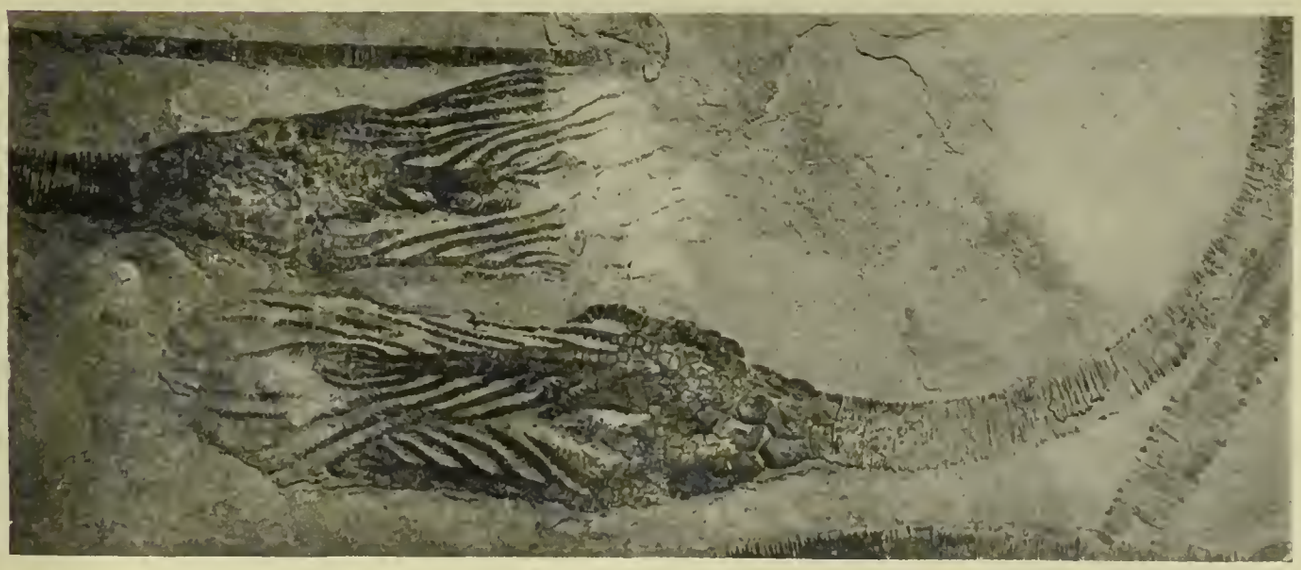

FIGURE 1.—*Melocrinus pachydactylus.*
FIGURE 2.—*Thysanocrinus arborescens.*
FIGURE 3.—*Mariacrinus beecheri.*

Melocrinus nobilissimus.

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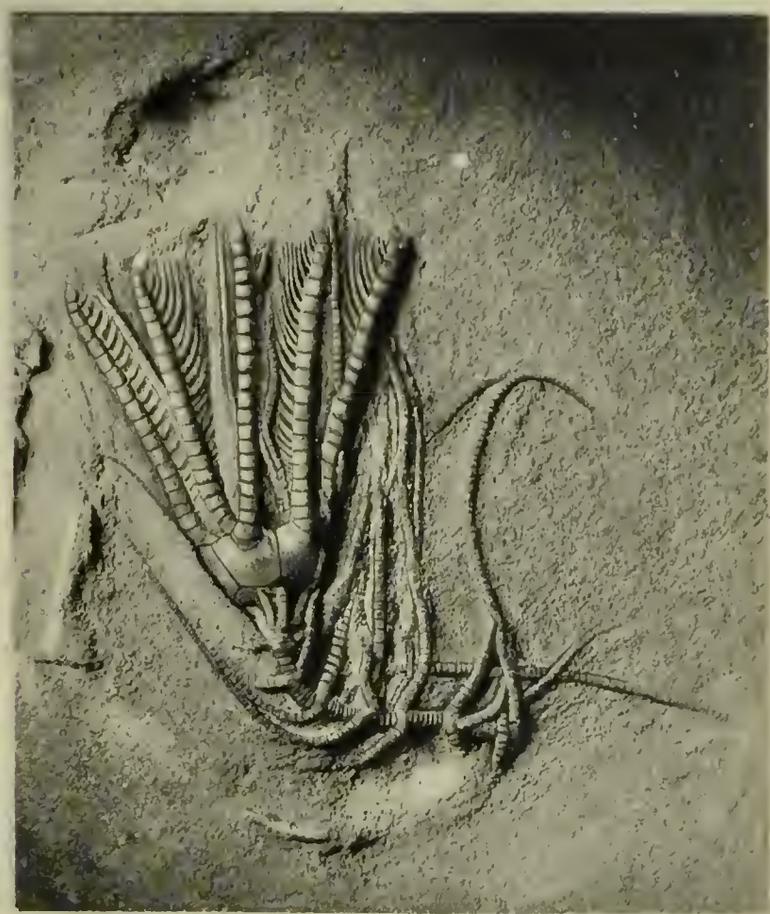

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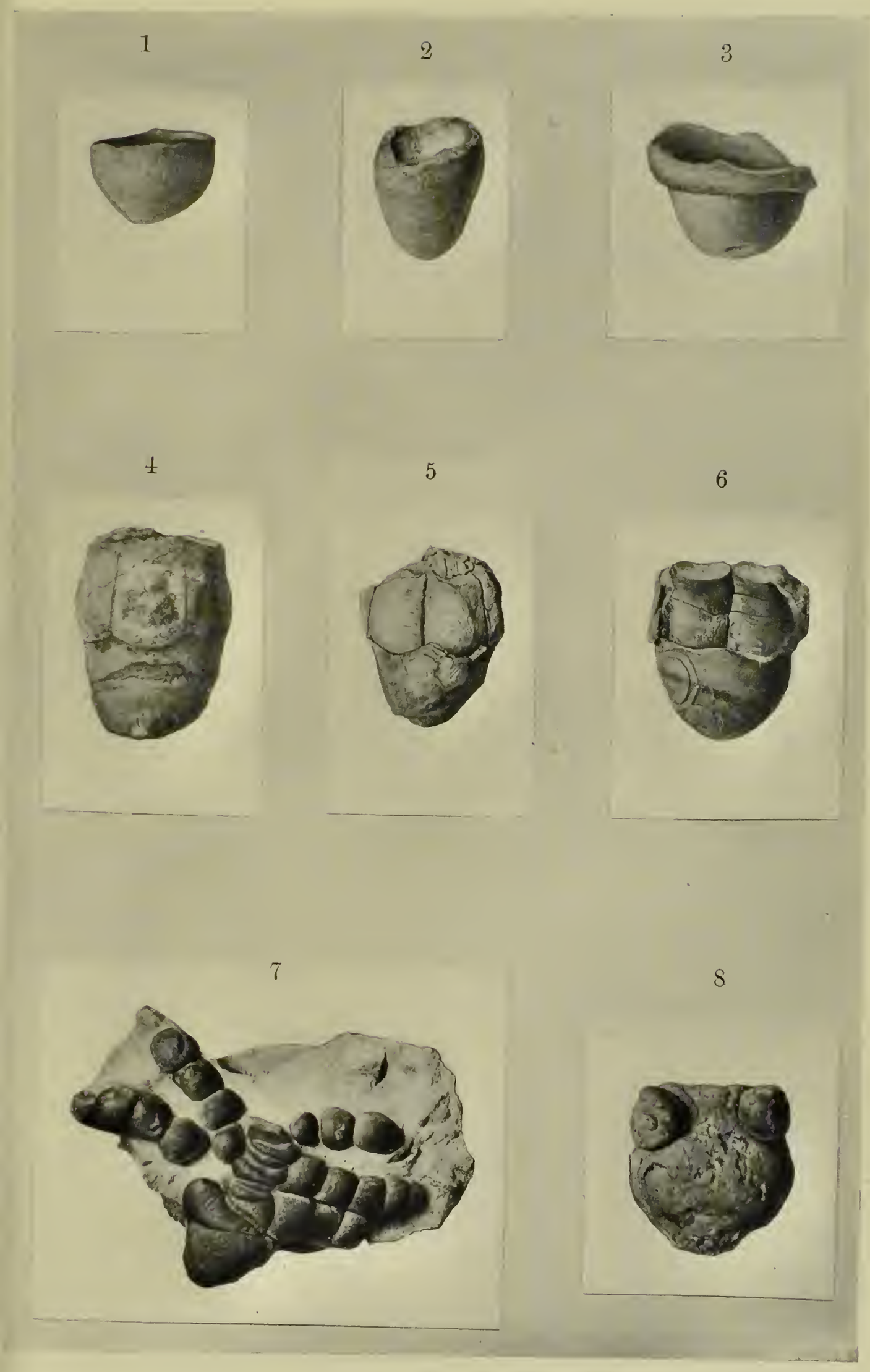
FIGURE 1.—*Ichthyocrinus schucherti.*
FIGURES 2 and 4.—*Cordylocrinus plumosus.*
FIGURE 3.—Stem of *Homocrinus scoparius.*



FIGURES 1–6.—*Edriocrinus pocilliformis.*
FIGURES 7 and 8.—*Brachiocrinus nodosarius.*