The University of the State of New York

New York State Museum

John M. Clarke, Director

Memoir 16

THE DEVONIAN CRINOIDS OF THE STATE OF NEW YORK

BY

WINIFRED GOLDRING

ALBANY

THE UNIVERSITY OF THE STATE OF NEW YORK

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HISTORICAL PREFACE

This monograph of the Devonian Crinoidea of New York is the result of long years of collecting and study. To students of paleontology the history of its development will not be without interest.

In the original program for the "Palaeontology of New York," the study of the Devonian crinoids was not provided for; they were not a part of the series of volumes as planned by the founder of the work, James Hall, and executed by him and his assistants. Organic remains of this kind proved of infrequent occurrence in the Devonian collections that were being made for other divisions of paleontological study, and all the crinoids which had been brought together during the early years of these investigations were haphazard occurrences.

During Professor Hall's period of activity as State Geologist of Iowa, 1855–1858, he had opportunity to study, describe and illustrate in his reports of that survey the beautiful Crinoidea of the Carboniferous Mississippian beds, his descriptions being based largely on the specimens which had been brought together by a number of active collectors who had preceded him in that field. Among these collectors was Charles Abiathar White, a young and impecunious doctor of medicine living at Burlington, who was for a while connected with that survey. At the suspension of the survey Doctor White was left without a position. Soon after returning to Albany, Professor Hall brought Doctor White to New

York and sent him out among the Devonian rocks of the State specially to collect these crinoids with whose mode of occurrence he was already so well acquainted.

When a scientific collector goes out to get a certain class of objects he is or should be blind to all else. Doctor White could see naught but crinoids and his explorations had not continued long before he uncovered, on the land of a Mr Sisson in the northern part of the town of Bristol, Ontario county, on a ravine slope at the village of Muttonville (now more euphoniously denominated Vincent), a colony of crinoids in the Hamilton (Middle Devonian) shales which proved to be the most extraordinary assemblage of these ancient stone lilies which the rocks of New York or of the Devonian system have ever afforded. Doctor White had for his assistant in the actual work of uncovering this extraordinary bed, the late Christian Van Deloo, a very successful collector of invertebrate fossils. Together the two removed the hillside and left barely a trace behind. They had, however, located a distinct crinoidal horizon now well known throughout the Finger Lakes region of western New York as the " Crinoid Layer " lying directly above the Tichenor limestone at about the middle of the Hamilton beds and recognized as the base of the Moscow shales. Doctor White continued his investigations and collections in this region during the season of 1860, and with that very successful campaign among the crinoids the special collecting of them was for many years abandoned. A few years later Doctor White became the State Geologist of Iowa and eventually United States Paleontologist.

Upon the results of the work of 1860, Professor Hall based his single descriptive publication of these fossils which appeared in the Sixteenth Annual Report of the State Museum (1863). During the years which followed in the preparation of the monographs of the Devonian fauna, crinoid material was accumulated by way of desultory collecting, but not till the fauna of the Portage Group and its members and the early faunas of the Chemung Group were opened up to closer study were notable additions made in this field. With these investigations, inaugurated by the writer and his colleague, D. Dana Luther, about the year 1879, novel acquisitions were constantly made and the later years of these field explorations, carried on by Mr Luther alone, brought many very interesting and unexpected forms of crinoids to light.

With the formal close of the series of volumes known as the "Palaeontology of New York" and published under the well-known quarto form with its black covers embellished by gilded insignia, it was the writer's desire and purpose to take up the descriptive account of these Devonian Crinoidea, a neglected division in New York paleontology. The material was assembled for this purpose; much of it was carefully prepared personally by the writer and drawings were made in preparation of the monograph. Duties of another kind, however, came in to embarrass the progress of the work and it seemed impracticable, among these counterclaims, to handle so large and intricate a problem alone. In search for assistance an arrangement was made with Edwin Kirk, a graduate student of Columbia University, who had been closely associated with the leading American authority on the Crinoidea, Mr Frank Springer, in accordance with which Mr Kirk was to spend a portion of his time on this study. For a number of summers Mr Kirk labored in this field diligently, intelligently and helpfully. It came about, however, that Mr Kirk became associated with the United States Geological Survey where he, too, found new duties growing urgently upon him. Much material had been assembled, much manuscript had been prepared and many drawings had been made, but again the book was unfinished and, in the state in which it was left, the work was, so far as availability was concerned, as though it had not been started.

In the year 1916 I asked my associate, Winifred Goldring, to undertake the revision and completion of the entire theme. It was not a tempting repast to offer to a paleontologist seeking opportunities for original investigation, and I feel that the work was taken over by Miss Goldring largely because of her recognition, with mine, that it was an important field to cover, which, if left unstudied, would leave a lamentable hiatus in our knowledge of the extinct life of New York. The present book is Winifred Goldring's work. She has revised and rewritten all previous manuscripts; she has compiled and checked up outstanding references; she has corrected the old drawings and supervised the making of many others; she has had the advantage of certain new materials which others who have touched the work did not have, and I am very glad to be able to say that her work has been done not only conscientiously and with assiduity but with reasonable completeness and with credit to the Paleontology of New York.

JOHN M. CLARKE
State Paleontologist

June 1919

DEVONIAN CRINOIDS OF NEW YORK

BY

WINIFRED GOLDRING

INTRODUCTION

Preliminary remarks. It is intended in this monograph to give a more or less popular treatment of the Devonian crinoids of New York State for the use of students of paleontology. With this purpose the introduction includes, for sake of reference, a brief discussion of the structure, ontogeny and habitat of crinoids. There is also given a grouping of the species here described, on the basis of Springer's classification (1913) which we have adopted, and a table showing the stratigraphic range of the species of the New York Devonian. A summary of terminology and a special bibliography will be found at the end of the introductory chapters.

Acknowledgments. In a work as comprehensive as this obligations have been incurred from many sides. The writer would wish to express in this place appreciation of all such favors received, but response to these courtesies of various kinds can be here made only to those from whom substantial assistance has been derived. My chief obligation is to Director Clarke, who has given me the privilege of undertaking the present work and has helped it forward to its completion, not only by smoothing out the obstacles in its way but by reading and reviewing the entire manuscript. For similar helpfulness I am under like obligation to Doctor Ruedemann, Assistant State Paleontologist.

Dr Frank Springer of the National Museum has assisted in the work by his counsel and his generous loan of specimens from his private collection. His aid in connection with the study of the Crinoidea Flexibilia and Dolatocrinus and allied genera, upon which he has been recently engaged, proved to be most opportune and with his permission a number of original drawings prepared by him have been introduced in this work. From Dr E. O. Ulrich of the United States Geological Survey, Dr Ray S. Bassler of the National Museum, Ernest Brown and Professor

George H. Chadwick of Rochester, Dr E. O. Hovey and Dr Chester A. Reeds of the American Museum of Natural History, Professor Charles Schuchert of Yale University, Dr Stuart Weller of Chicago University, and Professor Ernest J. Carman of Ohio State University, I have had material assistance either in the loan or location of important specimens. To this list should be added the names of Mr D. Dana Luther of Naples, N. Y.; Dr Elvira Wood of Waltham, Mass.; Dr Mignon Talbot of Mount Holyoke College; Dr Hervey W. Shimer of the Massachusetts Institute of Technology; Mr Charles W. Johnson of the Boston Society of Natural History; Dr Herrick E. Wilson of the National Museum; Dr Percy E. Raymond of Harvard University; Dr R. T. Jackson of Peterborough, N. H.; Dr Charles C. Mook of the American Museum of Natural History, and Dr Arthur W. Slocom of the Walker Museum, Chicago University.

The quality of the draftsmanship employed in the making of the illustrations for the plates of this book should speak for itself. The drawings are the work of Mr George S. Barkentin of the State Museum staff, whose skillful brush has illuminated many of the paleontological publications of this institution; finally, I desire to record my obligation to the expert assistance of Mr Jacob Van Deloo, secretary of the State Museum, in the preparation of the manuscript for publication and watchful attention to the proofs of the book as it has passed through the press.

Preliminary Discussion of Crinoids

1 *Structure*

A normal crinoid consists of three principal parts: the *theca* or *calyx*, the *arms* (*brachia*) and the *stem* or *stalk* (*columna*) (figure 1). The calyx and arms together form the *crown* (*corona*). The part of the calyx below the origins of the arms is known as the *dorsal cup* or simply the cup; the part above the origin of the free arms is called the *tegmen* (sometimes *disc* or *vault*). There is a radiate arrangement of the skeletal parts and many of the other systems, the dominant number being five.

a Theca or Calyx

The calyx contains the viscera of the crinoid. The dorsal cup (abactinal surface) is usually attached to a column, but sometimes the crinoid is attached directly by the base and more rarely it is free. The upper (ventral or actinal) surface, or tegmen, is homologous to the under side of the starfish and bears the mouth and ambulacral grooves.

(1) **Dorsal cup.** Most frequently in fossil crinoids only the lower and lateral portions of the calyx are visible, because the arms conceal the upper portions. In the simplest form of crinoid the dorsal cup is composed of two or three circlets of plates. Those supporting the arms and constituting the most important circlet of plates are known as the *radials;* the other one or two circlets constitute the *base.* Where there is but one circlet of plates in the base it is known as *monocyclic;* where there are two, as *dicyclic* (figure 2). In a monocyclic base the plates alternate with the radials and are called *basals;* in a dicyclic base the plates of the lower ring are radial and are known as the *infrabasals* (*under-*

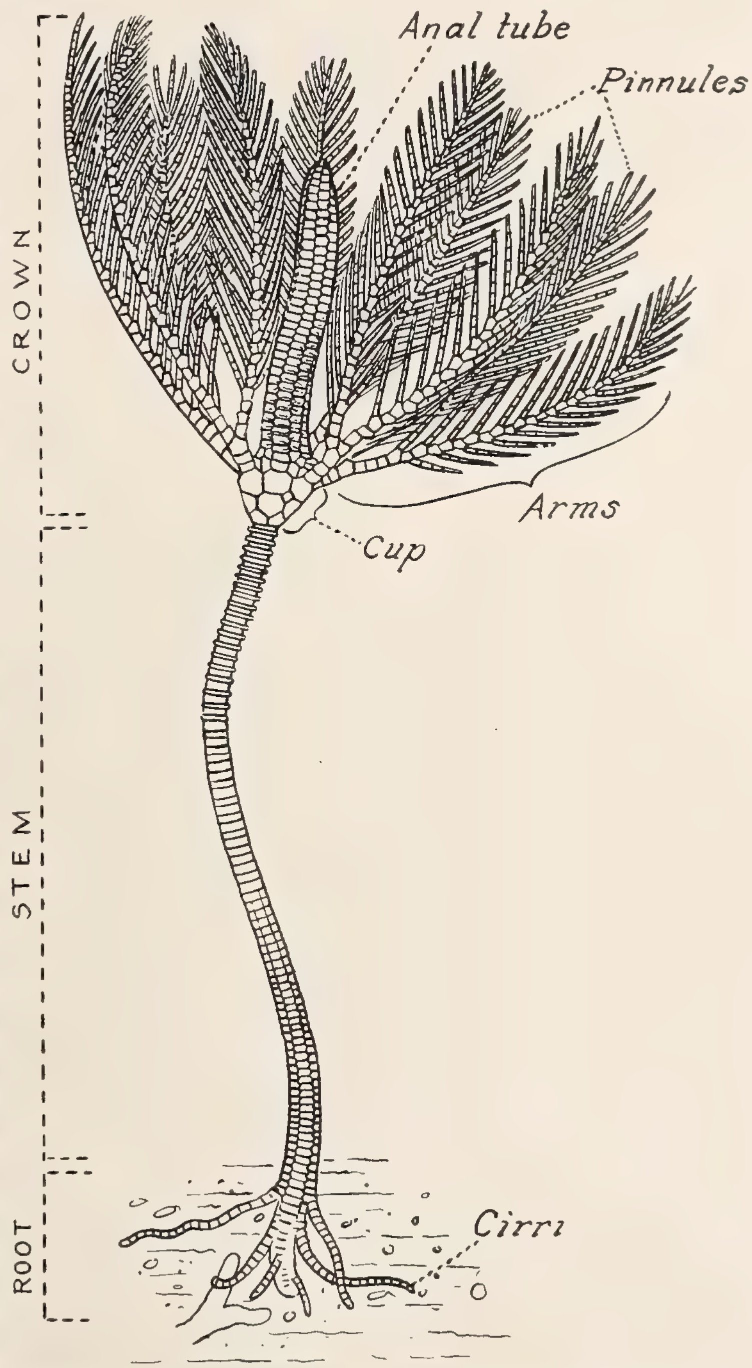


Figure 1 A simple form of crinoid: Botryocrinus decadactylus (Wenlock limestone) seen from the posterior interradius. (After Bather, 1900).

basals), the plates of the second ring are interradial and are the basals. The basals are the equivalent of the "parabasals" and "subradials" in older nomenclature.

The primary number of basals and infrabasals is five. There is a tendency to fusion in the proximal circlet, infrabasal or basal, the number of basals in monocyclic forms being thereby reduced to four, three, two or even one; that of the infrabasals in the dicyclic usually to three or one (figure 3). In the forms having four basals (quadripartite base) the two plates fusing are usually the right and left anterior basals (*see Orientation*, p. 76), rarely the left posterolateral (Wilson, 1916, p. 506). A quadripartite base is almost entirely restricted to monocyclic genera. Three basals (tripartite base) are produced by the fusion of two pairs of basals, giving two large and one small; the small plate is usually the left anterior, rarely the left posterior, posterior or right anterior (ref. cit., p. 507). Wilson (ref. cit.) also notes, in Zophocrinus, the formation of a tripartite base by the fusion of three adjacent basals, the posterior, left posterolateral and the left anterior (figure 3, no. 3). The bipartite base is found only in a few monocyclic forms. The pentagonal bipartite base is formed by the fusion of three and two basals. The only combination of this kind known is found in Mycocrinus (ref. cit., p. 507) and is shown here in figure 3, no. 4. Only in the Inadunata and Flexibilia among the dicyclic forms have three infrabasals been observed. The small plate in the former is usually, but not always, the anterior infrabasal (figure 3, no. 11); in the latter always the right posterior infrabasal (figure 3, no. 10). In both the monocyclic and dicyclic forms all plates, finally, may fuse to form a solid ring (figure 3, nos. 5, 12). Pseudomonocyclic types are produced by atrophy of the infrabasals or the infrabasals may fuse with the proximal columnal.

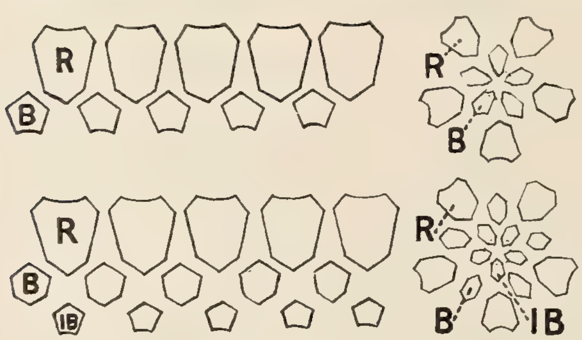


Figure 2 Imaginary analyses of the dorsal cups of crinoids with monocyclic and dicyclic bases. *R*, radial; *B*, basal; *IB*, infrabasal. (After Bather, 1900).

The symmetry of the base in monocyclic Camerata (ref. cit., pp. 665–682) may be modified by the interpolation at the posterior side of an additional plate, the anal (*see* discussion below, p. 14), which separates the posterior radials and truncates the posterior basal, forming a hexagonal, pentapartite base (figure 3, no. 6). The posterior basal is enlarged, the widening being bilaterally symmetrical. The quadripartite hexagonal base (figure 3, no. 7) is derived from the pentapartite by the fusion of the

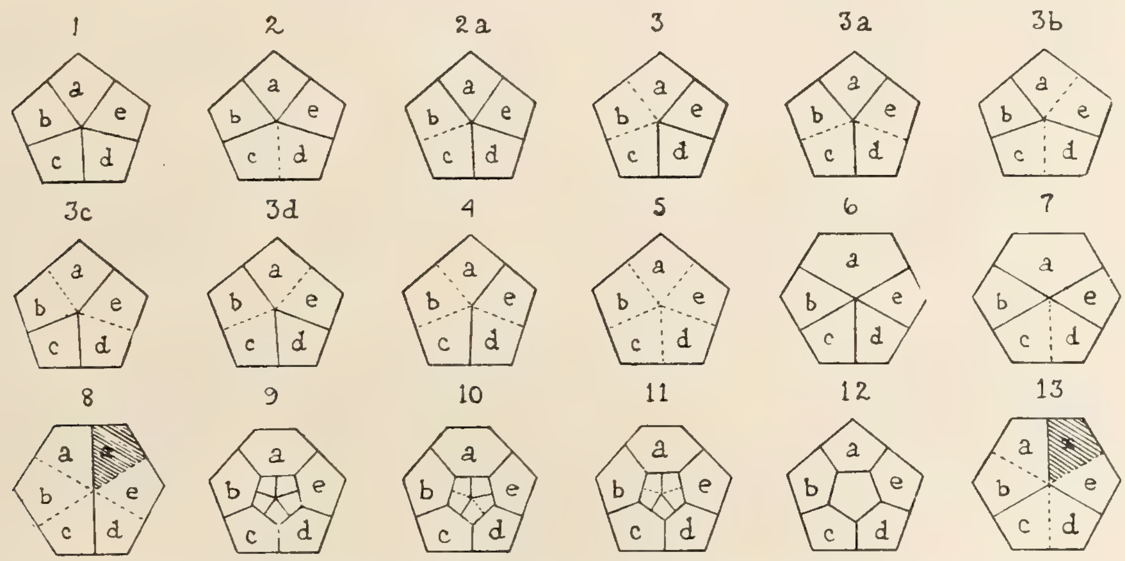


Figure 3 Bases and their modifications. 1–8, 12, 13, monocyclic; 9–11, dicyclic; 1–5, 12, pentagonal, unaffected by anal; 6–11, 13, hexagonal, affected by anal. *a*, posterior basal; *b*, left posterolateral; *c*, left anterior; *d*, right anterior; *e*, right posterolateral (*see Orientation*, page 76); additional piece marked *x*, shaded. 1 = 5 basals; 2, 2*a* = 4 basals; 3–3*d* = 3 basals; 4 = 2 basals; 5 = 1 basal; 6 = 5 basals; 7 = 4 basals; 8 = 2 basals; 9 = 5 infrabasals; 10 = 3 infrabasals as usual in Flexibilia; 11 = 3 infrabasals as usual in Dicyclic Inadunata; 12 = 1 infrabasal (Apiocrinidae, adult); 13 = 3 basals. (Adapted from Wachsmuth and Springer, 1897, and Wilson, 1916).

anterior pair of basals. The posterior suture in subequally tripartite and bipartite, hexagonal bases is the homologue of the right posterior suture in the pentapartite and quadripartite bases; its position has been shifted through atrophy of the right half of the posterior basal and compensating hypertrophy of the left half of the right posterolateral. An equally tripartite hexagonal base (figure 3, no. 13) may be derived from a pentapartite base by the interpolation of an anal plate, the shifting of the right posterior suture, and closure of the anterior and left posterior sutures, or from a quadripartite base by the shifting of the right posterior suture and closure of the left posterior suture. A bipartite hexagonal base is derived from a pentagonal, unequally tripartite base by interpolation of the anal plate, shifting of the right posterior suture and closure of the left anterior suture (figure 3, nos. 3*c*, 8).

With a few exceptions the infrabasals in dicyclic forms do not assume a hexagonal outline, for the anals do not reach down into the infrabasal circlet; the anal *x* truncates the posterior basal. For further and more detailed discussion of the modifications of the base see references to Beyrich, Wachsmuth and Springer, Bather and Wilson in the special bibliography. Bather (1917) gives a critical discussion of Wilson's paper, " Evolution of the Basal Plates in Monocyclic Crinoidea Camerata."

Many of the crinoids which are non-pedunculate, such as Uintacrinus and Marsupites, have an additional plate, the *centrale.* This plate rests against the infrabasals and probably represents an undeveloped stalk. The basals are united with one another and with the radials above by an immovable union known as close suture which is brought about by numerous short fibres of connective tissue which may be calcified in a varying degree. The apposed surface of the plates may be smooth or striated.

The radials receive their name from their position with reference to the rays. There are usually five radials, and these give rise directly to the arms. The arms may be free immediately above the radials, or may be incorporated for some distance into the cup by direct lateral union among themselves or by the introduction of supplementary plates between them. Some authors consider the arms to begin where they first become movable. Carpenter, Wachsmuth and Springer, Bather and others restrict the term " radial " to the first radially-situated circlet of plates, and the succeeding radially-situated plates are termed *brachials.*

These brachials are known as *fixed brachials* if they take part in the calyx, *free brachials* or arm-plates if they do not. Whether they are free or fixed, the first brachials above the radials, up to and including the first axillary plate, are known as *primibrachs* or *costals*. When there is more than one plate in this order they are known as first, second, third, etc., primibrachs, the axillary plate being termed the primaxil. The brachials of the second order are *secundibrachs* or *distichals*, with the axillary plate known as the *secundaxil;* the brachials of the third order are *tertibrachs* or *palmars*. The succeeding orders, formerly known as *post-palmars* are termed *quartibrachs*, *quintibrachs*, and so on.

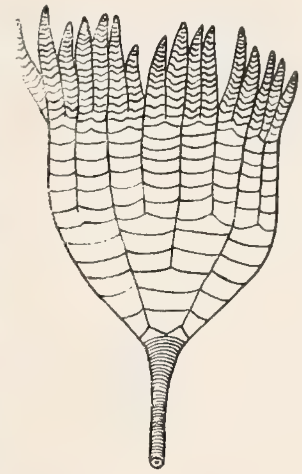


Figure 4 Ichthyocrinus laevis, showing the incorporation of brachials into the dorsal cup by the lateral union of the brachials themselves. (After Hall, 1852).

As noted above, brachials are incorporated into the cup by lateral union of the brachials themselves, as illustrated by Ichthyocrinus (figure 4) and Clidochirus (plate 38, figures 1, 2) among the Flexibilia, or by the introduction of supplementary interradial plates (figure 5). The interradial plates between the brachials are known as *interbrachials*. The interbrachials sometimes, though rarely, descend between the radials as in the Rhodocrinidae (plates 2–4). The first interbrachial is known as the *primary interbrachial;* the succeeding plates may be arranged irregularly or more or less regularly in ranks or rows. The interradial plates between the secundibrachs are *intersecundibrachs*, and so on. Sometimes *pinnulars* (pinnule ossicles) are incorporated as well as brachials, and in such cases *interpinnulars* are developed (Uintacrinus, Scyphocrinus); the fixed pinnulars are hard to distinguish from supplementary plates.

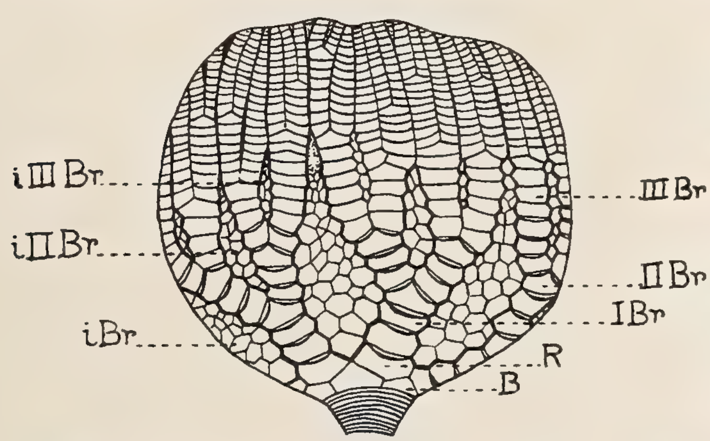


Figure 5 Forbesiocrinus wortheni, showing the incorporation of brachials into the dorsal cup by the introduction of supplementary plates. *B*, basals; *R*, radials; *IBr*, primibrachs; *IIBr*, secundibrachs; *IIIBr*, tertibrachs; *iBr*, interbrachials; *iIIBr*, intersecundibrachs; *iIIIBr*, intertibrachs. (From Grabau, 1910, after Meek and Worthen, 1873).

The above terminology for the plates of the calyx has been generally accepted. Jaekel (1918, p. 28) objects to the adoption of Bather's radial, primibrach, primaxil, etc., and brings forward a terminology which he believes is much simpler and more demonstrating. For the plates of the radial series (radial, primibrachs) he uses the term *costal;* the axillary costal is *ecostal.* Above this are *dicostals* with the axillary *diecostal, tricostals* with the axillary *triecostal*, etc. The plates between the costals are *intercostals;* between the dicostals, *interdicostals;* between the tricostals, *intertricostals;* etc.

There is a similarity of arrangement of the interbrachials in each interradius of the individual crinoid, except in primitive forms (Reteocrinidae), which is often used as a means of distinguishing genera and species. This regularity is disturbed in the posterior interradius by the introduction of special plates, the *anals.* These plates enlarge the posterior interradius, making room for the anus, hence the name anals; and they are continuous with the series of plates which support the anal tube, when present. The posterior interradius, frequently characterized by the peculiar number, size and position of the anal plates, is known as the *anal interradius.* The other interradii are termed *regular interradii* (figure 6).

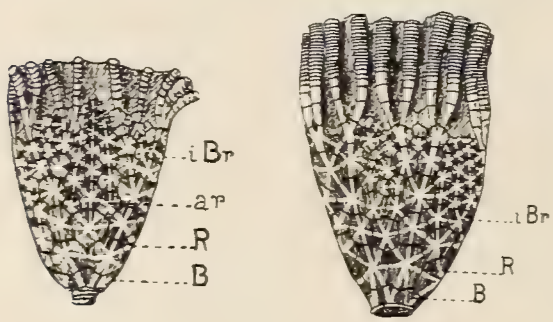
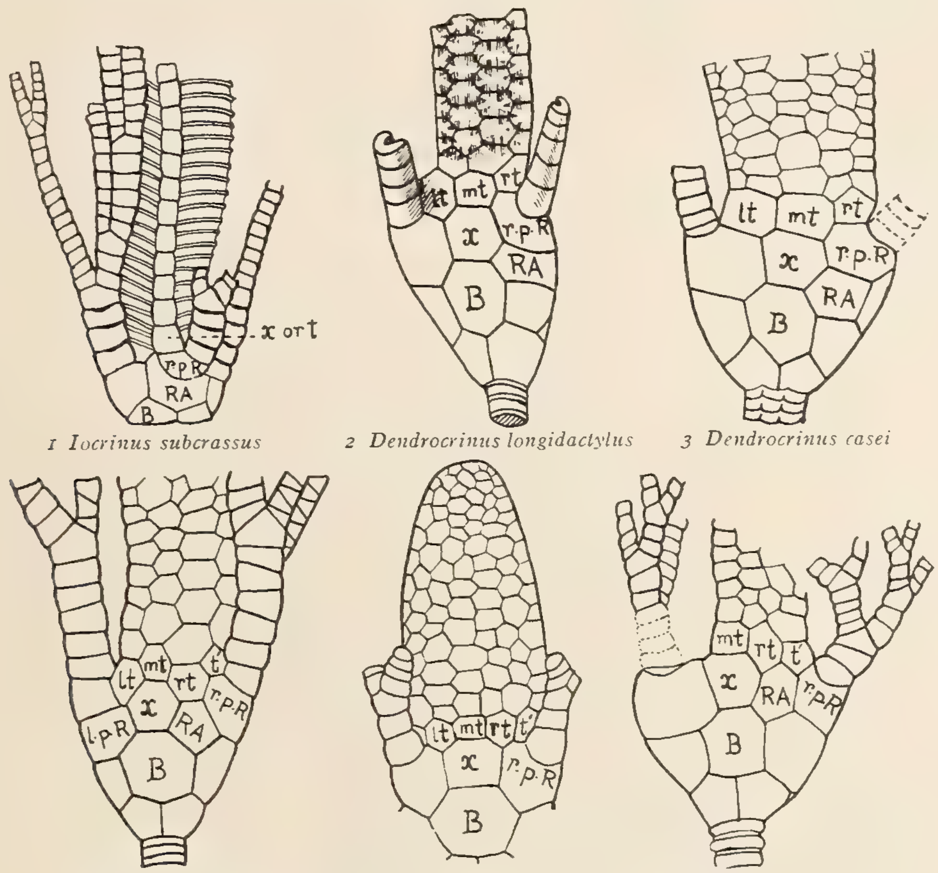


Figure 6 Glyptocrinus decadactylus. A, posterior or anal interradius. B, regular interradii, x 2/3. *B*, basals; *R*, radials; *iBr*, interbrachials; *ar*, anal ridge. (A, after Wachsmuth and Springer, 1897. B, after Meek and Worthen, 1873).

The anal plates are supplementary plates developed as occasion for them arose. In the Camerata they form a median line of plates, resembling a sixth ray, which splits the posterior interbrachials (figure 6; plate 2, figures 1, 3; plate 3, figures 4, 8; plate 26, figures 2, 3, 4, 7; plate 35, figures 6, 7). In forms where the anus is central or small they are rarely developed. A special plate (usually designated *x*) may be present, located between the radials and resting upon the truncated upper face of the posterior basal. In some forms (as Glyptocrinus and similar forms) a ridge extends up the median line of anals and passes up over the dorsal line of plates supporting the anal tube and continuous with the anals. The ridge is not present in later Camerata where the tegmen and interradii are less flexible;

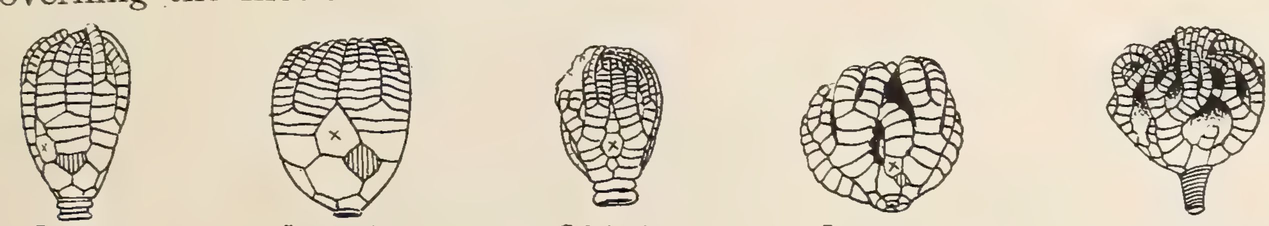


1 Iocrinus subcrassus *2 Dendrocrinus longidactylus* *3 Dendrocrinus casei*

4 Scaphiocrinus elegans *5 Cyathocrinus longimanus* *6 Parisocrinus*

Figure 7 Diagrams of the anal areas in various Inadunate crinoids. *B*, basals; *RA*, radianal; *r.p.R*, right posterior radial; *x*, first or special anal plate; *rt, mt, lt* right, middle and left tube plates; *t'*, tube plate. (From Bather, 1899, 1900, after Wachsmuth and Springer, Hall and Angelin).

it is connected with the ridges which join the posterior basal to the adjoining radials and its presence indicates the presence of an axial cord (*see* p. 17) governing the motion of the anal tube.



1 Clidochirus pyrum *2 Lecanocrinus macropetalus* *3 Calpiocrinus fimbriatus* *4 Gnorimocrinus expansus* *5 Taxocrinus shumardianus*

Figure 8 Anal areas in various Flexibilia. *x*, special anal plate; radianal shaded in vertical lines; 4, anals in tubelike series; 5, anals in tubelike series bordered by integument of small plates. (After Springer, 1906).

In the Inadunata and Flexibilia there may be one or two anal plates. The anal area in various Inadunate crinoids is shown in figure 7; in the Flexibilia in figure 8. When there are two plates present, one is the modified lower half of the right posterior radial (right posterior inferradial) which has taken on anal functions, and is known as the *radianal*.[1] The other plate is a special anal plate, the anal *x*. By the introduction of this plate into the posterior interradius, the right posterior superradial is pushed to the right so that the radianal is brought into contact with the anal *x*. The radianal helps in the widening of the anal area and the support of the anal tube.

The theory that the anal tube is a modified arm was proposed and rejected by Wachsmuth and Springer. Bather (1900, pp. 119, 120) favors the less extreme view that the median dorsal line of ossicles supporting the tube represents the proximal left branch of the posterior arm. This view is not proved, but, according to Bather, the only argument against the view is the improbability of change of function in the ramus. Certainly in such forms as Isocrinus, Merocrinus and the new Portage and Chemung genera, such as Glossocrinus and Liparocrinus, the character of the anal area and anal tube would seem to favor this view (plate 52; plate 53, figures 7, 8, 9).

There is a difference of opinion as to the origin of the anal *x*. Wachsmuth and Springer believe it to be a secondary element introduced as in the case of the anal of the Camerata; Bather believes it to be the proximal median plate of the tube which has gradually sunk down into the cup. For a full discussion of these views reference should be made to the works of these authors listed in the special bibliography (p. 76) and to Wilson (1916, pp. 547–553).

(2) **Tegmen.** It proves convenient under this heading to give a brief account of some of the body systems and their extensions; not only because it will give a better understanding of the tegmen, but also

[1] A paper entitled "What is the Radianal?" is in course of preparation by Dr Herrick E. Wilson. (*See* Springer 1920, p. 56).

because it will prove necessary to a clear understanding of the discussion of the arms.

The tegmen may be in the form of a coriaceous skin with a large number of imbedded thin calcareous ossicles or it may be a plated disk (figure 9; plate 19, figure 4; plate 20, figure 8; plate 33, figure 2). The *mouth* (*peristome*) is more or less central and leads into an oesophagus or gut which is at first directed downward to the bottom of the cup by a dextral curve; then it rises along the side of the cup and discharges through a usually excentric interradial aperture, the anal opening or *anus*. In most all of the recent crinoids the arms and the pinnules borne by them are each provided on the ventral surface with an open groove or furrow known as the *ambulacral furrow*. These ambulacral furrows unite at the base of the arms, forming five larger furrows which traverse the tegmen to the mouth. Below the floor of the ambulacral furrow in each arm is an epithelial nerve band and under this occur, in the order mentioned, the canals of the blood and water vascular systems, paired subtentacular nerves (one each side of the water vessel), paired subtentacular canals, the canal containing the genital rachis and the dorsal coeliac canal. A large nerve cord of the dorsal system, the *axial cord*, lies below all the other canals and is deeply buried within the calcareous substance of the plates. By the outgrowth of stereom the groove in which this dorsal nerve or axial cord lies is often separated from the brachial groove during the development of the individual. This groove is termed the *dorsal* or *axial canal* (figure 10).

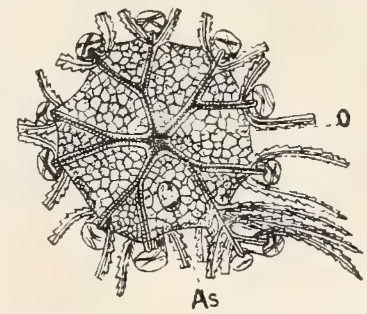


Figure 9 Isocrinus asteria. Tegmen showing very thin perisomic plates, central mouth, *O*, and excentric anus, *As*. (After Springer, 1913).

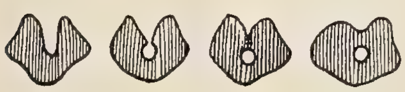


Figure 10 Stages in the separation of an axial canal, exemplified by brachials of Gissocrinus goniodactylus. 1, youngest; 4, oldest. x 6 diam. (After Bather, 1900).

The epithelial nerve, paired subtentacular nerves, and the water and blood vascular canals run to ringlike structures around the oesophagus. In each arm distensible tentacles are given off from the ambulacral water

2

vessels from alternate sides. The circumoesophageal water-vascular ring communicates with the body cavity which in turn communicates with the exterior by perforations or pores. Within the body cavity a division of the coelom, known as the axial sinus, passes down the vertical axis through the coil of the gut. Into this sinus the subtentacular canals enter. Surrounding the axial sinus and the gut is the division of the coelom known as the peri-intestinal cavity into which the dorsal coeliac canal passes. The remainder of the coelom surrounding the peri-intestinal cavity is known as the subtegumentary cavity. The genital rachis in each arm is connected with the axial organ, a complex of twisted, fine canals passing down the axial sinus. The axial organ widens in the middle, but becomes a thin strand where it passes between the five divisions of the chambered organ (*see* discussion of dorsal nervous system below).

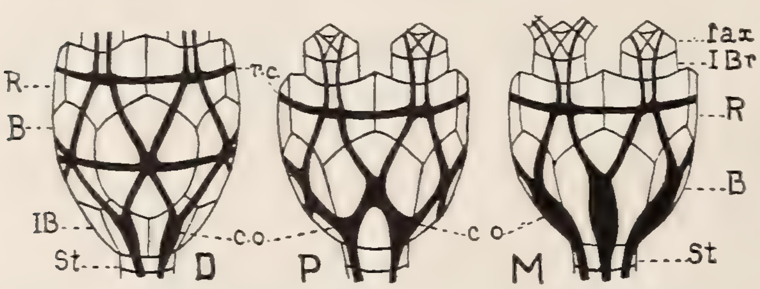


Figure 11 Course of axial nerve cords in Dicyclic (D), Pseudomonocyclic (P) and Monocyclic (M) Crinoids. *R*, radial; *B*, basal; *IB*, infrabasal; *IBr*, primibrach; *Iax*, primaxil; *St*, column; *r.c.*, ring commissure in radials; *c.o.*, lobes of chambered organ, the connecting nervous sheath omitted for greater clearness. (After Bather, 1898, 1900).

Unlike the other organs of the arm, the dorsal nerve cord does not lead to the oral center, but enters the calyx over the radial, passing to the nervous tissue which forms the outer wall of the five-lobed *chambered organ* situated in the dorsal apex of the calyx. All the divisions of the body cavity are separated from each other by connective tissue; and in this way are cut off at the aboral end of the peri-intestinal cavity five chambers which surround the axial sinus and which are covered on all sides by epithelium containing ganglion cells and nerve fibres. The term *chambered organ* is applied to the whole structure.

The passage of the dorsal nerve cords in a simple monocyclic or dicyclic crinoid is illustrated in figure 11. The nerve cords become bordered by stereom and are enclosed within the cup-wall. If the nerve cord is in a separate axial canal it passes into the calyx plates through the radial facet. Each nerve cord has a double structure; it separates when it enters the radial into two branches, sending one to the basal on the right and the other to the basal on the left. If the crinoid is monocyclic the cords which pass to the basals join in a ring which surrounds the chambered organ. Here the lobes of the chambered organ correspond with the basals and are interradial. The branches of each nerve are connected with each other and with the nerves of the other radii by a series of commissures which form a ring at the level of the radials. If the crinoid is dicyclic another such ring is formed at the level of the centers of the basals, from which paired branches are sent to the infrabasals. The arrangement in a pseudomonocyclic base is the same; and in both cases the lobes of the chambered organ are radial. The nervous system just described is a senso-motor nervous system; it is connected by branches with the other nervous systems.

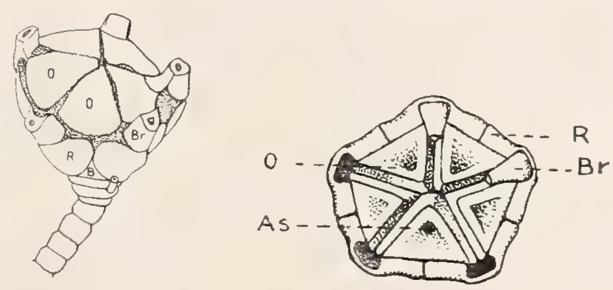


Figure 12 A, one of the larval stages of Antedon, with the arms cut away to show the orals surrounding the mouth. B, tegmen of Haplocrinus mespiliformis. *O*, oral; *R*, radial; *B*, basal; *Br*, brachial; *As*, combined pore and anus in posterior oral. (A, after W. B. Carpenter, 1866, x 1/3. B, after Wachsmuth and Springer, 1888).

In the larval Antedon (figure 12A), the mouth is covered by five triangular oral plates which rest upon the shoulders of the radials and are interradial in position. In the more primitive genera of crinoids, such as Haplocrinus (figure 12B; plate 40, figures 10–14), Hybocrinus and Carabocrinus are found five interradial plates which correspond in shape and position with the orals of the larval Antedon. The presence of a pore or pores in the posterior plate, as in the larval Antedon and the adult Hyocrinus, and the position of the anus (combined with pore in Haplocrinus) between this plate and the adjoining radials confirm the generally accepted view that these five interradial plates are orals.

Three stages in the evolution of the tegmen, according to Bather (1900), are shown in figure 13. The tegmen in its simplest form has the five orals; but usually more or less rounded *covering-plates* or *ambulacrals* are present. These plates cover the grooves which extend over or between the apposed edges of the orals to the arms. On the arms the covering plates are separated from the brachials and pinnulars by oblong or squarish plates known as *side plates* or *adambulacrals*. These side plates occur in most of the Inadunata and Flexibilia, but are rarely represented in the Camerata. Ambulacrals (and accompanying plates, if present) become irregular and ill-defined on the tegmen.

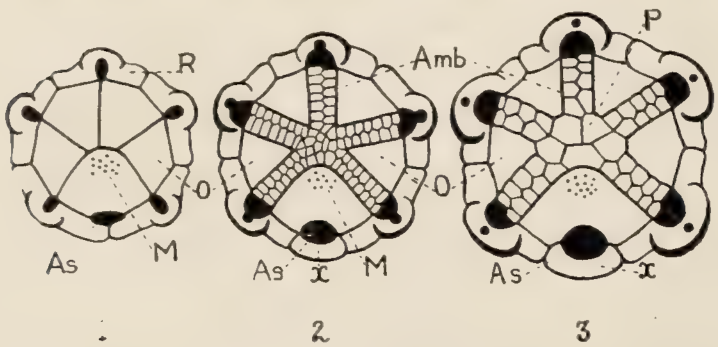


Figure 13 Three stages in the evolution of the tegmen (according to Bather). 1, orals only, *O*; 2, orals and ambulacrals, *Amb*; 3, orals (interradial plates of Springer), ambulacrals and enlarged peristomial ambulacrals, *P*, (orals of Wachsmuth and Springer). *R*, radial; *As*, anus; *x*, anal plate; *M*, madreporite. (After Bather, 1900).

Modifications of the tegmen accompany modifications of the dorsal cup. Where brachials are incorporated in the cup, ambulacrals of the ventral side of the arms are incorporated in the tegmen, lengthening the

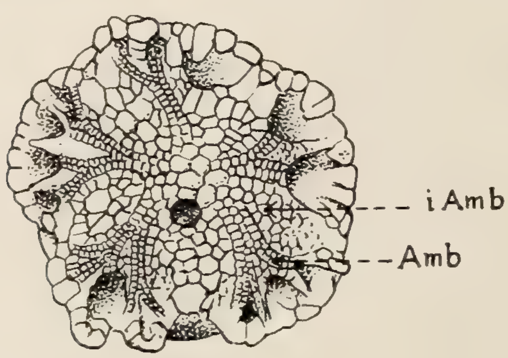


Figure 14 Marsipocrinus depressus. Tegmen showing the incorporated ambulacrals, *Amb*, and the interambulacrals, *iAmb*, between them. The orals are quite small and asymmetrically arranged. (After Wachsmuth and Springer, 1897).

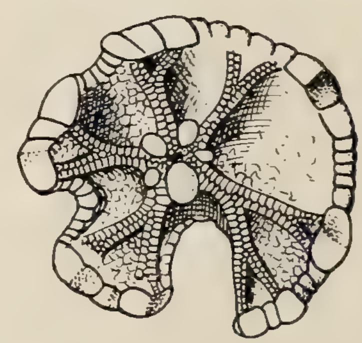


Figure 15 Taxocrinus intermedius. Tegmen showing the exposed mouth surrounded by five oral plates. (After Wachsmuth and Springer, 1888, 1897).

food grooves over its surface. Interambulacrals in the tegmen correspond to the interbrachials (figure 14) of the cup. The mouth may be exposed or closed. In the first case it is surrounded by the five orals (figure 15); in the second case, the posterior oral may be pushed in between the four others so as to conceal the mouth. The mouth then is said to be *subtegminal* (figure 16).

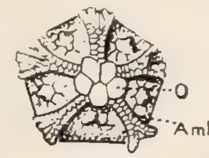


Figure 16 Platycrinus symmetricus. Tegmen showing subtegminal mouth. *O*, orals; *Amb*, ambulacrals. (After Wachsmuth and Springer 1888, 1897).

Changes from the primitive type of tegmen may take place along three different lines: (1) The ambulacrals pass over the apposed edges of the orals. Gradually the ambulacrals and sometimes the interambulacrals cover up the orals which, with the exception of the posterior, seem to diminish in size and sink beneath the surface. The posterior oral usually remains large, taking on the character of a madreporite, and is pushed by the increased size of the anal tube nearer the oral center. In accordance with the views of Bather (1900) the proximal (peristomial) ambulacrals become enlarged and assume

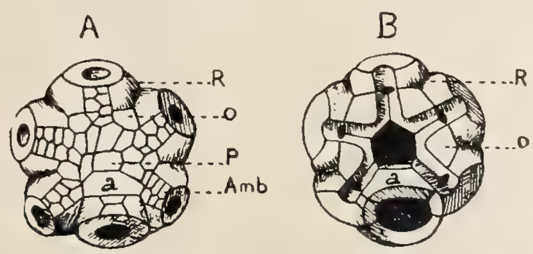


Figure 17 Cyathocrinus malvaceus. A, tegmen showing superficial plating. B, tegmen with the same removed. *R*, radial; *O*, orals of Bather, interradial plates of Wachsmuth and Springer; *P*, enlarged peristomial plates of Bather, orals of Wachsmuth and Springer; *Amb*, ambulacrals; *a*, anal interradial of Wachsmuth and Springer, posterior oral (madreporite) of Bather. (From Springer in Zittel, 1913, after Meek and Worthen).

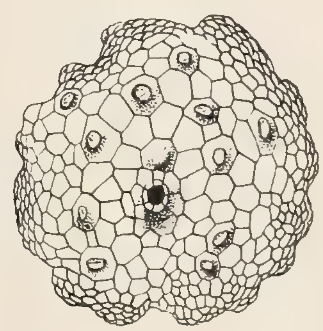


Figure 18 Megistocrinus nodosus. Tegmen showing the nodose radial dome plates. x 2/3. (After Wachsmuth and Springer, 1897).

a pentagonal arrangement like that of primitive orals (figure 13, no. 3). Wachsmuth and Springer (1897; Springer 1913) regard these plates as the orals. This line of modification of the tegmen is exemplified by such forms as Cyathocrinus, Euspirocrinus, Gissocrinus, Gasterocoma, etc. (figure 17). (2) The second line of modification is shown by such forms as Taxocrinus (figure 15). Here the ambulacrals pass between the orals, leaving the mouth open. The orals gradually atrophy. (3) The third line of modification is seen in the Camerata (plate 19, figure 4; plate 20, figure 8; plate 33, figure 2; figure 16). The modification here is very remarkable. The ambulacrals pass beneath the orals (figure 16) and gradually beneath the other tegminal plates which are developed at the same time that the brachials are incorporated in the cup and which separate the orals from the periphery of the tegmen. The tegmen plates in the Camerata are usually very numerous. They attain considerable thickness and fit into one another in such a way as to form a more or less convex, extremely rigid vault. Very often at the apex of this dome or vault may be distinguished five large plates, the one in the anal interradius commonly differing from the others in size and shape and wedged in among them. Wachsmuth and Springer (1897; Springer 1913) regard these plates as orals; Bather (1900, p. 127) suggests that they may after all be modified ambulacrals. According to their position in the tegmen, the other plates are distinguished as ambulacrals or interambulacrals. In some groups, as the Platycrinidae, the ambulacrals are generally arranged in two rows of rather large plates which, however, have to a certain extent lost their original character. In other groups, such as the Batocrinidae, the ambulacrals are not in alternate rows. Here the ambulacrals are represented by large single plates of one or more orders, separated from each other by supplementary plates. These large plates represent covering plates, particularly axillary pieces, which could not be so easily covered by other plates. They are known as *radial dome plates* (figure 18), and are frequently nodose or spinose.

A form highly developed along these lines of modification is shown in the illustrations of Catactocrinus proboscidialis (figure 19). In such forms, the food grooves, water vessels and blood vessels are completely sunk beneath the tegmen and are enclosed in a system of ramifying tubes which follow the inner floor of the tegmen. These tubes are composed of the alternating ambulacrals above and of the side plates or adambulacrals below. There are curious extensions from the interambulacral plates into the interior of the calyx which spread out and form what used to be regarded as a disk. The extensions have been regarded as due to the perforation of the plates for water canals by some; by others, as processes developed for strengthening purposes.

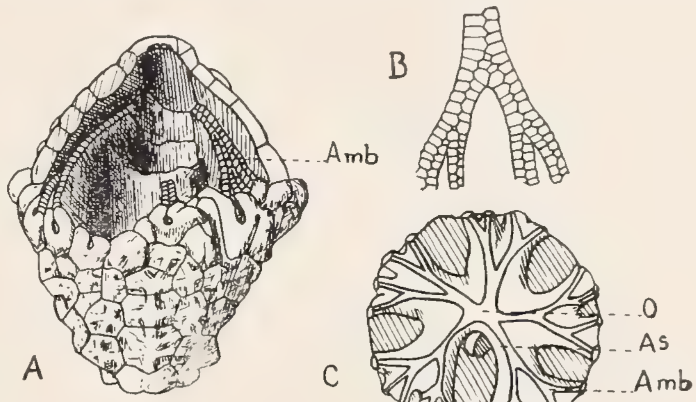


Figure 19 Catactocrinus proboscidialis. A, plates of tegmen partially removed showing covered ambulacral passages, *Amb*, leading from the arms to the mouth. B, plated upper surface of ambulacral galleries. C, natural cast of ventral disk with impressions of calyx ambulacra, *Amb*, leading to the mouth, *O; As*, anus. (From Springer in Zittel, 1913, after Meek and Worthen, 1873).

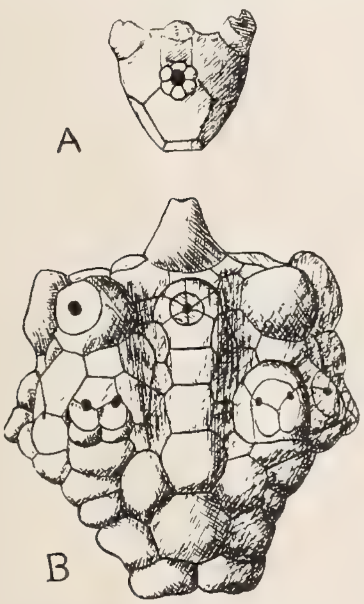


Figure 20 A, Gasterocoma antiqua. Speci men showing anus through the dorsal cup, below the level of the arm-bases. B, Dorycrinus quinquelobus. Specimen showing plates of the tegmen and excentric anus. (A, from Springer in Zittel, 1913, after L. Schultze. B, after Meek and Worthen, 1873).

The anus in most Paleozoic crinoids is the only opening, and, as stated above, is usually excentric and interradial. Sometimes the anus is central and again it may open through the dorsal cup (figure 20). In most of the Paleozoic Camerata, and in all recent species, the anus is situated at the upper end of a plated tube known as the *anal tube* or *proboscis* (plate 24, figures 2, 3, 4). This anal tube is rigid as is the vault which it surmounts. Various *anal tubes* or *ventral sacs* of the Fistulata are illustrated in figure 7 and on plates 42, 43, 47, 49, 54. In the Fistulata the anal opening is along the anterior side of the ventral sac, or between the ventral sac and the mouth.

Pores for the admission of water into the body cavity occur in the crinoids. A greater or smaller number of the interambulacral plates are perforated by such pores, and in some genera these are confined entirely to the vicinity of the mouth. Pores occur in some of the Fistulata, and here, instead of piercing the body of the plates, they enter their outer angles; in other Fistulata a madreporite is found. Pores have also been found piercing the ventral sac in Fistulate crinoids (Springer, 1900).

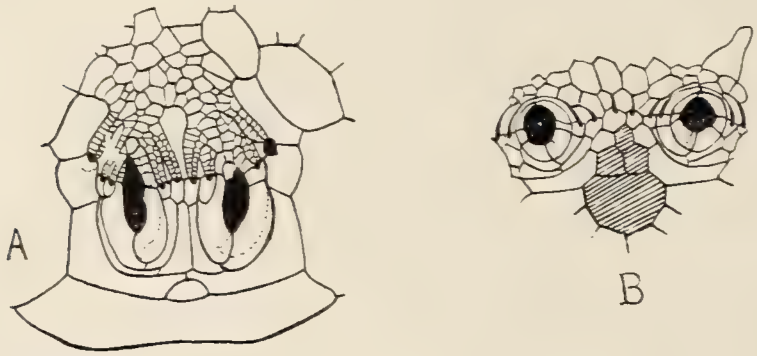


Figure 21 A, Marsipocrinus striatus (?). Diagram of one ray of a specimen showing position of pinnule openings and ambulacra leading to them. x 3/2. B, Scyphocrinus gorbyi. An interradius with adjacent arm-bases showing pores in plates corresponding in position to pinnule ossicles. x 5/2. (After Springer, 1917).

In the Camerata so-called "*respiratory pores*" have been observed near the arm-bases (figure 21). They occur in the interradii or between the arms and their branches. In the genus Dolatocrinus[1] there are four to six in each interradius and two to four between each series of fixed secundibrachs; some genera have only ten pores. It has now been demonstrated (Springer, 1917, pp. 40–46) that these pores connect with the food canals. The pores originated from pinnules which with progressive growth were incorporated into the body. These pinnules may have possessed a respiratory function, since the proximal pinnules in many recent crinoids are shown to be lacking the usual functions of pinnules. Extreme aberrant growth of pore or pinnule is seen in Gilbertso-

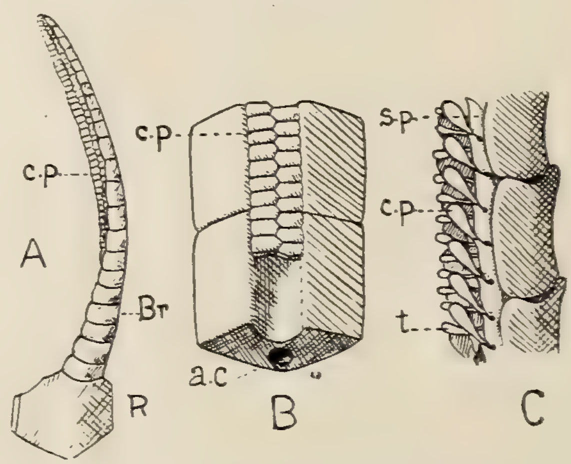


Figure 22 A, simple unbranched arm (Hybocrinus). B, ventral view of two brachials of Gissocrinus squamifer; covering plates, or ambulacrals, closed above, removed below. C, side view of brachials of Antedon basicurva with covering plates open showing tentacles. *R*, radial; *Br*, brachial; *c.p.*, covering plates or ambulacrals; *s.p.*, side plates or adambulacrals; *t*, tentacles; *a.c.*, axial canal. (After Bather, 1900).

[1] *See* discussion of genus Comanthocrinus, page 192.

crinus (plate 3, figures 1, 6) where the pore is situated at the end of a tubular interradial appendage (ref. cit., pp. 45, 46).

b Arms

The arms of a crinoid are the immediate prolongations of the radials. The simplest type of a crinoid arm (figure 22) is made up of a series of ossicles, the *brachials*, the proximal one of which is attached to the radial by a surface known as the *radial facet* or *arm facet*. The dorsal side of the arm is rounded and the inner or ventral side is provided with a groove which contains the soft parts. Beneath this ventral groove the brachials

1 2 3 4 5 6 7

Figure 23 Specialization of arm-branching. 1, a nonpinnulate, regularly dichotomous arm (isotomous); 2, a less regularly dichotomous arm, a type common in the Cyathocrinoidea; 3, 4, two stages in the evolution of unilateral heterotomy; 5, 6, 7, three stages in the evolution of bilateral heterotomy. (After Bather, 1900).

are perforated by the single (sometimes duplicate) axial canal which contains the double-structured dorsal nerve cord. The ventral groove is roofed over by covering plates, the *ambulacrals*. In less simple arms these covering-plates may be separated from the brachials by the *adambulacrals* or side plates. As described under *Tegmen*, the ventral grooves with the soft parts contained within them and the covering plates are continued across the tegmen to the mouth. The covering-plates are movable on the arms and pinnules, but on the disk only in those forms in which the mouth is exposed.

As discussed under the description of the dorsal cup, the brachials may be free immediately above the radials or a variable number of the proximal brachials may be incorporated in the cup. Just as the dorsal cup and tegmen undergo modifications, so there are modifications of the simple, unbranched type of arm. The first step is the occurrence of bifurcations (figure 23). If the bifurcations occur constantly at regular intervals the type of branching is termed *regular dichotomy* or *isotomy*. *Irregular dichotomy* or *heterotomy* is produced by the suppression of bifurcations at definite points. The resultant members of the bifurcation may be unequal, the smaller member occurring alternately at the right or left in each half arm. This gives a main trunk with smaller branches occurring alternately at the right and left, a type of branching called *bilateral heterotomy* (plate 41, figure 10; plate 42, figures 4, 8; plate 43, figures 1, 4, 6). The occurrence of the smaller branches only on one side of the main trunk is known as *unilateral heterotomy* (plate 26, figures 9, 10; plate 49, figure 4; plate 50, figure 1; plate 51). The smaller branches given off from the main arm-branch or *ramus* are termed *armlets* or *ramules*.

In the Camerata, the more highly organized Inadunata and all of the recent crinoids, the arms are furnished with jointed appendages, the *pinnules* (figure 1). The pinnules are usually regularly placed on alternate sides of successive brachials, but sometimes they alternate from every second or third brachial (plate 53, figure 3; plate 57, figures 4–6, 8). They may be missing from the proximal parts of the arms. Pinnules are the repetition of arms on a small scale; the ossicles composing the pinnules are termed *pinnulars*. The fertile portions of the genital organs are restricted to the pinnules.

There is a difference of opinion as to the origin of pinnules. Bather (1890, 1900) considers that they are ramules which have ceased to branch and have assumed the regular, alternating arrangement on successive brachials; they are the culmination of bilateral heterotomy. Jaekel (1894, 1918) accepts Bather's theory for most of the Inadunata and Neozoic crinoids, but calls the appendages ramules. The term pinnules he applies to similar appendages in the Paleozoic Camerata which he believes were formed through the transformation of the primary border plates. Wachsmuth and Springer (1897) appear to regard pinnules as of independent origin and the pinnule-bearing armlets of forms like Melocrinus (plates 6, 8, 12, 13, 15, 16) with compound main arms, as developed from pinnules. Kirk (1911) believes it more probable that the process opposite to that upheld by Bather has obtained. He states: "At times, no doubt, arm branches have become reduced in size forming ramules and even ultimately what might be styled pinnules. However, I do not think that this has been the normal process" (ref. cit, p. 113). In his recent "Monograph on the Existing Crinoids," A. H. Clark (1915) makes the following statement:

It is probable that the pinnules represent the original type of crinoidal appendages, and that these appendages were arranged in five pairs, the two components of each pair being, so to speak, back to back; but the pinnules have become enormously reduplicated, while in addition (they) have come to lie along either side of long body processes (arms) of subsequent development (ref. cit., p. 274, omitting references to cirri).

The terminology of the arm parts has already been partially discussed under the treatment of the extension of the dorsal cup. In a dichotomous arm without pinnules all the brachials up to and including the first axillary are *primibrachs*, the axillary being termed the *primaxil;* the brachials above the primaxil up to and including the axillary (secundaxil) are *secundibrachs;* above this the successive series are known as *tertibrachs*, *quartibrachs*, and so on. Wachsmuth and Springer (1897) use the same terminology for pinnulate arms. In accordance with Bather's interpretation of the origin of a pinnule, in pinnulate arms the primibrachs, which as a rule do not bear pinnules, are homologous with the primibrachs of nonpinnulate arms; in the next series the proximal brachial is a secundibrach, the pinnule borne by it and the following brachial representing the tertibrach of a simple arm. A special terminology for pinnulate arms has been brought out by Bather (1892), but it has not received general acceptance.

The upper sloping faces or shoulders of an axillary brachial may be equal or unequal. Even where the shoulders of the axillaries are unequal, the axillary on which the main arm-branches fork has equal shoulders and the axillary is distinguished as the *main-axil.* The ambulacral areas branch with the arms, and the series of ambulacrals formed are known as ambulacrals of the first order, second order, third order, etc., or as *primary ambulacrals, secondary ambulacrals,* and so on. For descriptive purposes an arm is viewed from the dorsal side and the right and left of the arm are the right and left of the observer.

Arms may be *uniserial* or *biserial.* In a uniserial arm the brachials are arranged in a single series. Simple arms are always uniserial, and here the brachials are more or less rectangular. In pinnulate arms the brachials tend to slope alternately to the right and the left. This tendency is increased, and either in the development of the individual or the race, the brachials become completely wedge-shaped. The next step is the arrangement of the brachials in two alternating rows with the smaller ends of the plates meeting midway, so as to form a zigzag suture line. This produces a biserial arm (figure 24). Pinnulars likewise may assume a zigzag biserial arrangement. The change from a uniserial to a biserial arm starts at the tips of the arms and proceeds proximad. This is true both in ontogeny and phylogeny. The development of biserial arms doubles the number of pinnules in a given length of arm, thereby aiding in the collection of food.

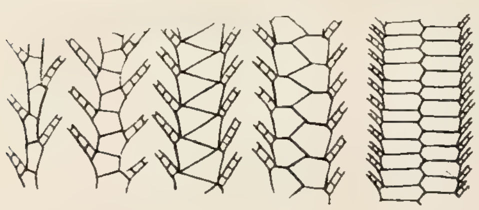


Figure 24 Evolution from uniserial through zigzag to compactly biserial arms. (After Bather, 1900)

The above conception of the origin of biserial arms is the one commonly accepted. According to A. H. Clark (1915, pp. 184, 189, 350, 352, 354) the biserial arrangement is more primitive in crinoids; the biserial arrangement is the Paleozoic type, while the uniserial arrangement arose chiefly in Post-Paleozoic times. His theory is very different from the commonly accepted one. He believes that crinoid arms were originally paired interradial structures and that in times previous to that of the actually known Paleozoic crinoids adjacent uniserial arms were united laterally in pairs in such a way as to give rise first to biserial arms, and, later, by ossicles slipping in between each other, to elongate pseudo-uniserial appendages (ref. cit., p. 350; *see* Foeste 1916).

Jaekel (1918) likewise believes that the biserial arrangement in crinoid arms is more primitive. He divides the arm structures into three types (ref. cit., pp. 22, 23). (1) As the oldest he places the biserial, unbranched, pinnuleless appendages, "*brachioles*," which are characteristic of the Cystoidea, Blastoidea and his new subclass Eocrinoidea. As a rule these appendages are in five groups of several each. (2) This type becomes more highly developed among the Cladocrinoidea through the transformation of the primary small side plates into pinnules which are borne by each one of the alternating "finger" ossicles. Jaekel applies the term "finger" to this type of arm form because it bears the same relation to the arm trunks as a finger to the hand. These "fingers" are primarily undivided and biserial; later they fork but not with pronounced axillary pieces. This biserial (*distichal*) structure can be changed through wedging (*sphenostichal*) or through fusion as in Carpocrinus and Melocrinus (*synstichal*). (3) To the third type belong the typical *arms* or *brachia* of the Pentacrinoidea. They are placed singly in each radius, are primarily and almost always uniserial. In the beginning, or through degeneration, they are undivided, but mostly they are divided. The axillary forking is carried so far that finally every ossicle is axillary. Through lateral pressure of these small side branches, which Jaekel terms ramules instead of pinnules, the ossicles of the trunk or main branch may become wedged within one another (*dichostichal*) or develop biserial arrangement (*parastichal*).

Fusion is found to occur among the brachials. This fusion may be either lateral or in a vertical line, or both may occur. From such fusions we may get forms like some of the Gissocrini where the secundibrachs and sometimes the tertibrachs are joined laterally; like Petalocrinus where all the brachials, with the exception of the primibrachs, are united to form a single petaloid plate; like Crotalocrinus (figure 25) where the arm branches are united by lateral processes to form a flexible network which may be divided into five broad, reticulate, fanlike fronds or may be continuous all around the crown; like Melocrinus in which the two main uniserial rami in each ray are fused for some distance or to their full extent by their inner margins, giving to the crown five compound main arms or radial appendages bearing pinnulate armlets or ramules at intervals from opposite plates in the ray and from one side only of each half (plates 6, 8, 12, 13, 15, 16).

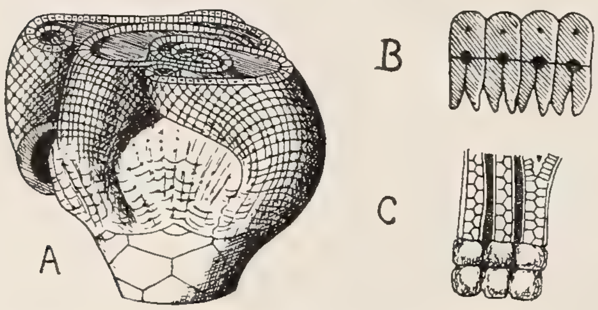


Figure 25 Crotalocrinus pulcher. A, calyx and arms cut across to show how the arms are rolled up. x 2/3. B, cross section of four contiguous arm-ossicles of the net-work. C, dorsal aspect of arm-plates, showing their intimate union; those above the two rows figured have been broken away so as to expose the side pieces and covering plates of the ambulacral furrows. (After Springer in Zittel, 1913)

When an immovable sutural union occurs between two brachials of a pinnulate arm, of which only the upper one is pinnule-bearing, the union is known as a *syzygy*. The lower brachial without apinnule is termed a *hypozygal*, the upper pinnule-bearing brachial is the *epizygal*.

By the fusion of the right and left ossicles of a biserial arm a compound brachial is formed bearing two pinnules, one on each side. This process may be carried still farther, and by the fusion of two or three two-pinnulid brachials a compound brachial may be formed with two or three pinnules on each side. Certain genera, as Cordylocrinus (p. 275), Clarkeocrinus (p. 180) and Liparocrinus (p. 397), have been studied in which are found two-pinnulid brachials (or fusions of two-pinnulid brachials) throughout the arms with no indication of previous biseriality.

c Column

The entire column or stalk of the crinoid has probably been produced through the reduplication of a single dorsal apical plate by a curious serial repetition which is common among the echinoderms. The length of the column is quite variable. The length of stems in Mesozoic crinoids was enormous; in one of the Jurassic Pentacrini a column has been observed measuring 70 feet in length. Some of the largest Palaeozoic crinoids, such as Megistocrinus and Strotocrinus have been found with stems 3 feet long, but the majority have a stem of about a foot. There are all gradations from this through forms with much abbreviated stems (Millericrinus) to those in which the column is atrophied and which are either attached directly by the base (Holopus) or are entirely free from attachment (Uintacrinus, Agassizocrinus, Comatulids). Some of the columns are wider in the proximal

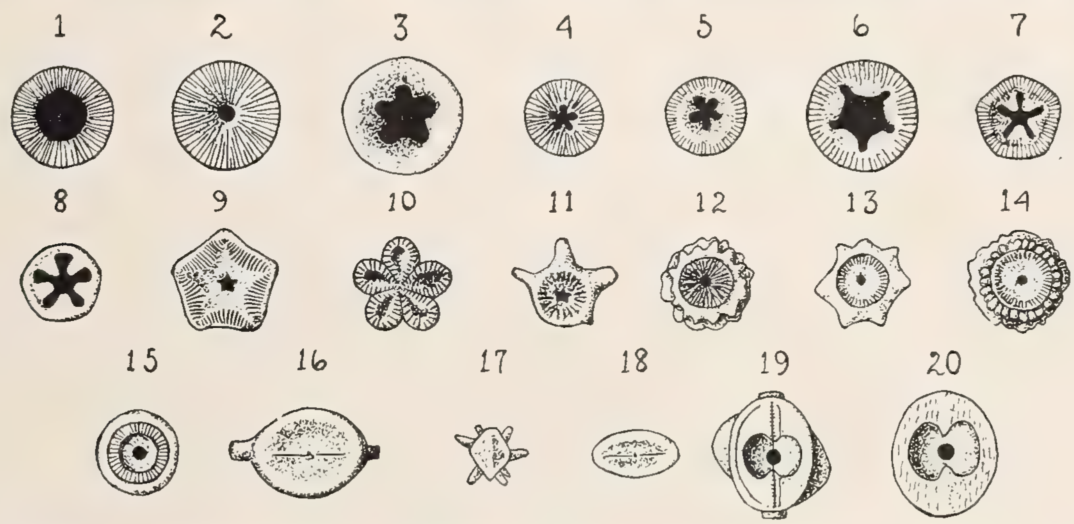


Figure 26 Various types of columnals showing articulating surfaces. 1, Periechocrinus; 10, Pentacrinus; 12, Catactocrinus; 16–18, Platycrinus; 19, Rhizocrinus; 20, Antedon sarsi; 2–9, 11, 13–15, undetermined genera. (After Wachsmuth and Springer, 1897; 9, 19, 20, after Bather, 1900)

portion and taper distad; others are larger at the distal end; still others are widest in the middle. The simplest form of column is round with a tendency to pentagonal outline. The column may also be elliptic, pentangular, stellate, semilunate or quadrangular (figures 26, 27*B*). Toward the distal part of the column the angularity becomes less pronounced and the column becomes rounded (plate 4, figures 1, 4; plate 53, figures 1, 4).

The column ossicles, the *columnals*, are distinguished as *nodals* and *internodals*. The nodals include the larger columnals and all the cirrus-bearing columnals (figure 27*A*). The diameter of the nodals is greatest in the upper part of the stem where they are often twice, and sometimes three times the diameter of the internodal columnals. The edges of the nodals may be crenulated, nodose, spinose, and sometimes the edge is very thin and knifelike. New columnals which become the nodals are introduced directly beneath the calyx or some distance from it. The youngest columnal therefore is usually the uppermost one. In some Mesozoic and recent forms and in fossil crinoids such as Onychocrinus and Apiocrinus (figure 27C, D) the top columnal remains permanently attached to the calyx, and the new nodal joints are formed beneath. The name *proximale* has been given to this fixed columnal (Bather, 1900, p. 108).[1] The internodes lengthen proceeding distad; that is, the column matured from the root up, the proximal portion being permanently in a state of immaturity. Some columns (Platycrinus) show no internodals; in others, the internodes begin at quite a distance from the calyx (figure 27C; plates 38, 39).

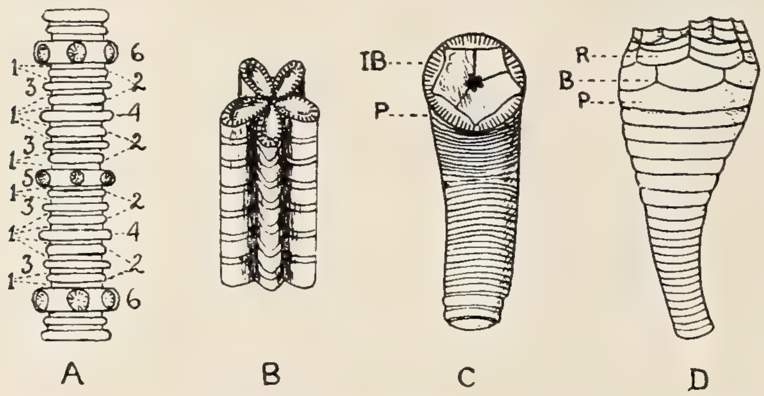


Figure 27 Some types of columns. A, diagram of column of Gastrocrinus patulus, the latest formed columnals numbered 1, the oldest 6; 5 and 6 bear cirri. B, quinquepartite column of Pentacrinus basaltiformis. C, proximal end of column of Onychocrinus, showing enlargement of column and infrabasals, *IB*, fused to the top columnal, the proximale, *P*. D, cup and part of the column of Apiocrinus elegans, showing proximale, *P*, and other enlarged columnals. *B*, basals; *R*, radials. (A, D, after Bather, 1900; B, after Springer in Zittel, 1913; C, after Wachsmuth and Springer, 1897)

Just as in the case of the arms, the column is pierced by a longitudinal, usually central, canal, the axial canal, which is circular, oval or pentagonal in cross section. There is a remarkable variation in the size of the axial

[1] Springer (1920, p. 29) believes that the view (expressed by Wachsmuth and Springer, 1897, pp. 39, 40) that in the Flexibilia the topmost columnal was persistently fused with the infrabasals is more theoretical than practical. It is doubtless true that such a fusion often occurred in adult specimens in which stem growth was completed, but the often persistent attachment of the proximal ossicles to the infrabasals can readily be accounted for by close suture.

canal in Paleozoic crinoids. It may be no larger than the point of a needle or it may be one-half to three-quarters the width of the columnals. There is an extension into the axial canal of a vessel from each of the five lobes of the chambered organ with its nerve sheath (the axial cord). The five cords comprising the axial cord surround a prolongation of the axial organ. In dicyclic crinoids the cords would be radial; in monocyclic, interradial.

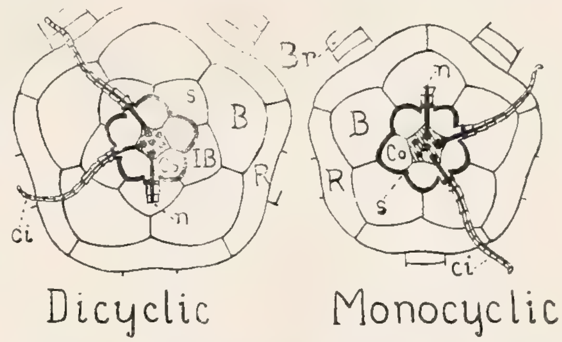


Figure 28 Diagrams of Dicyclic and Monocyclic bases showing the position of the cirri with reference to the plates of the dorsal cup. *IB*, infrabasal; *B*, basal; *R*, radial; *ci*, cirri; *co*, pentameres of column; *n*, nerves going to cirri from extensions of capsule; *s*, suture between pentameres of column. (After Bather 1898, 1900)

Wachsmuth and Springer (1897, p. 60) framed a " law " to the effect that when infrabasals are, or have been, present, the exterior angles of the stem are interradial; but the longitudinal sutures, the sides, the lobes of the axial canal and the cirri of the stem are radial; in crinoids with a true monocyclic base the conditions are reversed. This is true only of species with a pentangular or pentapartite stem or canal. Bather points out (1898, p. 423; 1900, p. 106) that this law is liable to exceptions; and he believes that a surer guide for discriminating between monocyclic and dicyclic forms is obtained by attending chiefly to the relation of the axial cords.

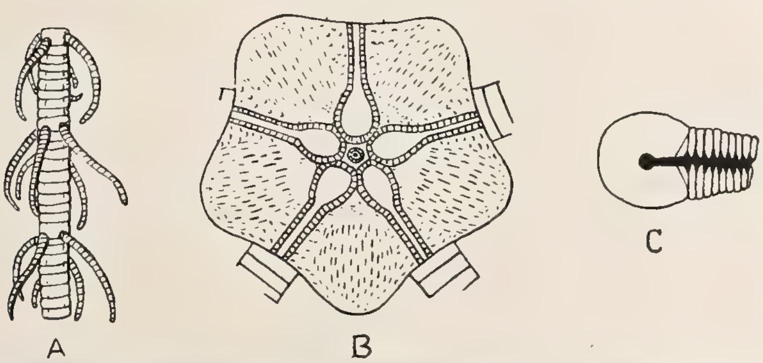


Figure 29 Relation of cirri to axial cords. A, part of stem of Isocrinus decorus, with cirri in whorls of five. B, section across stem of Isocrinus wyvillethomsoni at level of cirrus-whorl, the central portions disproportionally enlarged for greater clearness. C, section across stem of a fossil crinoid showing branch from axial canal to cirrus. (After Bather, 1900)

The appendages of the column are called *cirri* and the ossicles composing them are *cirrals*. The cirri are borne by the nodals and through the nodal communicate with the axial canal; they therefore correspond in position with the five axial cords (figures 28, 29). Cirri may be given off through the whole length of the column or may be restricted to the distal portions. In the majority of Paleozoic crinoids they are restricted to the distal parts. The cirri may be arranged singly, with two or three at a nodal or in whorls of five (plates 21, 22, 24; plate 23, figures 1, 2; plate 25; plate 52, figures 1, 2, 3). The cirri are variable in length and in flexibility. In most of the Camerata the cirri are capable of very little motion, and in many cases are restricted to the root; the cirri of the Inadunata are more flexible and slender and more frequently continue up the proximal part of the stem. In *Clarkeocrinus troosti* (plates 21–25) the cirri are very beautifully developed and are circinate; in *Brachiocrinus nodosarius* (plate 41, figures 1–4) the cirri are very heavy and the cirrals beadlike. Very strikingly developed cirri are also seen in the Carboniferous *Camptocrinus myelodactylus*. Here the stem is coiled around the crown, the columnals become concave and from the horns of the column thus formed extremely long cirri are given off from alternate sides. There is a similar development in *Herpetocrinus*. Cirri, particularly where they are very flexible, are used as hooks to catch neighboring objects to retain a hold.

In the study of *Gennaeocrinus eucharis* (plate 27; plate 28, figure 3) peculiar leaflike appendages were discovered attached to the nodals and arranged in three vertical rows. The purpose of these appendages is not known (*see* p. 214), but since they are immovable and often meet or overlap, it seems that they would lessen the flexibility of the column to a considerable extent.

The distal ends of the cirri sometimes appear to have been open so that there is communication with the sea water. Pores are left on columns and roots by the atrophying of cirri and cirri attachments. The under surfaces of encrusting roots are sometimes ridged as though grooves put the axial canal into connection with the exterior. These passages are supposed to be for purposes of nutrition and aeration (Bather, 1900, p. 133).

As stated above, crinoids may be free or attached. Some of the species of Pentacrinus and Metacrinus are loosely rooted in soft mud, and they can change their position by swimming with their pinnulate arms. This is a state intermediate between the fixed crinoids and the free genus Antedon. The crinoid may be fixed by a branching root which may be encrusting on some firm object or loosely rooted in the mud. Some crinoids end in a disk such as seen in Aspidocrinus (plate 59, figures 6–13) or in a bulbous base (plate 59, figure 17), such as seen in Camarocrinus (name given by Hall to the bulbous base of Scyphocrinus) or in a four or five-fluked grapnel such as Ancyrocrinus (plate 59, figures 14–16). Crinoids show a frequent tendency to become detached from the root. In such cases they may become attached to other objects by coiling around them or by the remaining cirri. Often, as seen in Lasiocrinus scoparius (p. 343) and Melocrinus paucidactylus (plate 9, figure 9; plate 11) the distal end of the free stem shows a tendency to coil. In Brachiocrinus nodosarius (plate 41, figures 3, 4) the column ends in a bulb. The tendency to detachment brought about a gradual shortening of the stem, and a continuance of this process has led to the evolution of the so-called unstalked crinoids, represented by such forms as Antedon, Agassizocrinus, Edriocrinus (plate 58), Saccoma, Marsupites and Uintacrinus.

d Articulation

The plates of crinoids are united by different types of suture or by articulations. In the primitive type of suture fibres of connective tissue are developed between the plates of crinoids which bind them together. Such sutures are those between the calyx plates, intercolumnar articulations in many of the older types, syzygies between brachials or just below the cirrus-bearing columnals; here the fibres are of uniform length and are uniformly distributed. Sutural unions have received modifications to which special names are applied. Crinoid plates may be very closely and immovably united by short fibres the ends of which have been surrounded by a deposit of stereom on the apposed faces of the ossicles. This produces a type of suture known as *close suture*. Syzygies are a special case of close suture. Plates may be cemented together by a deposition of stereom which causes a fusion of the plates, *anchylosis*. The above two types tend toward rigidity in crinoid parts; the following types tend toward flexibility: (1) *loose suture*, (2) *imperforate articulation*, (3) *perforate articulation*. In the type of loose suture, there are several possibilities: (*a*) the fibres lie at right angles to the suture and the stereom is thrown into corresponding folds; (*b*) there may be a slight facet which is either smooth or striated; or (*c*) there are interlocking crenulations (plate 15, figure 9; plate 36, figure 2). In imperforate and perforate articulation the fibres become differentiated into comparatively dense masses which form the elastic ligaments; true muscles are also developed. In imperforate articulation there may be a slight facet or a toothed articular surface; in perforate articulation there is a highly developed facet with a fulcral ridge and depressions for the ligaments and muscles. The muscle is innervated from the axial cord which perforates the fulcral ridge.

The plates of the dorsal cup may be united by close suture, anchylosis or loose suture; close suture and anchylosis are the more common. The tegminals may be united by primitive (or loose) suture (simpler crinoids) or by close suture. In the arms the brachials primitively and the pinnulars nearly always are united by loose suture; the final stage, seen in the more flexible arms, is perforate articulation. Close suture is seen in the syzygies between brachials. In the simplest form, the columnal is round and its surface is radiately striated (loose suture). Assumption of pentagonal form causes the restriction of the striation to the margin and the grouping of the ligament fibres into five bands. The type of loose suture in which crinoid ossicles show crenulated margins is quite common in columns. Perforate articulation is found in columns of greater flexibility; close suture is seen in syzygies between columnals.

2 Ontogeny and Phylogeny

Careful studies have been made of the life history of three recent species which all belong to the genus Antedon.[1] These life histories show phenomena of development, a knowledge of which is valuable to the student of fossil crinoids. Detailed discussion of the subject may be obtained in the references to Wyville Thomson, P. H., and W. B. Carpenter and Bury in the special bibliography appended; a brief summary will be given here.

The ripe eggs of the Antedon are extruded from the ovaries and hang from the genital pinnules in clusters like bunches of grapes. The eggs are fertilized externally and the early metamorphosis of the larva takes place within the egg. At about the seventh day the larva (gastrula) escapes from the egg. At this period in its development it is barrel-shaped, bilaterally symmetrical and provided with an anterior tuft of greatly elongated cilia and five encircling ciliated bands (figure 30), characters which give it something of a resemblance to the larvae of worms. Within the larva are the rudiments of the skeletal structures of the crinoid; five orals, five basals, three or five infrabasals (depending upon the species), which are arranged in horseshoe-shaped bands open toward the ventral surface, and about eleven columnars which likewise have not as yet formed complete rings.

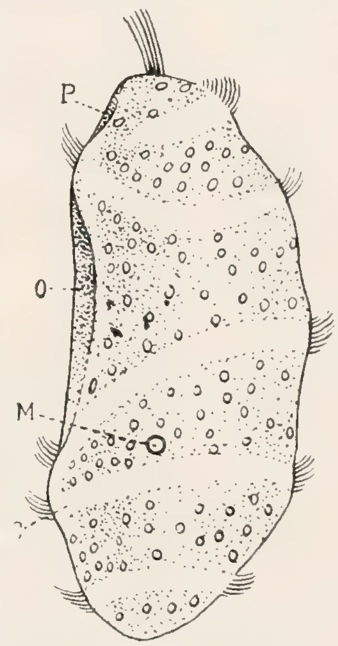


Figure 30 Ciliated larva of Antedon rosaceus, anterior end uppermost. *P*, preoral pit; *O*, larval mouth; *M*, water pore. (After Bury, 1888).

The larva swims about for a few hours and then attaches itself by a slight depression on the anteroventral face, the so-called preoral pit. A few hours after attachment the cilia disappear; the larval mouth becomes very shallow, gradually narrows and then disappears; and there is a

[1] Studies have recently been made of larval forms of Comactinia (Actinometra) meridionalis by Doctor Springer, and of larval forms of Promachocrinus kerguelensis by A. H. Clark (*see* Springer 1920, pp. 79–87).

rearrangement of the internal organs. The fixed larva is termed a *pentacrinoid* (figure 31). After fixation the orals become arranged in a pyramid over the superior or ventral portion of the animal, the basals form a similar, but inverted, pyramid in the proximal or dorsal portion of the calyx, the infrabasals occur between the apex of the basal pyramid and the top of the column. At this time the column is composed of about eleven cylindrical columnals and is terminated distally by a lobate terminal stem plate, the dorsocentral. Each columnal consists of the original central ring and numerous longitudinal, parallel calcareous rods which have been developed from it. The larva is now in what is termed the *cystid stage* of development. For convenience, the development of the larva in the fixed state has been divided into two stages: (1) the *cystid stage*, stalked forms without arms; (2) the *phytocrinoid stage*, still stalked but provided with arms and cirri.

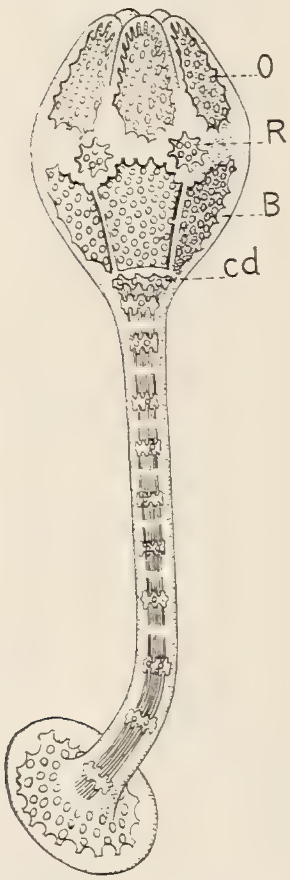


Figure 31 Pentacrinoid larva of Antedon rosaceus. *O*, orals; *R*, radials; *B*, basals; *cd*, centro-dorsal. (After Wyville Thomson, 1865).

Within a short time after fixation there appears in the diamond-shaped spaces between the divisions of the orals and the basals another series of five plates, the radials, which increase rapidly in size and encroach upon the orals. In one of the interradial spaces, in the zone of the radials, a sixth plate, the so-called anal, appears; but it gradually moves up into the tegmen with the orals and is resorbed. This so-called anal has been shown by A. H. Clark (1912), from a study of pentacrinoid larvae, to be in reality the radianal of the fossil forms. The true anal *x* has been found by him in the pentacrinoid larvae of other species of comatulids (*see also*, Springer's studies, 1920, pp. 79–87, of larval forms of Comactinia meridionalis). From each radial is given off a series of elongate cylindrical segments which bifurcate on the second. This is the beginning of the arms which grow rapidly by the addition of new plates at the distal extremity. The column ceases to add new columnals, and the infrabasals fuse with the last one formed, the most proximal one, forming the rudiment of the centro-dorsal found in the adult (figure 31). The larva is now in the *phytocrinoid stage.*

At the same time that the arms and column are being developed the orals and anal are undergoing resorption. The basals are metamorphosed into a delicate calcareous plate called the *rosette*, wholly internal, lying just above the chambered organ and possessing five radial and five inter-radial processes. Cirri are developed on the centro-dorsal which finally detaches itself from the rest of the column thus freeing the young crinoid. The centro-dorsal in free-swimming forms, such as Antedon, is the homologue of the whole column in stalked forms.

The study of the life history of Antedon shows that the most primitive skeletal structure of crinoids consists of the orals, basals, infra-basals and column and that the radials and brachials are a later development. The radials, according to A. H. Clark, are not properly calyx plates at all, but belong morphologically with the series of brachials (1915, p. 364). There are numerous fossil crinoids in which the basals and stem are strongly developed, the radials of small size and the arms rudimentary or absent. Springer has noted that "some of the Palaeozoic Flexibilia are almost identical, in fact, with the pedunculate stages of Antedon"[1] (1913, p. 182; Wachsmuth and Springer, p. 152; *see* remarks on young forms of Eutaxocrinus alpha, p. 312).

Material has not been sufficiently abundant to allow of any considerable ontogenetic studies among the species of Devonian crinoids here described; but where material has permitted observations on the development and variation of the species, such observations have been noted under the heading *Ontogeny* or *Ornamentation* in the description of the species.

A very complete series of Melocrinus paucidactylus has been obtained, a full discussion of which will be found on page 123 under

[1] Springer (1920, pp. 80, 81) points out the close resemblance between an early stage of the Comactinia larvae, his "Actinometra" stage, and the earliest genera of the Flexibilia.

the description of the species. The chief differences here between young and adult forms is in the character of the arms, strength of ornamentation and relative size of the basals. The basals are fairly large and conspicuous in the young forms; in the mature forms they are small compared to the other plates. The ornamentation changes from incipient ridges to well-defined radiating ridges or carinae. The most striking difference is shown by the arms. In the youngest forms they are simple and two to the ray. Intermediate stages lead from this condition to the complete lateral union of the two main arms of each ray, producing the typical compound radial appendage characteristic of Melocrinus.

It has been found here in the study of young forms that, outside of changes in ornamentation, there are two particular regards in which immature and mature forms differ: the incorporation of the brachials and the character of the arms. The proximal brachials are not incorporated to the same extent, the arms have fewer bifurcations and, in species with biserial arms, show uniserial arms throughout or biseriality only at the tips. It has been frequently observed that immature forms tend to have proportionately heavier arms and pinnules. Such observations as the above have been made here on the immature forms of Megistocrinus depressus (p. 231), Megistocrinus ontario (p. 237), Aorocrinus cauliculus (p. 251) and Hallocrinus ornatissimus (p. 380).

Variation within the species is common. This is particularly well shown in Megistocrinus depressus (p. 227). A study of a large number of individuals has shown this to be an extremely variable form as regards shape of theca, spinosity of vault and surface ornamentation. It would be impossible to give specific names to the many variations; and if the species were split up into a number of distinct species there would still be considerable variation in any given set of characters even within the narrow limits of these greatly restricted species.

A very interesting series of Dolatocrinus liratus shows particularly well the changes in ornamentation of the dorsal cup which accompany the growth of the individual (p. 161). In very young specimens the basal region is deeply excavated and the basals are deeply sunk in the basal pit. With the growth of the crinoid this pit gradually becomes filled by a thickening of the basals and the lower portion of the radials. The ridges or carinae in the younger forms are much fewer and coarser and the radial keel is quite strong. There are various stages from this condition to the *multilira* type. Here the ornamentation is very complex, the carinae being numerous, finer and sharper; the radial keel is an insignificant part of the ornamentation and in some cases is practically obsolete. Still older specimens show the breaking up of the carinae until they are represented by scattered tubercles.

Study of other forms, such as Rhodocrinus nodulosus (p. 91), Dolatocrinus glyptus (p. 156), Gennaeocrinus eucharis (p. 215), Gennaeocrinus nyssa (p. 218), Gennaeocrinus carinatus (p. 221), Decadocrinus multinodosus (p. 429), seem to indicate a general tendency for the ornamentation to reach its greatest development in mature forms and to break up or become less pronounced in old forms. In general, nodes or tubercles become blunter, carinae break up, radial keels are less pronounced or break up and radiating lines or ridges become fainter or disappear.

In discussing the relationships of the crinoids, both within and without the phylum, it is not intended to go into any great detail, but merely to give some idea of the views that have been generally held on this subject. The relations of the Phylum Echinoderma to the other groups of the animal kingdom has long remained obscure. It was formerly thought that there was a near relationship to the Coelenterata because of the presence of radial symmetry. This led to the grouping of the Echinoderma with the Coelenterata under the class-designation Radiata. The study of the anatomy of the various organs of the echinoderms, without taking into account the bilateral symmetry underlying the radial symmetry, led to the conclusion that the echinoderms were not closely or directly related to the coelenterates; furthermore, that the echinoderms were no more nearly related to the coelenterates than to some of the groups of worms

(Parker & Haswell, 1910, p. 436). The similarity of the bilateral larva to some of the lower forms of the worms was early recognized. In general, attempts to make comparisons between the echinoderms and the other groups have been avoided. Bather in his discussion of the group as a whole makes this statement: "Between adult echinoderms and other groups of the animal kingdom no comparisons are possible" (1900, p. 8). Parker and Haswell in discussing the relationships of the group conclude:

They are, in fact, a singularly isolated group, and we look in vain among the known members, living and fossil, of the other phyla for any really close allies....... Whatever may have been the group of animals from which the Echinodermata were developed, there is every probability that it was a group with bilateral and not radial symmetry (1910, p. 436).

A. H. Clark (1915) and Professor William Patten (1912), working independently, have made investigations which support the theory of the derivation of the echinoderms from a group with bilateral symmetry. In the words of A. H. Clark: "the echinoderms are not by any means the highly anomalous creatures that they have hitherto always been considered, but........ are in reality a very aberrant offshoot from the acraniate crustacean stock, finding their logical systematic position beyond the barnacles" (1915, pp. 125, 200). Professor Patten arrived at this conclusion through a critical comparative study of the development of the echinoderms and of the primitive crustaceans and a study of the abnormal young of the latter (1912, pp. 421–430). He doubted whether it would ever be possible to make precise or detailed comparisons of any value between the echinoderms and relatively modern types of arthropods, such as the decapods and the insects. Clark was led to a comparative study of the adults of the two groups "because of the high degree of specialization of the echinoderm larvae and the difficulty of bringing into satisfactory correlation the data offered by the very diverse young of the different echinoderm classes" (ref. cit., p. 128). He was led to his conclusion regarding the relationships of the echinoderms and crustaceans "through a careful study of the adult crinoidal nervous system which, though highly complicated and very anomalous, is seen when analyzed to belong to the type especially characteristic of primitive crustaceans" (ref. cit., p. 125). The relationships of the crinoids with other organisms both within and without the phylum are discussed in detail in volume 1 of his "Monograph of the Existing Crinoids" (ref. cit., pp. 125–194, 200).[1]

It has been generally accepted that stalked echinoderms were preceded by primitive free forms with pronounced bilateral symmetry. By selecting characters which are common to all the early stages of the echinoderms and setting aside those due to individual development, zoologists have imagined an ancestral type, the *Dipleurula*, a phylogenetic stage more or less repeated in the Dipleurula larvae of recent echinoderms. The cystids are recognized as more nearly approximating the eleutherozoic archetype of all the echinoderms, and the earlier and more primitive of these represent the pelmatozoic stage through which the echinoderm race passed from the Dipleurula ancestor to the various classes.

Bather (1900, pp. 39, 40, 43, 78, 95, 96) supports the commonly conceded view of the derivation of the crinoids from the blastoids, the most primitive of which can hardly be distinguished from their immediate ancestors among the cystids. Kirk (1914, p. 481) grants that the crinoids may have been derived from the cystids through the mediation of the blastoids, but he believes that we must look elsewhere than among the known cystids for the ancestors of the crinoids. The ancestors no doubt had much the same structure as the cystids, and might in a broad sense be termed "Cystidea," but they probably were minute Cystidea like the minute Crinoidea which we know to exist. Such minute "Cystidea," Kirk believes, might well have preceded and given rise to the known Cystidea as well as to the other classes of Pelmatozoa. The forms, according to Bather, suggestive of the connection between the crinoids and blastoids

[1] Since the completion of this monograph, a recent paper (1921) by Clark has appeared in the Smithsonian Miscellaneous Collections, treating more fully "The Echinoderms as Aberrant Arthropods." His conclusion, as in the earlier paper, is that "the crinoids represent a derivative from a branch of the same arthropod stock that gave rise to the barnacles, but they have gone much further" (p. 11).

are Carabocrinus, Hybocrinus and Stephanocrinus, Stephanocrinus has been at various times regarded as a cystid. blastoid or crinoid, and when it was unquestionably proven to be a crinoid its agreements with the cystids on the one hand and the blastoids on the other were recognized (Wachsmuth and Springer 1886, pp. 206–214). The mutual relationships, according to this view, of the different classes of echinoderms is shown in the following table taken from Bather (1900, p. 35):

Pelmatozoa	Cystidea ——	Edrioasteroidea	
	Blastoidea	—Holothurioidea	
	Crinoidea	—Echinoidea	(Eleutherozoa)
		—Stelleroidea	

Parker and Haswell (1910, p. 437) derive the classes of echinoderms through a primitive cystid in the manner shown in figure 32.

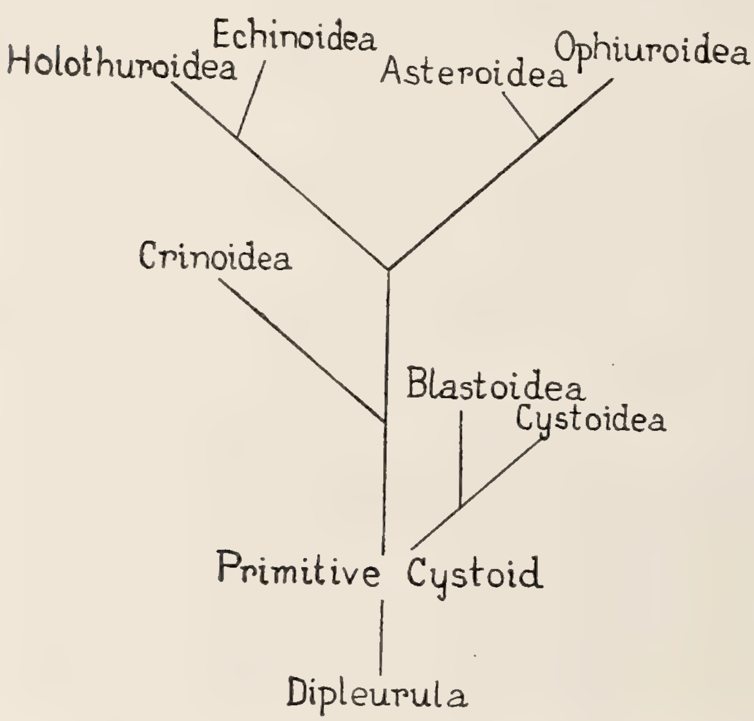


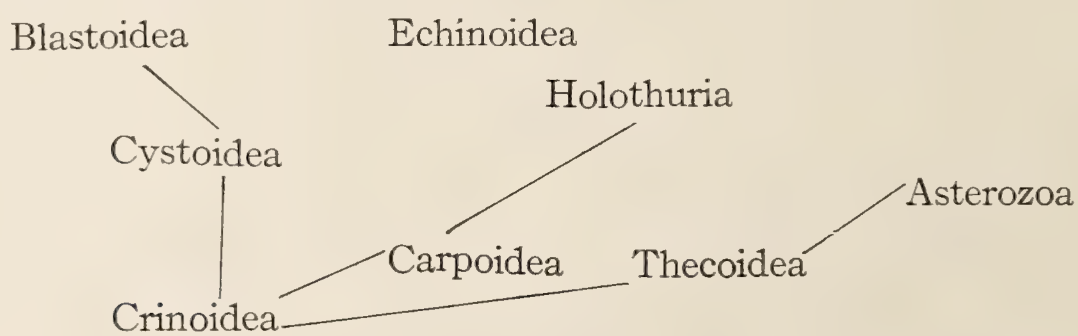
Figure 32 Diagram to illustrate one of the interpretations of the relationships of the classes of the Echinodermata. (After Parker and Haswell, 1910)

There is another view (ref. cit., p. 438) according to which the most primitive echinoderms are Synapta and its allies (Holothuroidea apoda). The other holothurians are supposed to be derived from a Synapta-like ancestor. The stalked classes were derived from the primitive stock of the holothurians; and the remainder of the free classes were derived from the ancestral stalked echinoderm (*see* Bell, 1891, for a view along these lines).

A very interesting view involving a holothurian-like ancestor is set forth by A. H. Clark (1915, p. 125) in his recent "Monograph of the Existing Crinoids." According to Clark, the echinoids and crinoids were derived from a common, holothurian-like ancestor (ref. cit., pp. 158–161, 164, 168). The echinoid, speaking broadly, is a holothurian encased in a solid calcareous covering, and the crinoid is a stalked echinoid (ref. cit., p. 168). The crinoids though most nearly related to the echinoids possess certain features both of the asteroids and of the ophiuroids, and so hold a position intermediate between the echinoids and the latter. The characters showing this relationship are most evident in older forms, and here the characters connecting crinoids and echinoids are more pronounced. In later forms and in all recent forms the connections with the echinoids have become largely obliterated, but the connections with the asteroids and ophiuroids have not been subjected to the same degree of suppression (ref. cit., p. 170). The most primitive type of crinoid very possibly existed in the Paleozoic rocks along with the other types that have come down to us as fossils; but they were undoubtedly small and delicate creatures with little chance for preservation (ref. cit., p. 185). Blastoids are regarded by Clark as "essentially imperfect, or more properly speaking, too perfect crinoids, and in a sense they are remotely intermediate between the crinoids and echinoids" (ref. cit., p. 186). Just what is the exact position of the cystids according to this view is not clear, but they appear to be placed with the more primitive holothurians near the ancestral type (ref. cit., pp. 137–140).[1]

[1] In a recent paper (1921) on "The Echinoderms as Aberrant Arthropods," published since the completion of this monograph, Clark points out that "the only nervous system in the echinoderms which in its details is at all comparable to the central nervous system of the other higher invertebrates is the so-called apical nervous system of the crinoids...... This nervous system of the crinoids, which is possibly (though not by any means probably) represented by the so-called mesodermal nerve plexus in the starfishes, but which is quite unrepresented in the other echinoderms, affords the best indication of the probable affinities of these animals, and at the same time its high state of development suggests that the crinoids have departed less widely from the ancestral type than have the other classes" (p. 4).

A quite different view of the relationships of the different classes of echinoderms has been brought forward by Jaekel (1918) in his paper on the "Phylogenie und System der Pelmatozoen," which, on account of the war, has only recently come into our hands. According to Jaekel the Phylum Echinoderma falls not into two but into three great natural groups: the Pelmatozoa (four classes: Crinoidea; Cystoidea, including the Blastoidea; Thecoidea; Carpoidea); the Asterozoa (two classes: Stelleroidea, Ophiuroidea); Echinozoa (two classes: Holothurioidea, Echinoidea). The Pelmatozoa are the starting point of the Echinoderma. In his earlier work (1899, p. 174) Jaekel derived the Crinoidea (Cladocrinoidea) from the Cystoidea by way of the Dichoporita through the Macrocystellidae and a subsection of the Cladocrinoidea which he then called the Eocrinites. In this last paper all the classes of the echinoderms are derived from the Crinoidea as follows (*see also* discussion of his classification of the Crinoidea, pages 54-60):



Jaekel further states that the homologies between the plates or parts of the Pelmatozoa and such of the Eleutherozoa (Asterozoa, Echinozoa) do not exist (ref. cit., pp. 6–12).

The study of the phylogeny of Paleozoic crinoids is hampered by the fragmentary records, particularly as regards the earlier ontogenetic stages. The composition of very young forms is not favorable to preservation, and by the time the calyx has reached the stage where its preservation is possible, there is no high degree of difference from the adult form. Doctor Wood (1914) made a very interesting phylogenetic study of the arms of a number of species of Cactocrinus. She found that there are series of changes which succeed one another in a definite order in proceeding from the proximal to the distal portion of the arm; and reaches the conclusion that " these changes may be interpreted as stages in development, each individual repeating the stages present in its immediate ancestor and adding in the distal portion, new characters of its own until the number of characters becomes too great for representation in the life history of a single organism, and certain characters, usually the earlier ones, are greatly abbreviated or are omitted from the ontogeny of highly modified descendants. When thus interpreted, the arms of crinoids furnish evidence from which the phylogenetic relations of different species and genera can be inferred " (ref. cit., p. 17). It will probably be found that this method of studying crinoid phylogeny may be applied with satisfactory results to other genera.

A study of the phylogenetic relations of the Flexibilia has recently (1920) been made by Springer in his monograph on " The Crinoidea Flexibilia." Much valuable data has been added to what was already known. The order is an offshoot from the dicyclic Inadunata through the nonpinnulate Dendrocrinidae. This differentiation took place in the middle of the Ordovician, the time, in fact, at which most of the ordinal differentiation of the crinoids occurred. He states:

It seems that at this very early stage in the geological scale we have several forms exhibiting variously intermingled characters of the larger divisions of the crinoids, with some of the essential cystid structure more or less impressed upon one of them; and that these represent relatively recent departures from the common ancestral type, tending in different degrees toward the lines of evolution which produced the several orders of the crinoids. In Protaxocrinus the Flexible characters were already well established; in Cupulocrinus and Reteocrinus the tendency was toward the Inadunata and Camerata respectively, while still complicated by other characters; while in Cleiocrinus the strong survival of cystid characters prevented the establishment of a distinct evolutionary line in either of the crinoidal orders. (Springer, 1920, p. 91).

Attention has been called above (page 39) to the very full series of ontogenetic stages of Melocrinus paucidactylus which show the development of the arms from simple, uniserial appendages to the characteristic compound appendage of Melocrinus (*see* plate 8, figure 5; plates 9, 10). The species here, in its individual development, repeats the evolutionary development from the genus Mariacrinus to Melocrinus, which development is carried still further in Melocrinus (Trichotocrinus). Olsson (1912, pp. 2, 3) discusses this evolution under his diagnosis of his new subgenus Trichotocrinus; but attention is called to it here because of the added emphasis given by the above-mentioned ontogenetic series.

Mariacrinus and Melocrinus differ from each other mainly in their arm characters. In Mariacrinus the arms are typically uniserial and they may branch a few times. " The next step is the fusion of its uniserial arms in the production of biserial ones, which commences proximally, finally extending throughout the entire length of the arms. Species occur in which this fusion has been but partially completed (Mariacrinus beecheri, plate 5, figure 5). The complete fusion of the arms gives rise to the genus Melocrinus (plates 6–16) with armlets arranged on opposite sides and which are usually biserial. The last step in this evolution would necessarily be in the development of its armlets and which becoming concentrated in a pair of them resulted in the Trichotocrinus type of arm (plate 16, figures 10–12). This development has been attended by the formation of secondary armlets along these two lateral branches and which bear pinnules. We see in this genus a case where some of the pinnules have developed into pinnule-bearing armlets. . . . This evolution as traced above is also brought out when these forms are considered in their relation to geologic time.

Trichotocrinus	Upper Devonian (Portage formation)
Melocrinus	Silurian and Devonian
Mariacrinus	Silurian and Lower Devonian" (ref. cit., pp. 2, 3).

Undoubtedly, if an ontogenetic series of either M. (Trichotocrinus) lutheri or harrisi could be obtained all stages from the Mariacrinus type to the Trichotocrinus type would be shown. We have one rather young specimen of M. (Trichotocrinus) lutheri (plate 16, figure 9) which, so far as preserved, shows only the Melocrinus type of arm, but with the other characteristics of the arm of M. (Trichotocrinus) lutheri. If the trichotomous type of branching is present it must occur rather high up in the arm.

At present a large part of the phylogenetic questions concerning crinoids are still to be answered.

3 *Habitat and Distribution*

The geographic distribution of existing crinoids is fully as extensive as that of the other echinoderms. The free forms range between the parallels of 81° 4′ N and 52° 5′ S, while the stalked forms have a range of 68° N to 46° S. Crinoids are found existing in depths of water ranging from between tide marks to 2900 fathoms; stalked forms have been found ranging only from 5 to 2325 fathoms. Antedon has been dredged at 2900 fathoms in the Pacific and 2600 fathoms in the Southern sea; the ten-armed species of Antedon have a wider range both in depth and in space than any other species of the genus. The great majority of existing types of crinoids are littoral or sublittoral. As a general rule, the individual species of crinoids are much limited in their range though there are a few well-marked exceptional cases. The East Indian region is assumed to be the center of distribution, and the generation center, of the recent crinoid fauna.

Though a few forms are of a more solitary habit, crinoids, in general, like the other echinoderms are gregarious in their habits. This is especially the case with those living near the shore and in depths down to 150 fathoms. Masses of crinoids in the East Indian region have been found to contain twenty or more different species. As a rule recent crinoids are very local and very unevenly distributed over the sea-floor.

Fossil crinoids apparently were also gregarious in their habits. Their remains are found in Paleozoic rocks together with those of reef-building

4

corals. Sometimes stems, detached joints of stems, roots and arms of crinoids are so abundant as to form crinoidal limestone beds of considerable thickness, which occur in numerous formations from the Ordovician to the Jurassic, being particularly characteristic in the Carboniferous and the Muschelkalk (Triassic of Germany). Fossil crinoids are usually found in a fragmentary condition because of the looseness with which the plates and segments are bound together and the delicacy of some of the skeletal parts. Calyces or dorsal cups are found much more frequently than perfect crowns, which, indeed, are of rather rare occurrence.

A fragment from one of the largest and finest colonies of Devonian crinoids ever found is shown in photographic reproduction, about one-half natural size, on plate 25. On this slab from Vincent, N. Y., are shown a number of specimens of Clarkeocrinus troosti (Hall), and also Acanthocrinus spinosus (Hall), Gilbertsocrinus spinigerus (Hall), and Eleutherocrinus whitfieldi Hall.

Recent crinoids have hitherto been considered as the impoverished and decadent remains of a once numerous and powerful class. A. H. Clark in 1915 made a study of existing crinoids. From his observations at sea he has reached the conclusion that " recent crinoids are in every way as much a factor in present day marine biology, and play fully as important a part, as the echinoids, the holothurians, or the asteroids " (ref. cit., p. 5). The small importance attached to the crinoids as recent animals in comparison with other echinoderms he believes has arisen from three causes (ref. cit., p. 5): (1) The paleontological record is remarkably complete. Because of the large percentage of lime and other inorganic materials in the organization of the crinoids they are more adapted to fossilization, and their fossils include a far greater variety of diverse types than the fossil representatives of other echinoderm classes. This makes the crinoids appear to have exceeded the other classes in the past in numbers, variety and general importance; and likewise blinds one to the true importance of recent representatives by causing them to appear relatively insignificant in comparison with the recent representatives of the other classes. (2) The number of species (living) hitherto known is small. The fact that the majority of specimens collected have slipped unheralded into museums and their study has presented many difficulties to investigators has allowed the proportionate number of known forms in the group to slip far behind those known in the other groups. (3) There is a paucity or absence of accessible species along the shores of the countries where there is the greatest interest and enthusiasm in zoology.

Springer, in discussing the distribution of the crinoids in his recent monograph, states:

> Instead of only 12 genera and 212 species of stalked crinoids and comatulids known at the date of P. H. Carpenter's monographs upon the collections of the "Challenger" expedition, there are now known 142 genera and 576 species, of which 123 genera and 343 species have been described by Clark alone; these are distributed among 20 families and 8 sub-families. The crinoids, therefore, constitute one of the richest and most varied faunas of the present seas, the extent and importance of which will continue to increase; for, notwithstanding the great acquisitions of the past dozen years due to the activities of numerous dredging expeditions maintained by different governments, the fact still remains that all these dredgings represent only the imperfect gleanings of a few out of the 140,000,000 square miles which the oceans cover. The number of crinoids existing in certain localities is amazing; as many as 10,000 have frequently been brought up by a single haul of the dredge. A. Agassiz speaks of "a field of Rhizocrinus" growing on the sea bottom in the West Indies. At Singapore 24 species of crinoids have been taken within a radius of a few miles, a variety which is surpassed by but few localities of Paleozoic crinoids. (Springer, 1920, pp. 97, 98).

4 *Classification*

No attempt will be made here to give a history of the classification of the crinoids. An account of the earlier literature on this subject will be found in Koninck and Le Hon (1854) and W. B. Carpenter (1866). Accounts of later growth of knowledge are found in Zittel (1876–1880, 1895), P. H. Carpenter (1884) and Wachsmuth and Springer (1897). A very good summary of the main stages is given in Bather (1900).

The classification followed here is that used by Springer (1913).[1] The divisions established by Wachsmuth and Springer are used as a basis. The name Flexibilia proposed by Zittel in 1895 is adopted instead of their Articulata; and the name Articulata in the sense of Miller and Müller is retained for a fourth division which includes the recent and most of the Mesozoic crinoids. The definition of the primary divisions of the Crinoidea as given by Springer are repeated here:

Primary Divisions of the Crinoidea (Springer, 1913, p. 185; 1920, p. 105)

I

Crinoids with a rigid calyx in which the lower brachials are to a varying extent firmly incorporated into the dorsal cup, being rendered fixed and immovable by union either with dorsal or ventral structures. Plates of the calyx united by close suture. Mouth and calyx food-grooves chiefly subtegminal. Subject to modification as to either character in transition forms. Arms pinnulate. *Order*......................Camerata.

II

Crinoids with a flexible calyx in which the lower brachials are loosely incorporated into the dorsal cup either by lateral union with each other, by means of interbrachials, or of a skin studded with calcareous particles. All plates beyond the radials united by loose suture, and more or less movable. Mouth and tegminal food-grooves exposed. Arms nonpinnulate. *Order*.....................Flexibilia.

III

Crinoids with rigid calyx in which the brachials are free (or sometimes loosely connected) above the radials. Plates of the calyx united by close suture. Mouth subtegminal; food grooves suprategminal, but may be closed by fixed ambulacral plates. Arms pinnulate or nonpinnulate. *Order*.....................Inadunata.

IV

Crinoids in which the mode of union of the radials with the plates they bear is by complete muscular articulation, and in which are combined the following additional characters: open mouth and food-grooves; dorsal canals perforating radial and arm

[1] The definitions of the primary divisions following are taken mainly from his more recent paper (1920, p. 105).

plates; uniserial arms only; pinnules; the general presence of a modified columnal, or proximale; the general absence of bilateral, and presence of pentamerous, symmetry, modified only by loss or addition of rays and not by anal structures. Brachials either free, or more or less incorporated. *Order*....................Articulata.

The first three of these divisions are represented in the Ordovician. The Camerata were the most specialized, and the first to disappear, being confined to the Paleozoic, and becoming extinct in the Lower Coal Measures. The Flexibilia were similarly limited. The Articulata range from the Mesozoic to the present time. The Inadunate type, representing the most generalized structure of the crinoids, is in its most essential features, though variously modified, carried forward with the Articulata, and thus has an unbroken range from the earliest Ordovician to the present.

The Inadunata are further divided in the above classification into two suborders: (1) Larviformia, (2) Fistulata. The Larviformia are monocyclic, with a very simple form of dorsal cup and tegmen, with no anal plates; the arms are nonpinnulate, simple and uniserial (with one exception). In the Fistulata the tegmen is composed of numerous plates; a strongly plated anal tube or ventral sac is present; the arms are pinnulate or nonpinnulate, usually uniserial, but biserial in some later genera; the base is monocyclic or dicyclic.

The grouping of all the species here described according to the classification used by Springer will be found below.

Bather (1899, 1900) in an endeavor to work out a classification more along phylogenetic lines has adopted a classification in which the distribution of the groups is quite different from that previously accepted. The classification is as follows (1900, p. 94):

Subclass 1 MONOCYCLICA
- *Order* 1 Inadunata
- *Order* 2 Adunata
- *Order* 3 Camerata
  - *Suborder* 1 Melocrinoidea
  - *Suborder* 2 Batocrinoidea
  - *Suborder* 3 Actinocrinoidea

Subclass 2 DICYCLICA
Order 1 Inadunata
Suborder 1 Cyathocrinoidea
Suborder 2 Dendrocrinoidea
Order 2 Flexibilia
Grade 1 Impinnata
Grade 2 Pinnata
Order 3 Camerata

Bather uses suborders and families where Springer uses families and sub-families. The Adunata of Bather includes the two families Platycrinidae and Hexacrinidae which are regarded as atypical Camerata by Springer; and Springer's Articulata are divided between Bather's Articulate Grade of the Dendrocrinoidea and Grade Pinnata of the Flexibilia.

The crinoids are first of all divided according to the presence or absence of infrabasals into *Monocyclica* and *Dicyclica*, and Bather traces in each of these sub-classes a gradual and to some extent parallel modification. The simplest forms in each division are the Inadunata, which pass through the Larviform stage with simple tegmen to a Fistulate stage with more complex anal tube and tegmen. The Monocyclic Camerata are derived from Monocyclic Inadunata at an early period (? Cambrian), and at a later period (Silurian) the Monocyclic Adunata (or Platycrinoidea) arose. From the Dicyclic Inadunata, similarly, arose the Dicyclic Camerata. About at the same time as the Adunata arose from the monocyclic strain, a modification of the Dicyclic Inadunata gave rise to the Flexibilia. The links between the nonpinnulate and pinnulate Flexibilia are missing. The Dicyclic Inadunata assumed an articulate modification in Mesozoic times, and only this type persisted to the present time.

Jaekel (1918) characterizes Bather's system of classification as unnatural and artificial and proposes a classification along natural lines which is a revision and enlargement of his earlier works along these lines. It is clear that in a circle of forms so narrowly limited similar structures are repeated in diverse places, so that parallelism and convergence are, so to speak, the order of the day. This, Jaekel says, must be recognized in classifications (ref. cit., pp. 1–4, 19). Jaekel's classification is taken up here somewhat in greater detail, because it differs so much from those generally accepted.

The crinoids represent in their finished forms the normal ascending line of evolution of the Pelmatozoa. Aberrant forms occur here as everywhere, and in the beginning, with unfinished types, the results were more pronounced than later in the quiet stream of evolution. For these reasons Jaekel established the subclass Eocrinoidea. A part of these forms separate themselves as individual aberrant, experimental forms just as far from the normal type of crinoids as perhaps the Cystoids. The aberrant forms are isolated, the others are the forbears of crinoids in general (ref. cit., p. 13).

The forms seen in the Inadunata Larviformia, which Bather and Wachsmuth and Springer place as the starting point of the whole system, are regarded differently by Jaekel. He believes, while the simple form is doubtless didactically convenient as a starting point, that as a rule it is the final result of much transformation and most decidedly not primitive. Development brings complications, and leads to practically simple forms. The idea in organic progress is that every biological process should be accomplished in the best way and by the least means. In the beginning this is not simplicity, but lack of regularity, as shown in the forms placed by Jaekel in his subclass Eocrinoidea (ref. cit., p. 13).

The Crinoidea are divided by Jaekel into three subclasses: Eocrinoidea (Jaekel 1899); Cladocrinoidea (Jaekel 1894); Pentacrinoidea (Jaekel 1894). The Eocrinoidea, constituting a new subclass, is the subdivision Eocrinites of the Cladocrinoidea used by Jaekel in 1899 (p. 174). This group comprises the more primitive crinoids of the Cambrian and Lower Silurian forms such as Acanthocystites, Eocystites, Protocystis, Ascocystis of the order Atava; Lichenoides, Cryptocrinus, of the order Reducta; Macrocystella of the order Plicata; Malocystis of the order

Deviata, previously placed with the Cystoidea (ref. cit., pp. 24–27). The many plated Eocrinoidea (Order Atava) from the Lower and Middle Cambrian, of all the at present known crinoids, Jaekel believes stand nearest the primitive form of the Pelmatozoa — a form such as Acanthocystis Barrande with irregular arrangement of plates and biserial appendages, which Jaekel terms " fingers " because they are formed in handlike groups, five in number (ref. cit., p. 15).

Under his discussion of stem and root Jaekel states that originally the stem and root were the rear extension of the body which, however, through the curvature of the intestine to the upper side came no longer to be occupied by this chief organ of the body and was thereby reduced to a passive appendage. He further states that it is probable that in the lower Pelmatozoa in its often very wide lumen it contains not only the coelom but also the parietal organ, probably originally genital (ref. cit., p. 5). Jaekel now places in his Eocrinoidea Cigara dusli Barrande, a root form, formerly described with the cystids, which is the bulky hind end of the body still in the process of transformation to stem and root. From its associations, Jaekel judges this to be the root and stem of an Ascocystites or a form like it. In Ascocystites the arm groups indicate the regularity of the echinoderm body, but the calyx skeleton is almost indifferent to regularity of arrangement under the arms, except that later a carina is developed under each finger group. This is brought about, according to Jaekel, through the pressure of the arm groups, which, he believes, governs the whole regularity of the calyx skeleton (ref. cit., pp. 15, 16, 18).

Forms like Acanthocystites and Cigara (Order Atava) Jaekel has made the types of his Eocrinoidea to which forms such as Lichenoides (Order Reducta) and Macrocystella (Order Plicata; placed with cystids by Jaekel in 1899) belong as aberrant side forms (ref. cit., p. 18). The order Plicata containing the Macrocystellidae (Macrocystella, etc.) Jaekel believes leads to the regular cystids, especially to Cheirocrinus (ref. cit., p. 26). Under the order Reducta

Jaekel has placed the Family Paractocrinidae containing new genera (Paractocrinus, Parorthocrinus, Tetractocrinus) from the Lower Silurian, Petersburg, which are somewhat intermediate in development. These genera have pentamerous rings of plates which do not completely alternate; but lie over one another in a steplike formation, because each succeeding ring of plates instead of being moved laterally one-half the breadth of the plates is moved one-quarter or less (ref. cit., pp. 22, 25, 26).

Comarocystites Billings is placed in the Eocrinoidea provisionally. The arms are described by Billings as *uniserial with lateral branches.* If, Jaekel says, this statement, up to now unproved, should be established, one must reckon with the possibility that Comarocystites is an aberrant form of a higher type of crinoid, since such specialized arm structure is so far entirely unknown within the Eocrinoidea (ref. cit., p. 27). Foerste (1916, pp. 69–73) has described Comarocystites and Caryocrinites as the only cystids known at present in which the arms are free and pinnuliferous; Comarocystites has uniserial arms and uniserial pinnules, Caryocrinites has biserial arms and biserial, brachiolar pinnules. This, according to Jaekel's definition, excludes these forms from the Eocrinoidea and places them as aberrant forms of a higher crinoid type. Foerste's paper undoubtedly did not reach Jaekel on account of the war. Hudson (1918) describes a primitive crinoid which he calls Embryocrinus problematicus. It has two arms and is associated with biserial pinnules which Hudson believes belonged to it. Under other classifications this form would belong to the cystids with Comarocystites; under Jaekel's classification it would belong among the crinoids with Comarocystites and Caryocrinites as an aberrant form of a higher crinoid type.

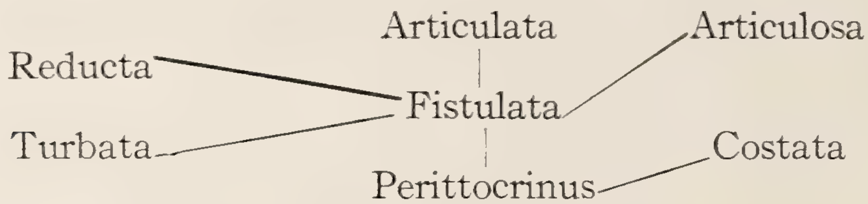
The chief thing, then, is that the Eocrinoidea form the starting point of the genuine crinoids and doubtless of the many plated forms which Wachsmuth and Springer have grouped together as Camerata and which Bather has divided into Adunta, Monocyclica Camerata and Dicyclica

Camerata. Bather's system, Jaekel believes, tears apart a natural group of the crinoids and in particular in the Monocyclica Adunta separates from the Monocyclica Camerata their immediate descendants (ref. cit., p. 18). Jaekel's subclass Cladocrinoidea is practically the equivalent of the Camerata of Wachsmuth and Springer. The essential progress and development from the Eocrinoidea to the Cladocrinoidea lies in this; that their "fingers" became more efficient through the transformation of the small side plates into pinnules and also became heavier; that through this they pressed more strongly upon the calyx wall and the calyx plates became arranged in a costal series under each arm group. The starting point of the Cladocrinoidea must be far back within the Eocrinoidea, since only among the most primitive representatives, as Acanthocystites, were the brachioles arranged in groups in a pentamerous fashion and the calyx composed so indifferently of small plates that they could be shoved into the right place under the arms in the arrangement characteristic of the primitive Cladocrinoidea calyx. The changes brought about through the development of the "fingers" would change before everything the costal calyx skeleton in a great variety of ways; while the deep lying base would be relatively little affected and therefore a good character for the separation of forms (ref. cit., pp. 29, 30).

Jaekel divides the Cladocrinoidea into two orders Monocyclica and Dicyclica; but he says that the dicyclic base of the Cladocrinoidea has an entirely different morophological meaning than that of the Pentacrinoidea, and this, therefore, is another objection to Bather's division of the crinoids into Monocyclica and Dicyclica. In the Cladocrinoidea the monocyclic and dicyclic bases are due to differences in transference of pressure. The monocyclic base is considered the higher form by Jaekel, and this type of base is carried over into the Pentacrinoidea. Here the infrabasal ring is formed from the uppermost small stem pieces. Continued strong pressure of the much branched arms leads in most of these "dicyclic" Pentacrinoidea to a reduction of the infrabasals, which in the living comatulids are only preserved in the embryonic development (ref. cit., pp. 19, 20, 30)

The Pentacrinoidea stand nearest to the tetramerous monocyclic Cladocrinoidea. Perittocrinus, from the Lower Silurian, Petersburg, is a transitional form between the Cladocrinoidea and the Pentacrinoidea; and it is perhaps altogether the most interesting transitional form, because it not only binds together two divergent classes, but also makes the path of the transformation process clear. The intercostal plates noted in the calyx of the Cladocrinoidea were suppressed here; they are pressed into the angles between the plates which belong to the radials and basals of the Cladocrinoidea. That these small plates are here no new formation is demonstrated by their pore-rhombs which have been developed from an earlier system of tension-carinae which bound together equivalent plate centers. This same system of carinae is found in the same places in the somewhat younger Porocrinus (Fistulata), but here there are no small plates in the angles. Likewise, the calyx here shows pentamerous regularity; the number of the basals has been increased from four to five and the eight groups of the small upper stem pieces of Perittocrinus have fused to uniform infrabasals (ref. cit., pp. 43, 46–48).

Jaekel's subclass Pentacrinoidea includes all forms except the Camerata, and is divided into several orders: (1) Order Fistulata (W. & Sp. modified by Jaekel; *see* Orders Reducta, Turbata and Costata below); (2) Order Articulata (Joh. Müller, not W. & Sp.; *see* Order Costata below); (3) Order Articulosa (Flexibilia of Springer, Flexibilia impinnata of Bather). The Articulosa, Jaekel believes, started before the Articulata, probably as descendants of Lower Silurian Dendrocrinidae, along the same lines of development, but in this did not go as far as the Articulata (ref. cit., p. 77); (4) Order Reducta. This order and the following include the Larviformia of Wachsmuth and Springer, which Jaekel regards not as the most primitive crinoids but as simplified crinoids (see p. 55), and some of the forms placed in Wachsmuth and Springer's Fistulata; (5) Order Turbata; (6) Order Costata (Jaekel 1894). In this order are included forms placed by Springer (1913) in the Fistulata, under the family Platycrinidae in the Camerata (Coccocrinus, Thallocrinus, etc.) and forms (Saccoma, Hyocrinus, Plicatocrinus etc.) grouped under the Articulata. The relationships of the divisions of the Pentacrinoidea are given as follows (ref. cit., p. 49):



Arrangement of Species of New York Devonian Crinoids According to the Classification Used by Springer

Order CAMERATA Wachsmuth and Springer

Family DIMEROCRINIDAE Bather

Genus Dimerocrinus Phillips 1836

Dimerocrinus arborescens (Talbot) n. comb.

Dimerocrinus whitfieldi sp. nov.

Genus Pterinocrinus nov.

Pterinocrinus quinquenodus sp. nov.

Family RHODOCRINIDAE Roemer

Genus Rhodocrinus J. S. Miller 1821

Rhodocrinus nodulosus Hall

Rhodocrinus nodulosus var. *pernodosus* nov.

Genus Acanthocrinus Roemer 1850 (em. Jaekel 1895)

Acanthocrinus spinosus (Hall) n. comb.

Acanthocrinus onondaga sp. nov.

Genus Gilbertsocrinus Phillips 1836

Gilbertsocrinus spinigerus (Hall)

Genus Sphaerotocrinus nov.

Sphaerotocrinus ornatus sp. nov.

Genus Thylacocrinus Oehlert 1878

Thylacocrinus clarkei W. & Sp.

Thylacocrinus gracilis (Hall) n. comb.

Family MELOCRINIDAE Zittel (em. Wachsmuth and Springer)

Section Melocrinites W. & Sp.

Genus Mariacrinus Hall 1859 (restr. W. & Sp. 1881, 1897)

Mariacrinus plumosus Hall

Mariacrinus ramosus Hall

Mariacrinus stoloniferus Hall

Mariacrinus beecheri Talbot

Genus Melocrinus Goldfuss 1826 (W. & Sp. 1897)

Melocrinus nobilissimus (Hall)

Melocrinus pachydactylus (Conrad)

Melocrinus paucidactylus (Hall)

Melocrinus nodosus (Hall)

Melocrinus breviradiatus Hall

Melocrinus bainbridgensis Hall & Whitfield

Melocrinus clarkei (Hall Ms) Williams

Melocrinus gracilis W. & Sp.

Melocrinus reticularis Olsson

Melocrinus williamsi Olsson

Melocrinus naplesensis sp. nov.

Melocrinus sp. (?)

Melocrinus sp. nov.

Melocrinus splendens sp. nov.

Melocrinus willetensis sp. nov.

Melocrinus willetensis var. *perstriatus* nov.

Nomen Nudum

Encrinites triciclas Eaton

Subgenus Trichotocrinus Olsson 1912

Trichotocrinus harrisi Olsson

Trichotocrinus (?) *lutheri* sp. nov.

Section Dolatocrinites W. & Sp.

Genus Clonocrinus Quenstedt 1876

Clonocrinus (?) *macropetalus* (Hall) n. comb.

Genus Dolatocrinus Lyon 1857 (W. & Sp. 1897)

Dolatocrinus glyptus (Hall)

Dolatocrinus glyptus var. *intermedius* (Hall)

Dolatocrinus liratus (Hall)

Dolatocrinus liratus var. *parvulus* nov.

Dolatocrinus lamellosus (Hall)

Dolatocrinus speciosus (Hall)

Dolatocrinus ornatus Meek

Dolatocrinus marshi var. *glaber* nov.

Dolatocrinus insignis sp. nov.

Dolatocrinus lobatus sp. nov.

Genus Clarkeocrinus nov.

Clarkeocrinus troosti (Hall) n. comb.

Genus Craterocrinus nov.

Craterocrinus ruedemanni sp. nov.

Craterocrinus schoharie sp. nov.

Genus Comanthocrinus Springer 1920

Comanthocrinus indianensis (Miller & Gurley)

Comanthocrinus priscus Springer

Genus Himerocrinus Springer 1920

Himerocrinus (?) *polydactylus* (Hall)

Family BATOCRINIDAE Wachsmuth and Springer

Subfamily Periechocrininae W. & Sp.

Genus Acacocrinus W. & Sp. 1897

Acacocrinus pentadactylus (Grabau) n. comb.

Genus Corocrinus nov.

Corocrinus ornatus sp. nov.

Corocrinus (?) *calypso* (Hall) n. comb.

Genus Saccocrinus Hall 1852

Saccocrinus (?) *hamiltonensis* sp. nov.

Genus Gennaeocrinus W. & Sp. 1881, 1897

Gennaeocrinus kentuckiensis (Shumard)

Gennaeocrinus eucharis (Hall)

Gennaeocrinus nyssa (Hall)

Gennaeocrinus carinatus Wood

Gennaeocrinus carinatus var. *crassicostatus* nov.

Gennaeocrinus decorus sp. nov.

Gennaeocrinus peculiaris sp. nov.

Genus Megistocrinus Owen & Shumard 1852 (W. & Sp. 1897)

Megistocrinus depressus Hall

Megistocrinus ontario Hall

Genus Thamnocrinus nov.

Thamnocrinus springeri sp. nov.

Subfamily Batocrininae W. & Sp.

Genus Aorocrinus W. & Sp. 1897

Aorocrinus cauliculus (Hall)

Aorocrinus praecursor (Hall)

Aorocrinus armatus sp. nov.

Aorocrinus formosus sp. nov.

Aorocrinus longidactylus sp. nov.

Family PLATYCRINIDAE Roemer

Genus Cyttarocrinus nov.

Cyttarocrinus eriensis (Hall) n. comb.

Cyttarocrinus (?) *jewetti* sp. nov.

Genus Cordylocrinus Angelin 1878

Cordylocrinus plumosus (Hall)

Cordylocrinus (?) *ramulosus* (Hall)

Genus Marsipocrinus Bather 1889 (for Marsupiocrinus Phillips 1839)

Marsipocrinus tentaculatus (Hall)

Family HEXACRINIDAE Wachsmuth and Springer

Genus Arthracantha Williams 1883

Arthracantha eboracea (Hall) n. comb.

Arthracantha punctobrachiata (Hall)
Arthracantha carpenteri (Hinde)
Arthracantha ithacensis Williams
Arthracantha depressa W. & Sp.
Arthracantha granosa sp. nov.
Arthracantha splendens sp. nov.

Order FLEXIBILIA Zittel

Suborder SAGENOCRINOIDEA Springer

Family ICHTHYOCRINIDAE Wachsmuth and Springer

Genus Clidochirus Angelin 1878

Clidochirus schucherti (Talbot)

Genus Synaptocrinus Springer 1920

Synaptocrinus nuntius (Hall)

Family TAXOCRINIDAE Bather em. Springer

Genus Eutaxocrinus Springer 1906

Eutaxocrinus ithacensis (Williams)
Eutaxocrinus alpha (Williams)
Eutaxocrinus curtus (Williams)
Eutaxocrinus pulcher Springer
Eutaxocrinus amplus Springer
Eutaxocrinus dumosus sp. nov.

Genus Taxocrinus Phillips 1843

Taxocrinus lobatus (Hall)

Order INADUNATA Wachsmuth and Springer

Suborder LARVIFORMIA Wachsmuth and Springer

Family PISOCRINIDAE Angelin

Genus Hypsocrinus Springer & Slocom 1906

Hypsocrinus fieldi Springer & Slocom

Family ANAMESOCRINIDAE nov.

Genus Anamesocrinus nov.

Anamesocrinus lutheri sp. nov.

Family HAPLOCRINIDAE Roemer

Genus Haplocrinus Steininger 1837

Haplocrinus clio Hall

Family SYMBATHOCRINIDAE Wachsmuth and Springer

Genus Symbathocrinus Phillips 1836

Symbathocrinus subtrigonalis sp. nov.

Symbathocrinus sulcatus sp. nov.

Genus Stylocrinus Sandberger 1850

Stylocrinus (?) *canandaigua* sp. nov.

Suborder FISTULATA Wachsmuth and Springer

Family HETEROCRINIDAE Zittel

Genus Brachiocrinus Hall 1859

Brachiocrinus nodosarius Hall

Family CREMACRINIDAE Ulrich

Genus Deltacrinus Ulrich 1886

Deltacrinus clarus (Hall)

Genus Halysiocrinus Ulrich 1886 (em. Bather 1893)

Halysiocrinus secundus (Hall) n. comb.

Family CYATHOCRINIDAE Roemer (em. Wachsmuth and Springer)

Subfamily Carabocrininae Springer

Genus Lasiocrinus Kirk 1911

Lasiocrinus scoparius (Hall)

Lasiocrinus (?) *schohariensis* sp. nov.

Genus Iteacrinus nov.

Iteacrinus flagellum sp. nov.

Iteacrinus robustus sp. nov.

Genus Cradeocrinus nov.

Cradeocrinus elongatus sp. nov.

Cradeocrinus pergracilis sp. nov.

Subfamily Gasterocominae Springer

Genus Schultzicrinus Springer 1911

Schultzicrinus typus Springer

Schultzicrinus (?) *elongatus* Springer

Genus Arachnocrinus Meek & Worthen 1866

Arachnocrinus bulbosus (Hall)

Arachnocrinus extensus W. & Sp.

Arachnocrinus ignotus Stauffer

Genus Myrtillocrinus Sandberger 1855

Myrtillocrinus americanus Hall

Myrtillocrinus (?) *levis* (Wood)

Genus Mictocrinus nov.

Mictocrinus robustus sp. nov.

Family BOTRYOCRINIDAE Bather

Genus Botryocrinus Angelin 1878 (em. Bather 1891)

Botryocrinus nycteus (Hall) n. comb.

Botryocrinus crassus (Whiteaves)

Botryocrinus americanus Rowley

Botryocrinus concinnus sp. nov.

Botryocrinus obconicus sp. nov.

Botryocrinus sentosus sp. nov.

Genus Hallocrinus nov.

Hallocrinus ornatissimus (Hall) n. comb.

Genus Maragnicrinus Whitfield 1905

Maragnicrinus portlandicus Whitfield

Family GLOSSOCRINIDAE nov.

Genus Glossocrinus nov.

Glossocrinus naplesensis sp. nov.

Glossocrinus cornellianus (Williams) n. comb.

Genus Liparocrinus nov.

Liparocrinus batheri sp. nov.

Liparocrinus halli sp. nov.

Genus Charientocrinus nov.

Charientocrinus ithacensis sp. nov.

Genus Catactocrinus nov.

Catactocrinus leptodactylus sp. nov.

Family POTERIOCRINIDAE Roemer (em. Wachsmuth and Springer)

Subfamily Poteriocrininae Springer

Genus Poteriocrinus Miller 1821 (em. W. & Sp. 1881)

Poteriocrinus (?) *diffusus* Hall

Poteriocrinus nassa Hall

Poteriocrinus clarkei Williams

Poteriocrinus clarkei var. *alpha* Williams

Poteriocrinus zethus Williams

Poteriocrinus (?) *dignatus* sp. nov.

Nomina Nuda

Poteriocrinus verticillus Hall

Poteriocrinus indentus Hall

Genus Decadocrinus W. & Sp. 1879

Decadocrinus nereus (Hall) n. comb.

Decadocrinus gregarius Williams

Decadocrinus decemnodosus sp. nov.

Decadocrinus insolens sp. nov.

Decadocrinus killawogensis sp. nov.

Decadocrinus multinodosus sp. nov.

Decadocrinus multinodosus var. *serratobrachiatus* nov.

Decadocrinus rugistriatus sp. nov.

Genus Corematocrinus nov.

Corematocrinus plumosus sp. nov.

Genus Logocrinus gen. nov.

Logocrinus infundibuliformis sp. nov.

INCERTAE SEDIS

Family (?)

Genus Aspidocrinus Hall 1859

Aspidocrinus scutelliformis Hall

Aspidocrinus digitatus Hall

Aspidocrinus callosus Hall

Aspidocrinus onondagensis sp. nov.

Family EDRIOCRINIDAE S. A. Miller (Talbot)

Genus Edriocrinus Hall 1859 (em. Springer 1920)

Edriocrinus pocilliformis Hall

Edriocrinus sacculus Hall

Edriocrinus pyriformis Hall

Edriocrinus becraftensis Clarke

Edriocrinus dispansus Kirk

Edriocrinus holopoides Springer

Family (?)

Genus Ancyrocrinus Hall 1862

Ancyrocrinus bulbosus Hall

Ancyrocrinus quinquepartitus sp. nov.

Synonyms

Gilbertsocrinus indianensis (M. & G.) = ? *Gilbertsocrinus spinigerus* (Hall)

Dolatocrinus liratus var. *multilira* (Hall) = *Dolatocrinus liratus* (Hall)

Megistocrinus ornatus M. & G. = *Megistocrinus depressus* Hall

Aorocrinus ? pocillum (Hall) = *Megistocrinus depressus* Hall

Cordylocrinus parvus (Hall) = *Cordylocrinus plumosus* (Hall)

Nomina Nuda

Encrinites triciclas Eaton

Poteriocrinus indentus Hall

Poteriocrinus verticillus Hall

Stratigraphic Distribution of the New York Devonian Crinoids

As shown by the accompanying table and list, the species of Devonian crinoids here described have no extensive range. As far as collections already made show, they are for the most part confined to one formation. The majority of the Camerata occur in the Lower Devonian; the majority of the Flexibilia in the Upper Devonian. The Inadunata are about equally abundant in the Lower and Upper Devonian, the largest number coming from the Hamilton and Chemung beds.

TABLE SHOWING THE STRATIGRAPHIC DISTRIBUTION OF THE SPECIES OF NEW YORK DEVONIAN CRINOIDS

						Oriskany Beds				Marcellus Beds				Hamilton Beds						Genesee Beds					Portage Beds (Naples Fauna)													Portage Beds (Ithaca Fauna)				Chemung Beds			
	Lower Helderberg (Lewiston l. s.) Penn.	Lower Helderberg (Linden formation) Penn.	Coeymans limestone	New Scotland limestone	Becraft limestone	Oriskany limestone	Oriskany (Glenerie) limestone	Schoharie grit	Onondaga limestone	Marcellus black shale	Cherry Valley l. s. (incl. in Marcellus)	Stafford limestone	Cardiff shale	Skaneateles shale	Ludlowville shale (incl. Centerfield l. s. at base)	Tichenor limestone	Moscow shale (incl. Menteth l. s.)	Hamilton shales	Tully limestone	Genesee black shale	Huron shales (Ohio)	Genundewa limestone	West River shale	Standish flags and shales	Middlesex shale	Cashaqua shale (incl. Parrish l. s. at top)	Rhinestreet shale	Angola shale (<- Lower Hatch)	Hanover shale (<- Upper Hatch)	Hatch shales	Dunkirk shale	Grimes sandstone	Gardeau flags	Nunda sandstone	Laona sandstone (= L. Nunda)	Wiscoy shale	Portage (Naples) beds	Sherburne sandstone	Ithaca beds	Enfield shale	West Hill flags	Lower Chemung beds	L. Chemung (Prattsburg sandstone)	Upper Chemung beds	Chemung beds
CAMERATA																																													
Acacocrinus pentadactylus																	x																												
Acanthocrinus onondaga									x																																				
Acanthocrinus spinosus																	x	x?																											
Aorocrinus armatus																	x																												
Aorocrinus cauliculus																	x																												
Aorocrinus formosus																	x																												
Aorocrinus longidactylus																	x																												
Aorocrinus praecursor																	x																												
Arthracantha carpenteri																		x																											
Arthracantha depressa																																											x		
Arthracantha eboracea															x		x																												
Arthracantha granosa																																x										x?			
Arthracantha ithacensis																																							x			x?			
Arthracantha punctobrachiata																		x																											
Arthracantha splendens																																										x			
Clarkeocrinus troosti																	x																												
Clonocrinus (?) macropetalus					x																																								
Comanthocrinus indianensis																	x	x																											
Comanthocrinus priscus									x																																				
Cordylocrinus plumosus			x																																										
Cordylocrinus (?) ramulosus			x																																										
Corocrinus (?) calypso																	x																												
Corocrinus ornatus															x																														
Craterocrinus ruedemanni									x																																				
Craterocrinus schoharie				x																																									
Cyttarocrinus eriensis																	x																												
Cyttarocrinus (?) jewetti																		x																											
Dimerocrinus arborescens			x																																										
Dimerocrinus whitfieldi																	x																												
Dolatocrinus glyptus															x		x																												
Dolatocrinus glyptus var. intermedius																	x																												
Dolatocrinus insignis																	x																												
Dolatocrinus lamellosus									x																																				
Dolatocrinus liratus															x		x		x																										
Dolatocrinus liratus var. parvulus																	x																												
Dolatocrinus lobatus									x																																				
Dolatocrinus marshi var. glaber									x																																				
Dolatocrinus ornatus									x																																				
Dolatocrinus speciosus									x																																				
Gennaeocrinus carinatus															x		x	x																											
Gennaeocrinus carinatus var. crassicostatus																	x																												
Gennaeocrinus decorus																		x																											
Gennaeocrinus eucharis															x		x																												
Gennaeocrinus kentuckiensis																	x																												
Gennaeocrinus nyssa															x		x																												
Gennaeocrinus peculiaris																	x																												
Gilbertsocrinus spinigerus																	x																												
Himerocrinus (?) polydactylus				x																																									
Mariacrinus beecheri			x																																										
Mariacrinus plumosus			x																																										
Mariacrinus ramosus			x																																										
Mariacrinus stoloniferus				x																																									
Marsipocrinus tentaculatus				x																																									
Megistocrinus depressus															x		x																												
Megistocrinus ontario															x		x																												
Melocrinus bainbridgensis																					x																								
Melocrinus breviradiatus																	x																												
Melocrinus clarkei																							x			x		x																	
Melocrinus gracilis																	x																												
Melocrinus naplesensis																																									x				
Melocrinus nobilissimus			x																																										
Melocrinus nodosus																		x																											
Melocrinus pachydactylus			x																																										
Melocrinus paucidactylus			x																																										
Melocrinus reticularis																																							x						
Melocrinus sp (?)																																									x				
Melocrinus sp. nov																	x																												
Melocrinus splendens																																												x	
Melocrinus willetensis																																										x			
Melocrinus willetensis var. perstriatus																																										x			
Melocrinus williamsi																																							x						
Melocrinus (Trichotocrinus) harrisi																																							x						
Melocrinus (Trichotocrinus) lutheri																																									x				
Pterinocrinus quinquenodus																																										x			
Rhodocrinus nodulosus																	x	x																											
Rhodocrinus nodulosus var. pernodosus																	x																												
Saccocrinus (?) hamiltonensis																	x																												
Sphaerotocrinus ornatus	x																																												
Thamnocrinus springeri																	x																												
Thylacocrinus clarkei																	x																												
Thylacocrinus gracilis																	x																												
FLEXIBILIA																																													
Clidochirus schucherti				x																																									
Eutaxocrinus alpha																																										x			
Eutaxocrinus amplus																																												x	
Eutaxocrinus curtus																																										x			
Eutaxocrinus dumosus																																							x						
Eutaxocrinus ithacensis																																						x	x						
Eutaxocrinus pulcher																																										x			
Synaptocrinus nuntius															x?		x	x																											
Taxocrinus lobatus																	x																												
INADUNATA																																													
Anamesocrinus lutheri																																			x							x			
Arachnocrinus bulbosus									x																																				
Arachnocrinus extensus									x																																				
Arachnocrinus ignotus									x																																				
Botryocrinus americanus																		x																											
Botryocrinus concinnus														x																															
Botryocrinus crassus																		x																											
Botryocrinus nycteus																	x																												
Botryocrinus obconicus																	x																												
Botryocrinus sentosus																	x																												
Brachiocrinus nodosarius			x	x																																									
Catactocrinus leptodactylus																																										x			
Charientocrinus ithacensis																																							x						
Corematocrinus plumosus																																	x									x			
Cradeocrinus elongatus																																										x			
Cradeocrinus pergracilis																																							x						
Decadocrinus decemnodosus																																							x						
Decadocrinus gregarius																																										x			
Decadocrinus insolens																							x																						
Decadocrinus killawogensis																																x							x						
Decadocrinus multinodosus																	x																												
Decadocrinus multinodosus var. serratobrachiatus																	x																												
Decadocrinus nereus																	x																												
Decadocrinus rugistriatus																																							x		x				
Deltacrinus clarus																	x																												
Glossocrinus cornellianus																																							x			x			
Glossocrinus naplesensis																																x									x	x			
Hallocrinus ornatissimus																																					x								
Halysiocrinus secundus									x																																				
Haplocrinus clio											x																																		
Hypsocrinus fieldi																	x																												
Iteacrinus flagellum																																										x			
Iteacrinus robustus																																										x			
Lasiocrinus (?) schohariensis								x																																					
Lasiocrinus scoparius			x																																										
Liparocrinus batheri																																										x			
Liparocrinus halli																																													x
Logocrinus geniculatus																	x																												
Logocrinus infundibuliformis																																										x			
Maragnicrinus portlandicus																																					x								
Mictocrinus robustus									x																																				
Myrtillocrinus americanus									x																																				
Myrtillocrinus (?) levis									x																																				
Poteriocrinus clarkei																																												x	x
Poteriocrinus clarkei var. alpha																																										x		x	
Poteriocrinus (?) diffusus																	x																												
Poteriocrinus (?) dignatus														x																															
Poteriocrinus nassa																	x																												
Poteriocrinus zethus																																							x						
Schultzicrinus (?) elongatus									x																																				
Schultzicrinus typus									x																																				
Symbathocrinus subtrigonalis																	x																												
Symbathocrinus sulcatus									x																																				
Stylocrinus (?) canandaigua																	x																												
INCERTAE SEDIS																																													
Ancyrocrinus bulbosus															x		x																												
Ancyrocrinus quinquepartitus							x																																						
Aspidocrinus callosus				x																																									
Aspidocrinus digitatus				x																																									
Aspidocrinus onondagensis									x																																				
Aspidocrinus scutelliformis				x	x																																								
Edriocrinus becraftensis						x																																							
Edriocrinus dispansus		x																																											
Edriocrinus holopoides						x																																							
Edriocrinus pociliformis				x																																									
Edriocrinus pyriformis			x																																										
Edriocrinus sacculus						x	x																																						

List of Species of New York Devonian Crinoids According to the Formations in Which They Occur

LEWISTON LIMESTONE (Lower Helderberg, Pa.)

Camerata

Sphaerotocrinus ornatus sp. nov.

LINDEN FORMATION (Lower Helderberg, Tenn.)

Incertae sedis

Edriocrinus dispansus Kirk

COEYMANS LIMESTONE

Camerata

Cordylocrinus plumosus (Hall)
Cordylocrinus (?) ramulosus (Hall)
Dimerocrinus arborescens (Talbot) n. comb.
Mariacrinus beecheri Talbot
Mariacrinus plumosus Hall
Mariacrinus ramosus Hall
Melocrinus nobilissimus (Hall)
Melocrinus pachydactylus (Conrad)
Melocrinus paucidactylus (Hall)

Inadunata

Brachiocrinus nodosarius Hall
Lasiocrinus scoparius (Hall)

Incertae sedis

Edriocrinus pyriformis Hall

NEW SCOTLAND LIMESTONE

Camerata

Craterocrinus schoharie sp. nov.
Himerocrinus (?) polydactylus (Hall)
Mariacrinus stoloniferus Hall
Marsipocrinus tentaculatus (Hall)

Flexibilia

Clidochirus schucherti (Talbot)

Inadunata

Brachiocrinus nodosarius Hall

Incertae sedis

Aspidocrinus callosus Hall
Aspidocrinus digitatus Hall
Aspidocrinus scutelliformis Hall
Edriocrinus pocilliformis Hall

BECRAFT LIMESTONE

Camerata

Clonocrinus (?) macropetalus (Hall) n. comb.

Incertae sedis

Aspidocrinus scutelliformis Hall

ORISKANY LIMESTONE

Incertae sedis

Edriocrinus becraftensis Clarke
Edriocrinus holopoides Springer

ORISKANY (GLENERIE) LIMESTONE

Incertae sedis

Ancyrocrinus quinquepartitus
Edriocrinus sacculus Hall

SCHOHARIE GRIT

Inadunata

Lasiocrinus (?) schohariensis sp. nov.

ONONDAGA LIMESTONE

Camerata

Acanthocrinus onondaga sp. nov.
Comanthocrinus priscus Springer
Craterocrinus ruedemanni sp. nov.
Dolatocrinus lamellosus (Hall)
Dolatocrinus lobatus sp. nov.
Dolatocrinus marshi var. glaber nov.
Dolatocrinus ornatus Meek
Dolatocrinus speciosus (Hall)

Inadunata

Arachnocrinus bulbosus (Hall)
Arachnocrinus extensus W. & Sp.
Arachnocrinus ignotus Stauffer
Halysiocrinus secundus (Hall) n. comb.
Mictocrinus robustus sp. nov.
Myrtillocrinus americanus Hall
Myrtillocrinus (?) levis (Wood)
Schultzicrinus (?) elongatus Springer
Schultzicrinus typus Springer
Symbathocrinus sulcatus sp. nov.

Incertae sedis

Aspidocrinus onondagensis sp. nov.

MARCELLUS (CHERRY VALLEY LIMESTONE)

Inadunata

Haplocrinus clio Hall

HAMILTON SHALES

1 Skaneateles shale

Inadunata

Botryocrinus concinnus sp. nov.

Poteriocrinus (?) dignatus sp. nov.

2 Ludlowville shale

Camerata

Arthracantha eboracea (Hall) n. comb.

Corocrinus ornatus sp. nov.

Dolatocrinus glyptus (Hall)

Dolatocrinus liratus (Hall)

Gennaeocrinus carinatus Wood

Gennaeocrinus eucharis (Hall)

Gennaeocrinus nyssa (Hall)

Megistocrinus depressus Hall

Megistocrinus ontario Hall

Flexibilia

Synaptocrinus nuntius (Hall) (?)

Incertae sedis

Ancyrocrinus bulbosus Hall

3 Moscow shale

Camerata

Acacocrinus pentadactylus (Grabau) n. comb.

Acanthocrinus spinosus (Hall) n. comb.

Aorocrinus armatus sp. nov.

Aorocrinus cauliculus (Hall)

Aorocrinus formosus sp. nov.

Aorocrinus longidactylus sp. nov.

Aorocrinus praecursor (Hall)

Arthracantha eboracea (Hall) n. comb.

Clarkeocrinus troosti (Hall) n. comb.

Comanthocrinus indianensis (Miller & Gurley)

Corocrinus (?) calypso (Hall) n. comb.

Cyttarocrinus eriensis (Hall) n. comb.

Dimerocrinus whitfieldi sp. nov.

Dolatocrinus glyptus (Hall)

Dolatocrinus glyptus var. intermedius (Hall)

Dolatocrinus insignis sp. nov.

Dolatocrinus liratus (Hall)

Dolatocrinus liratus var. parvulus nov.

Gennaeocrinus carinatus Wood

Gennaeocrinus carinatus var. crassicostatus nov.

Gennaeocrinus eucharis (Hall)

Gennaeocrinus kentuckiensis (Shumard)

Gennaeocrinus nyssa (Hall)

Gennaeocrinus peculiaris sp. nov.

Gilbertsocrinus spinigerus (Hall)

Megistocrinus depressus Hall

Megistocrinus ontario Hall

Melocrinus breviradiatus Hall

Melocrinus gracilis W. & Sp.

Melocrinus sp. nov.

Rhodocrinus nodulosus Hall

Rhodocrinus nodulosus var. pernodosus nov.

Saccocrinus (?) hamiltonensis sp. nov.

Thamnocrinus springeri sp. nov.

Thylacocrinus clarkei W. & Sp.

Thylacocrinus gracilis (Hall) n. comb.

Flexibilia

Synaptocrinus nuntius (Hall)

Taxocrinus lobatus (Hall)

Inadunata

Botryocrinus nycteus (Hall) n. comb.

Botryocrinus obconicus sp. nov.

Botryocrinus sentosus sp. nov.

Decadocrinus multinodosus sp. nov.

Decadocrinus multinodosus var. serratobrachiatus nov.

Decadocrinus nereus (Hall) n. comb.

Deltacrinus clarus (Hall)

Hypsocrinus fieldi Springer & Slocom

Logocrinus geniculatus sp. nov.

Poteriocrinus (?) diffusus Hall

Poteriocrinus nassa Hall

Stylocrinus (?) canandaigua sp. nov.

Symbathocrinus subtrigonalis sp. nov.

Incertae sedis

Ancyrocrinus bulbosus Hall

4 Hamilton shale (*division undetermined or outside State*)
Camerata
Acanthocrinus spinosus (Hall) n. comb.
Arthracantha carpenteri (Hinde)
Arthracantha punctobrachiata (Hall)
Cyttarocrinus (?) jewetti sp. nov.
Gennaeocrinus decorus sp. nov.
Melocrinus nodosus (Hall) (Wisconsin)
Flexibilia
Synaptocrinus nuntius (Hall)
Taxocrinus lobatus (Hall)
Inadunata
Botryocrinus americanus Rowley (Indiana)
Botryocrinus crassus (Whiteaves)

TULLY LIMESTONE
Camerata
Dolatocrinus liratus (Hall)

GENESEE SHALES
1 Huron shales (Ohio)
Camerata
Melocrinus bainbridgensis Hall & Whitfield
2 West River shales
Camerata
Melocrinus clarkei (Hall Ms) Williams
Inadunata
Decadocrinus insolens sp. nov.

PORTAGE (NAPLES) BEDS
1 Cashaqua shale
Camerata
Melocrinus clarkei (Hall Ms) Williams
2 Angola shale
Camerata
Melocrinus clarkei (Hall Ms) Williams
3 Grimes sandstone
Camerata
Arthracantha granosa sp. nov.
Inadunata
Decadocrinus killawogensis sp. nov.
Glossocrinus naplesensis sp. nov.
4 Gardeau flags
Inadunata
Corematocrinus plumosus sp. nov.
5 Laona sandstone
Inadunata
Anamesocrinus lutheri sp. nov.
6 Portage (Naples) beds (*division undetermined*)
Inadunata
Hallocrinus ornatissimus (Hall) n. comb.
Maragnicrinus portlandicus Whitfield

PORTAGE (ITHACA) BEDS
1 Sherburne sandstone
Flexibilia
Eutaxocrinus curtus (Williams)
Eutaxocrinus ithacensis (Williams)
2 Ithaca beds
Camerata
Arthracantha ithacensis Williams
Melocrinus reticularis Olsson
Melocrinus williamsi Olsson
Melocrinus (Trichotocrinus) harrisi Olsson
Flexibilia
Eutaxocrinus dumosus sp. nov.
Eutaxocrinus ithacensis (Williams)
Inadunata
Charientocrinus ithacensis sp. nov.
Cradeocrinus pergracilis sp. nov.
Decadocrinus decemnodosus sp. nov.
Decadocrinus killawogensis sp. nov.
Decadocrinus rugistriatus sp. nov.
Glossocrinus cornellianus (Williams) n. comb.
Poteriocrinus zethus Williams
3 West Hill flags
Camerata
Melocrinus naplesensis sp. nov.
Melocrinus sp. (?)
Melocrinus (Trichotocrinus) lutheri sp. nov.
Inadunata
Decadocrinus rugistriatus sp. nov.
Glossocrinus naplesensis sp. nov.

LOWER CHEMUNG BEDS
1 Prattsburg sandstone
Camerata
Arthracantha depressa W. & Sp.

2 Lower Chemung (*division undetermined*)

Camerata

Arthracantha granosa sp. nov.
Arthracantha ithacensis Williams (?)
Arthracanthra splendens sp. nov.
Melocrinus willetensis sp. nov.
Melocrinus willetensis var. perstriatus nov.
Pterinocrinus quinquenodus sp. nov.

Flexibilia

Eutaxocrinus alpha (Williams)
Eutaxocrinus curtus (Williams)
Eutaxocrinus pulcher Springer

Inadunata

Anamesocrinus lutheri sp. nov.
Catactocrinus leptodactylus sp. nov.
Corematocrinus plumosus sp. nov.
Cradeocrinus elongatus sp. nov.
Decadocrinus gregarius Williams
Glossocrinus cornellianus (Williams) n. comb.
Glossocrinus naplesensis sp. nov.
Iteacrinus flagellum sp. nov.
Iteacrinus robustus sp. nov.
Liparocrinus batheri sp. nov.
Logocrinus infundibuliformis sp. nov.
Poteriocrinus clarkei var. alpha Williams

UPPER CHEMUNG BEDS

Camerata

Melocrinus splendens sp. nov.

Flexibilia

Eutaxocrinus amplus Springer

Inadunata

Poteriocrinus clarkei Williams
Poteriocrinus clarkei var. alpha Williams

CHEMUNG BEDS (*division undetermined*)

Inadunata

Liparocrinus halli sp. nov.
Poteriocrinus clarkei Williams

Summary of Terminology Used (Springer *1913;* Bather *1900*)

Crown. The crinoid without the column.

Calyx. The crinoid without column or free arms.

Dorsal cup. The part of the calyx below the origin of the free arms.

Tegmen. The part of the calyx above the origin of the free arms, including the disk ambulacra, mouth and anus. Other names which have been used for the tegmen are *ventral disk*, *vault*, *dome*, and *summit.*

Base. The proximal part of the dorsal cup, lying just above the column. It may be composed of one (*monocyclic*) or two (*dicyclic*) rings of plates.

Basals (*B*). The proximal ring of plates in a monocyclic base. The basals are interradial in position, alternating with the radials which they adjoin.

Infrabasals (*IB*). The proximal ring of plates in a dicyclic base. The infrabasals are radial in position.

Radials (*R*). The ring of plates above the basals, radially situated. In some of the earlier crinoids the presence of a radianal or inferradials gives the appearance of transverse bisection of the radials.

Brachials (*Br*). The succession of radially situated plates above the radials. When they are incorporated in the dorsal cup, they are termed *fixed brachials*; otherwise, *free brachials* or *arm-plates*.

Primibrachs (*IBr*). The brachials of the first order; that is, the brachials above the radial, up to and including the first axillary which is termed the *primaxil* (*Iax*). The brachials of the first order are also termed *costals*.

Secundibrachs (*IIBr*). Brachials of the second order; also known as *distichals*. The axillary is termed the *secundaxil* (*IIax*).

Tertibrachs (*IIIBr*). Brachials of the third order, to which the name *palmars* also is given. The succeeding orders which were known as *post-palmars* are, according to position, *quartibrachs*, (*IVBr*), *quintibrachs* (*VBr*), etc.

Interbrachials (*iBr*). The supplementary plates occupying the space between the rays proper. The interbrachials and the interambulacrals as well are termed *interradials* (*IR*).

Intersecundibrachs (*iIIBr*). The supplementary plates between the secundibrachs. Those between the tertibrachs are known as *intertertibrachs* (*iIIIBr*), etc.

Anals. Interbrachials of the posterior side forming the base of the anal structures.

Anal x. The special or first anal plate (*x*), which, when present, is situated between the radials and rests upon the truncated upper face of the posterior basal. Higher anal plates may be present even when the anal *x* is missing; they form a median series of plates between the interbrachials.

Radianal (*RA*). One of the anal plates occurring in the Inadunata and Flexibilia, when there are two present, and disturbing the bilateral symmetry of the cup. Primitively the radianal is located below the right posterior radial; but in later genera it is situated obliquely to the left, assisting in the widening of the anal area and the support of the anal tube.

Orals (*O*). Five large interradial plates which surround the mouth or cover it (*see* pages 21, 22 for views of Bather and Springer on orals). When they are nearly of the same size they are said to be *symmetrical*; when the posterior plate is larger than the other four or pushed in between them they are said to be *asymmetrical.*

Ambulacrals (*Amb*). The covering-plates of the ventral groove (*ambulacrum* or *ambulacral groove*) of the arms which may be incorporated into the tegmen where they form radially situated rows of small plates. The ambulacrals may be separated from the brachials or pinnulars by squarish *side-plates* or *adambulacrals.* When the ambulacra branch the ambulacrals, as in the case of the brachials, are termed ambulacrals of the first order or *primary ambulacrals* (*IAmb*), of the second order or *secondary ambulacrals* (*IIAmb*), etc.

Interambulacrals (*iAmb*). Supplementary plates of the tegmen which lie between the ambulacra. When the branches of the ambulacra are incorporated into the tegmen the supplementary plates between them are known as *interambulacrals of the second order* (*iIIAmb*), *interambulacrals of the third order* (*iIIIAmb*), etc.

Rami. The main arm-branches.

Ramules. The smaller branches, or *armlets,* given off from the main arm-branch.

Regular dichotomy or *isotomy.* A type of branching in which the bifurcations occur constantly at regular intervals.

Irregular dichotomy or *heterotomy.* A type of branching produced by the suppression of bifurcations at definite points.

Bilateral heterotomy. A type of branching in which armlets occur alternately at the right and left of the main branch.

Unilateral heterotomy. A type of branching in which armlets occur only on one side of the main branch.

Uniserial arms. Arms in which the brachials are arranged in a single series and are more or less rectangular or wedge-shaped.

Biserial arms. Arms in which the brachials are arranged in two alternating rows with the smaller ends of the plates meeting midway.

Pinnulars. Ossicles composing the *pinnules,* jointed appendages of the arms.

Columnals. Ossicles composing the *column* or stem.

Nodals. The larger columnals and all cirrus-bearing columnals.

Internodals. The smaller columnals between the nodals.

Proximale. The proximal columnal which in some forms remains fixed to the calyx and may be fused with the infrabasals.

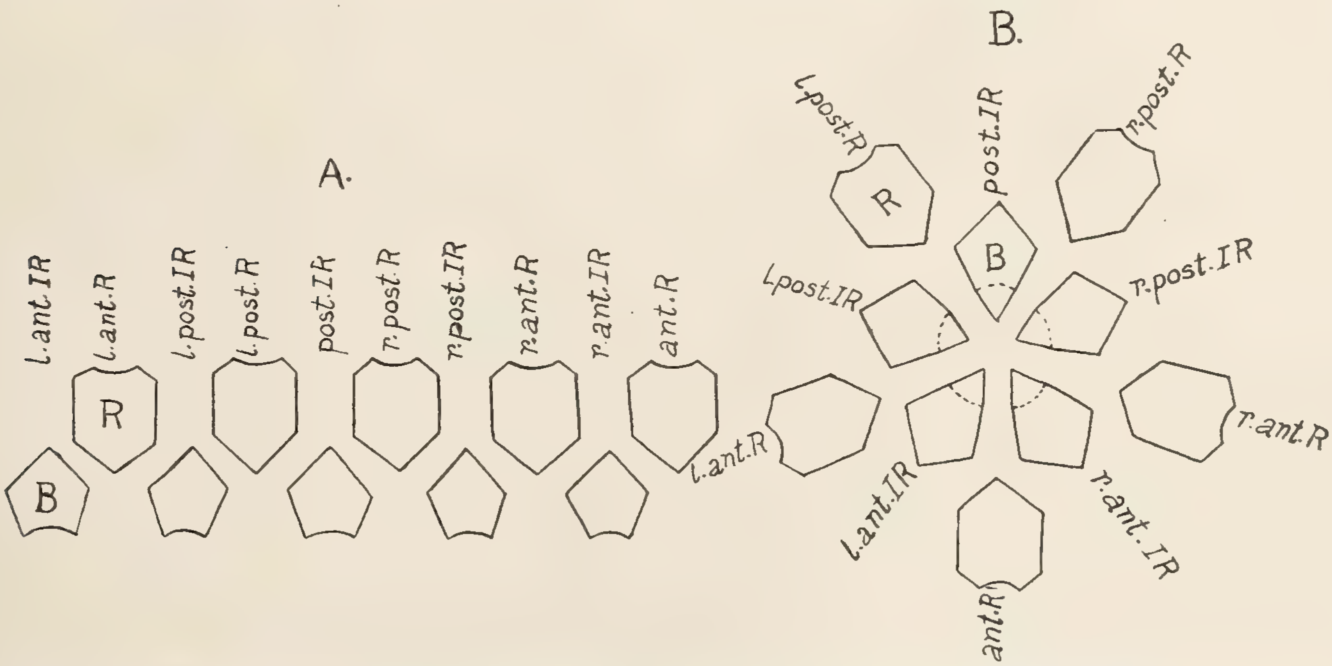


Figure 33 Diagrammatic analyses of a dorsal cup showing orientation and giving nomenclature; *ant. R,* anterior radius; *r. ant. IR,* right anterior interradius; *r. ant. R,* right anterolateral radius; *r. post. IR,* right posterolateral interradius; *r. post. R,* right posterior radius; *post. IR,* posterior interradius; *l. post. R,* left posterior radius; *l. post. IR,* left posterolateral interradius; *l. ant. R,* left anterolateral radius; *l. ant. IR,* left anterior interradius.

Cirrals. The ossicles composing the *cirri,* jointed appendages of the column.

Syzygy. An immovable sutural union between two brachials of a pinnulate arm. The lower brachial bears no pinnule and is termed the *hypozygal;* the upper, pinnule-bearing one is the *epizygal.* The term syzygy is also applied to a similar union between a cirrus-bearing nodal and the next lower columnal.

Orientation. For orientation the crinoid is placed in the natural position with the mouth and arms uppermost; and it is viewed from the anal side, which is always the posterior. The radius opposite the anal interradius is always anterior, and right and left are the right and left of the observer (fig. 33). According to this orientation, when viewed from above the anal side is nearest the observer (downwards in a figure); when viewed from below the anal side is always away from the observer (upwards in a figure). In analyses such as that shown in figure 33 *A* the anterior radius is always at the right.

The above method of orientation suggested by Bather has received almost general acceptance. Jaekel (1918, p. 8) objects to this orientation and the consequent terminology as unnatural and confusing. It can not be carried out in a part of the Pelmatozoa, because, as he points out, the anus among the cystids is not constant. Furthermore, among the Calceocrinidae with a new symmetry plane it works out in quite a confusing way. The same argument is carried over to the bilateral Echinoidea.

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DEVONIAN CRINOIDS OF NEW YORK

DESCRIPTIONS OF SPECIES

Order CAMERATA Wachsmuth & Springer

Family DIMEROCRINIDAE Bather

Genus DIMEROCRINUS Phillips 1836 (syn. Thysanocrinus Hall)

Dimerocrinus arborescens (Talbot) n. comb.

Plate 1, figure 1

1905 Thysanocrinus arborescens Talbot. Amer. Jour. Sci., 4th ser., v. 20, no. 115, p. 23, pl. 1, fig. 2

A small species, the largest specimen seen having a dorsal cup measuring but little more than 12 mm in height. Cup and arms of the type specimen give a total measurement of about 47 mm. Greatest width of the dorsal cup (crushed) 11.7 mm; height, to the base of the free arms, 11.8 mm.

Dorsal cup somewhat elongate, but owing to the badly crushed state of all the specimens, it appears almost globose. Infrabasals five, small, triangular, scarcely projecting beyond the column. The largest infrabasal observed has a height of 1.2 mm with a base of 2.4 mm. Basals comparatively large, hexagonal. Posterior basal heptagonal, being truncated above to support the primary anal plate. Owing to crushing, no satisfactory measurements can be made of the basals. Radials heptagonal, larger than the basals. Those bordering the posterior interradius seem to be hexagonal. In the holotype, a radial gives 2.8 mm for height and 2.8 mm for greatest width. First primibrachs hexagonal, narrower than the radials and with a height of 2.1 mm in the type. Primaxils appear to be heptagonal, somewhat smaller than the first primibrachs and longer, in the type having a length of 2 mm. Each supports two series of secundibrachs. First three or four secundibrachs larger than the others and incorporated in the dorsal cup. Primary anal plate, which rests upon the truncated upper face of the posterior basal, octagonal with a height of 2.4 mm and a breadth of 2.9 mm. Upon its upper faces rest three plates. Above these the number can not be made out with certainty. The other interradial areas are very poorly shown. Primary interbrachial apparently followed by two plates in the second range and two in the third. A few intersecundibrachs are present.

Tegmen unknown.

Arms. Free arms biserial, stout at the base and taper rapidly distad. Pinnules long and slender. The free arms divide dichotomously, branching twice.

Column pentagonal, or perhaps better described as obscurely stellate. Angles of the stem radial in position. Near the calyx the columnals alternate in size; farther down the column every third or fourth columnal is larger. The larger columnals are the nodals. The type specimen has the stem preserved for some 45 cm, though still imperfect distally. The diameter of the stem of this specimen in the proximal portion is 3.3 mm while distally it tapers to 1.8 mm. No cirri are borne on the column so far as preserved.

Horizon and locality. From the upper third of the Coeymans limestone at North Litchfield, Herkimer county, New York.

Types. Holotype in the museum of Yale University.

Remarks. All the specimens of Dimerocrinus arborescens known are badly crushed, and show the plates very poorly. There is abundance of these specimens but the study of them has been made difficult, and the drawing of them impossible, by the fact that they are mostly preserved on slabs immovably mounted in museum wall cases, Yale University.

The figure given here (plate 1, figure 1) is somewhat in the nature of a reconstruction, being made by the artist from an enlarged photograph furnished by Professor Schuchert. The general proportions are fairly accurate, having been taken from wax impressions of the original specimen.

The name Dimerocrinus Phillips 1836 is preferred to that of Thysanocrinus Hall 1852 (Bather, 1898, p. 126; 1900, p. 198; Springer, 1913, p. 187).

Dimerocrinus whitfieldi sp. nov.

Plate 1, figure 2

Dorsal cup subturbinate, about 20 mm in height. Infrabasals comparatively large, projecting beyond the stem. Basals averaging 4.6 mm in height by 4 mm in breadth. Posterior basal heptagonal, being truncated at the top to support the first anal plate; remaining basals hexagonal. Radials heptagonal, of about the same height as the basals and as wide as high. First primibrachs hexagonal, somewhat smaller than the radials. Primaxils pentagonal or hexagonal, smaller than the first primibrachs, supporting 2 x 10 secundibrachs, which in turn support 2 x 20 tertibrachs. Primary interbrachials hexagonal, nearly as large as the radials, and followed by two plates in the second range, three in the third and apparently three in the fourth. Posterior interradius wider than the others. The proximal anal plate lies between the radials of the posterior rays, and is supported by the truncated upper face of the posterior basal. It is probably followed in the second range by three plates. The succeeding plates in the anal interradius are unknown.

At least three small intersecundibrachs are present, and possibly more. The first is hexagonal and of about the size of the first tertibrach. One intertertibrach in each half ray.

Arms. Free arms 20 in number, slender and biserial; composed of short brachials which bear long slender pinnules. The arms had a length of probably not less than 40 mm.

Column. Stem large and round, and measuring 5.4 mm in diameter in the proximal portion; composed near the calyx of alternating wide and narrow ossicles. The axial canal appears obscurely pentalobate in cross-section.

Ornamentation. Each radial series is traversed by the rounded ridge characteristic of most species of Dimerocrinus. Passing downward, this ridge bifurcates on the radial, the two resulting branches passing to the centers of the adjoining basals. The plates of the interradii are marked by a series of indistinct ridges which radiate from the centers. These ridges are shown, but much less distinctly, on the lower plates of the radial series.

Horizon and locality. The specimen figured is from the Hamilton (Moscow) shales of Jaycox's run, between Geneseo and Avon, Livingston county, New York

Types. The type is in the American Museum of Natural History, and is numbered $\frac{5026}{1}$ in the type catalog of that institution where it is listed as the type of "Actinocrinus" eucharis.

Remarks. The anal area of the specimen figured is badly crushed, and the adjoining edges of the first primibrach and primaxil are fractured, giving these plates a somewhat deceptive outline.

This specimen is listed in the American Museum of Natural History as the type of Hall's Actinocrinus eucharis. This reference is undoubtedly incorrect, as Hall's description of eucharis does not agree in any way with this form. There is a specimen in the New York State Museum which bears Hall's manuscript label Actinocrinus eucharis, however, which does fit the original description, and should therefore be taken as the type of that species. It is a Gennaeocrinus and will be found described under that genus.

The name whitfieldi for this species was suggested in manuscript by Doctor Kirk in honor of the late Professor R. P. Whitfield, of the American Museum of Natural History. The name is here retained.

Genus PTERINOCRINUS nov.

[Ety. πτέρινος, *feathery;* κρινον, *lily*]

This new genus is based upon a single species represented by several moulds in the Chemung sandstone.

Infrabasals five. Radials in contact except at the posterior side where they are separated by an anal plate. Interbrachials in several rows. First anal plate followed by three plates in the second row; in the other interradii the primary interbrachial followed by two plates. Brachials incorporated up to and including the first secundibrachs. Arms uniserial and column round.

This genus is very similar to Dimerocrinus, but the latter has biserial arms whereas this genus has uniserial arms throughout.

Genotype. Pterinocrinus quinquenodus

Distribution. Upper Devonian (lower Chemung) of New York.

Pterinocrinus quinquenodus sp. nov.

Plate 1, figures 3–10; text figure 34

This species is represented only by sharp moulds in sandstone. The description is based upon gutta-percha squeezes made from these moulds.

Crown with a graceful feathery appearance due to the long pinnules. The length of the crown at maturity can not be given, since the specimens in which the arms are preserved to any extent are all young.

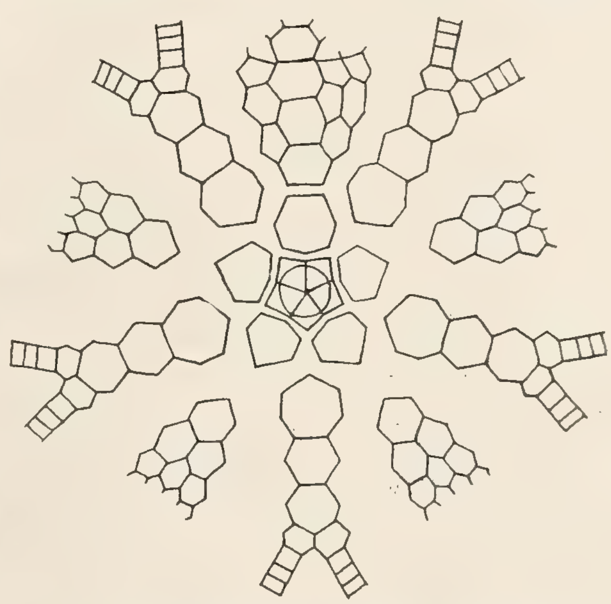


Figure 34 Analysis of calyx of Pterinocrinus quinquenodus, the genotype

Dorsal cup broadly obconical, higher than wide, broadest at or just below the primaxil, and constricted at the arm bases. Infrabasals five, small, pentagonal; so small they are concealed by the prominent nodes on the basals. They are shown quite clearly in the natural moulds. Basals of about the same height and width and hexagonal, except the posterior one which is heptagonal, being truncated above for the reception of the first anal plate. The radials are the largest plates of the cup, heptagonal, usually wider than high. Primibrachs two, smaller than the radials and the second smaller than the first. First primibrach hexagonal; the second, the primaxil, heptagonal. First secundibrachs incorporated in the cup. Above this point the arms are free.

Primary interbrachial smaller than the radial, hexagonal, resting upon the upper shoulders of two adjoining radials. One exception to this statement has been found among the specimens (plate 1, figure 6) but it is due to individual abnormality. Here the primary interbrachial appears to have been extended downward and the basal upward so that a short lower face of the interbrachial rests upon the truncated basal. This gives a heptagonal primary interbrachial and heptagonal basal. The primary interbrachial is followed in the second rank by two plates, in the third by three, and in the fourth rank the interradial area merges by a row of four plates into the plates of the tegmen.

In the posterior interradius the radials are separated by a hexagonal anal plate. This plate is followed by a median line of large hexagonal plates gradually decreasing in size upwards. The plates on each side of this median line are small and rather irregularly distributed, so that the plates cannot be clearly separated into ranks or rows. Three plates follow the anal plate.

Tegmen not known.

Arms two to each ray. In younger specimens (plate 1, figures 3, 4) where some of the arms are preserved almost to the tips, they are 3 times, or over, the length of the calyx. Just what the length of the arms might be in older specimens cannot be accurately stated, but from the many scattered fragments of arms it is assumed that they were proportionately as long or longer.

The arms are strictly uniserial, made up of short, quadrangular brachials, each bearing a pair of long, slender pinnules, one to each side. The short brachials bring the pinnules very close together, and this combined with the length and slenderness of the pinnules tends to enhance the feathery effect of the arms. Apparently one arm of each ray remains unbranched. This has been found in most cases to be the left arm, but one specimen has been found (plate 1, figure 8) which suggests that the right arm is the unbranched member of the ray. The other arm bifurcates twice, first on the fifth or sixth secundibrach and then a few brachials above this point on the exterior ray. No bifurcations have been observed in the more distal portions of the arms.

Column round. The columnals in the ultimate proximal portion are thin and projecting, and there is an alternation in sizes; but they gradually become longer until in more distal portions the columnals are all of about the same size, each with a wide projecting ringlike thickening.

Ornamentation. The basals are provided with conspicuous blunt nodes. A faint ridge runs from the basal node to the radial on each side where it joins, near the center, with the ridge from the adjacent basal and forms a stronger rounded ridge which extends up the radial series, branching on the primaxil, and is even prominent on the first secundibrachs. Central tubercles are present on the interradial plates, particularly on the plates of the second rank and above. The primary interbrachial may have a faint tubercle, or none.

Horizon and locality. Pterinocrinus quinquenodus occurs in the lower Chemung beds, Chemung Narrows, Chemung county, N. Y.

Types. Cotypes in the collection of the New York State Museum.

Family RHODOCRINIDAE Roemer

Genus RHODOCRINUS J. S. Miller 1821 (restr. W. & Sp. 1881)

Rhodocrinus nodulosus Hall

Plate 2, figures 1–5

1862 Rhodocrinus (Acanthocrinus) nodulosus Hall. 15th Rep't N. Y. State Cab. Nat. Hist., p. 126

1868 Rhodocrinus nodulosus Shumard. Trans. Acad. Sci. St Louis, 2:394

1872 Rhodocrinus (Acanthocrinus) nodulosus Hall. N. Y. State Mus. Bul. 1, pl. 1, fig. 8. (Photographic plates distributed privately)

1877 Rhodocrinus nodulosus S. A. Miller. Amer. Pal. Foss., p. 90

1881 Rhodocrinus nodulosus Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 212 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:386

1889 Rhodocrinus nodulosus S. A. Miller. N. Amer. Geol. & Pal., p. 278

1897 Rhodocrinus nodulosus Wachsmuth & Springer. N. Amer. Crin. Cam. 1:225, pl. 13, fig. 8 (authors' ed.); Mem. Mus. Comp. Zool., v. 20

1900 Rhodocrinus (Acanthocrinus) nodulosus Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 3, p. 198

1903 Rhodocrinus nodulosus Clarke & Ruedemann. N. Y. State Mus. Bul. 65, pp. 78, 79

1904 Rhodocrinus nodulosus Clarke & Luther. N. Y. State Mus. Bul. 63, p. 52

Species of medium size.

Dorsal cup short and turbinate, widening rapidly up to the top of the second primibrachs. Height and greatest width about equal; plates convex; interradial and intersecundibrach spaces depressed.

Infrabasals five in number, small pentangular, but plainly visible. Basals five, heptagonal, larger than any of the other plates, slightly longer than wide. Radials five, a little smaller than the basals, the two posterior ones hexagonal, the others pentagonal. Primibrachs two, smaller than the radials, the first being hexagonal, wider than high. Primaxils pentagonal, or sometimes unequally hexagonal. The secundibrachs of the first five or six ranges enter into the formation of the calyx. The first three or four are subquadrangular, the next two or three are smaller, cuneate, and interlocking. Primary interbrachials slightly smaller than the radials and followed by two, two, and three, or two, three, and three plates, except on the anal side where there are three plates in the second and four or five in the third row. Intersecundibrachs three or more.

Tegmen not known.

Arms ten in number, biserial, bifurcating 3 times, rather stout at the proximal ends, but decreasing in size rapidly with each new bifurcation.

Column missing. Its cicatrix shows it to be large and round with a pentalobate canal.

Ornamentation. Surface of the plates covered with obscure radiating ridges. The basals and primary interbrachials are distinctly nodose in the center, the basals very strongly so; the radials and primibrachs are elevated but not nodose in the center; the interbrachials above the first one and the interaxillaries (intersecundibrachs) are strongly nodose.

Ontogeny. In young specimens the plates are convex, but are without the radiating ridges or the central nodes, except on the basals. Even in the youngest specimen (plate 2, figure 4) the basal nodes are so strongly developed that the infrabasals are partly hidden. In the mature forms (plate 2, figures 1–3) where ridges and nodes have been developed on the other plates of the dorsal cup, the nodes of the basal plates are less conspicuous. In the old form (plate 2, figure 5) the basal nodes are again more prominent, the nodes on the other plates are much less conspicuous and the radial ridges have almost disappeared.

Horizon and locality. Hamilton (Moscow shale) beds at Canandaigua lake, Bristol, Bellona, Cashong creek near Bellona, N. Y. and in the Hamilton beds at the falls of the Ohio, Louisville, Ky.

Types. Cotypes in the collection of the New York State Museum, where they bear the catalog numbers $\frac{4501}{1}$, $\frac{4501}{2}$.

Rhodocrinus nodulosus var. **pernodosus** nov.

Plate 2, figure 6

This variety occurs in the same beds and in the same locality as the specimens of Rhodocrinus nodulosus shown on plate 2, figures 1, 4, 5. There is only one specimen and it is in a fragmentary condition. However, where some of the plates have been lost their outlines are still visible on the matrix, so that enough can be made out to place the specimen. The arrangement of the plates, etc. is the same as in Rhodocrinus nodulosus. The dorsal cup is more slender than in that species, flaring less in the region of the primibrachs. If the interradii are depressed they are only slightly so. The most striking variation is in the size of the nodes ornamenting all the plates of the cup. They are very strong and almost spinose on the basals and somewhat flattened in the direction of the vertical axis of the cup. The next largest nodes are on the radials and primary interbrachials, and they are very strongly developed on the median line of anal plates.

Horizon and locality. Hamilton (Moscow shale) beds along the west shore of Canandaigua lake.

Types. Holotype in the collection of the New York State Museum.

Genus ACANTHOCRINUS Roemer 1850 (em. Jaekel 1895)

Wachsmuth and Springer (1897, p. 219) regarded this genus as synonymous with Rhodocrinus and it is so listed by Springer in Zittel-Eastman (1913, p. 188). Bather (1900, p. 201) lists the genus Acanthocrinus among the Rhodocrinidae, recognizing the similarity to the American genus Rhodocrinus. Wachsmuth and Springer do not discuss Hall's "Rhodocrinus" spinosus, and list it as "too little known to be recognized." There are five very well preserved specimens, four of them types, in the New York State Museum, and three of them are figured here (plate 2, figures 7–9). This species and the new species onondaga (plate 2, figure 12) with their characteristic spinose ornamentation seem enough distinct from the species of Rhodocrinus to be placed in a separate group; and they are here placed under Acanthocrinus which seems at least to merit subgeneric value.

Acanthocrinus spinosus (Hall) n. comb.

Plate 2, figures 7–11

1862 Rhodocrinus spinosus Hall. 15th Ann. Rep't N. Y. State Cab. Nat. Hist., p. 127

1868 Rhodocrinus spinosus Shumard. Trans. Acad. Sci. St Louis, 2:394

1872 Rhodocrinus spinosus Hall. N. Y. State Mus. Bul. 1, pl. 1, fig. 10. (Photographic plates distributed privately)

1877 Rhodocrinus spinosus S. A. Miller. Amer. Pal. Foss., p. 90

1878 Rhodocrinus spinosus Bigsby. Thesaurus Dev.-Carb., p. 20

1881 Rhodocrinus spinosus Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 212 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:386

1889 Rhodocrinus spinosus S. A. Miller. N. A. Geol. & Pal., p. 278

1897 Rhodocrinus spinosus ("species too little known to be recognized") Wachsmuth & Springer. N. Amer. Crin. Cam., 1:220 (authors' ed.); Mem. Mus. Comp. Zool., v. 20

1903 Rhodocrinus spinosus Clarke & Ruedemann. N. Y. State Mus. Bul. 65, p. 79

1904 Rhodocrinus spinosus Clarke & Luther. N. Y. State Mus. Bul. 63, p. 52

Calyx of medium size, with subrotund dorsal cup and low vault.

Dorsal cup. Five infrabasals are sunk in the deep columnar pit. Basals hexagonal, slightly longer than wide, the lower part of the plates incurving sharply and taking part in the basal excavation. Radials heptagonal, longer than wide, somewhat smaller than the basals. First primibrachs hexagonal, small. Primaxils heptagonal, supporting 2 x 10 secundibrachs. They are a trifle smaller than the first primibrachs. Primary interbrachial hexagonal, supporting three plates in the second, three in the third and three in the fourth range. Posterior interradius not shown, but undoubtedly with more interbrachials. There is one intersecundibrach.

Tegmen composed of numerous small plates.

Arms biserial (joint-lines between the ossicles form a "zigzag") sharply recumbent, 10 in number. They bifurcate once, quite near the calyx, but not again so far as the arms are preserved. The pinnules are slender and of unknown length.

Column stout with thin plates in the proximal portion, becoming thicker distally. The nodes and internodes are hardly differentiated.

Ornamentation consists of the typical Acanthocrinus spines on the basals, radials, and primary interbrachials, rather prominent radial ridges from the radials upward, nodes and low radiating ridges on the higher ranges of interbrachials. The maximum length of the spines observed in the specimens under study was about 1 cm.

Horizon and locality. This species was collected from the Hamilton (Moscow shale) beds, Vincent, N. Y., and at Menteth's point, Canandaigua lake. An internal mold of a Rhodocrinoid which may be doubtfully referred to this species has been found in the Hamilton beds near Cazenovia, N. Y.

Types. Cotypes in the collection of the New York State Museum where they bear the catalog numbers $\frac{4502}{1}$, $\frac{4502}{2}$, $\frac{4502}{3}$, $\frac{4502}{4}$.

Remarks. Acanthocrinus spinosus may be easily distinguished from the European species, A. longispinus Roemer, by its more globose form, its smaller number of interbrachials and its excavate base. It also has but two secundibrachs, whereas all the figures of the European forms show three.

By far the best preserved calyx of this species is the one found at Menteth's point, Canandaigua lake by Mr Ernest Brown of Rochester, N. Y., and loaned to the State Museum for study (plate 2, figure 10). The dorsal cup is beautifully preserved, so that all the plates up to the secundibrachs are well shown. One of the interesting features of this specimen is the attachment at the anal side of a parasitic gastropod, a Platyceras. The gastropod is so attached that the posterior interradius is entirely covered; the other specimens are not well enough preserved to show this interradius.

Acanthocrinus onondaga sp. nov.

Plate 2, figure 12

This species is founded on a single specimen which, although showing the dorsal cup, arms and a portion of the column, is in a quite unsatisfactory state of preservation. The specimen is imbedded in a fine-grained, dense limestone which may be cleared away only with great difficulty. The plates of the dorsal cup are somewhat dissociated, and this portion of the specimen has been exposed and weathered. As a result it is difficult accurately to determine the sequence of plates. Nevertheless, the generic designation of the species is made with considerable assurance, and there should be little difficulty in recognizing it. Before the specimen under consideration was collected, material was found in the Onondaga limestone in the vicinity of Le Roy, N. Y., which strongly suggested the genus Acanthocrinus. The material consisted of numerous isolated plates produced into long spines, which could not be referred to any of the known crinoids of the region. This, together with the thinness of the plates, suggested a dorsal cup of such fragility that it could be preserved only under the most favorable conditions. There are in the New York State Museum a number of specimens of the Onondaga limestone from the vicinity of Lime Rock which show these spines either scattered or several clustered together One slab shows a very badly crushed calyx which undoubtedly belongs to this species but is in too poor a condition either for figuring or descriptive purposes.

The species is a small one, judging from the only complete individual observed, which shows no evidence of immaturity. The crown in all has a height not greatly in excess of 25 mm.

Dorsal cup probably subglobose as in A. spinosus. Infrabasals hidden because of the crushed condition of the specimen. Basals larger than any of the other plates and provided with spines which in their unbroken condition probably measured 5 mm or 6 mm. Spines are not distinguishable on any of the other plates. Radials smaller than the basals, and the primibrachs smaller than the radials. The succession of plates is not accurately determinable on account of the crushed condition, but up to the primaxil it appears to be the same as in A. spinosus. There appear to be more than two secundibrachs.

Tegmen not known.

Arms bifurcate once, quite near the calyx, giving twenty arms, four to each ray, biserial, directed upward and provided with long pinnules.

Column rather stout, plates thin in the proximal portion and becoming thicker distally.

Ornamentation. The only ornamentation that can be distinguished in the single specimen observed is the spinous character of the basal plates.

Horizon and locality. The holotype and other specimens were collected in the Onondaga limestone, Lime Rock, Genesee county, N. Y.

Types. In the collection of the New York State Museum.

Remarks. This species can readily be distinguished from spinosus by its smaller size, the fewer spines on the plates of the dorsal cup, and the upright arms. The species has received its name from the formation from which it was collected.

Genus GILBERTSOCRINUS Phillips 1836

Gilbertsocrinus spinigerus (Hall)

Plate 3, figures 1-6

1862 Trematocrinus spinigerus Hall. 15th Ann. Rep't N. Y. State Cab. Nat. Hist., p. 128

1866 Gonioasteroidocrinus spinigerus Meek & Worthen. Geol. Surv. Ill., 2:222

1872 Gilbertsocrinus (Trematocrinus) spinigerus Hall. N. Y. State Mus. Bul. 1, pl. 1 *a*, fig. 9. (Photographic plates distributed privately)

1877 Gonioasteroidocrinus spinigerus S. A. Miller. Amer. Pal. Foss., p. 80

1878 Gilbertsocrinus spinigerus Bigsby. Thesaurus Dev.-Carb., p. 17

1881 Ollacrinus spinigerus Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 219 (authors' ed.); Proc. Acad. Nat. Sci. St Louis, 33:393

1889 Ollacrinus spinigerus Whiteaves. Contr. Can. Pal., v. 1, pt. 2, p. 103, pl. 13, figs. 4, 4 *a*, 4 *b*

1889 Gonioasteroidocrinus spinigerus S. A. Miller. N. Amer. Geol. & Pal., p. 250

1891 Gilbertsocrinus spinigerus Whitfield. Ann. N. Y. Acad. Sci., 5:553, pl. 11, fig. 12

1895 Gilbertsocrinus indianensis Miller & Gurley. Bul. Ill. State Mus., no. 6, p. 38, pl. 3, figs. 16-22

1897 Gilbertsocrinus spinigerus Wachsmuth & Springer. N. Amer. Crin. Cam., 1:247, pl. 15, figs. 3 *a*, *b*, *c* (authors' ed.); Mem. Mus. Comp. Zool., v. 20

1898 Gilbertsocrinus spinigerus Whiteaves. Contr. Can. Pal., v. 1, pt. 5, pp. 368, 369

1900 Gilbertsocrinus spinigerus Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 3, p. 196

1901 Gilbertsocrinus spinigerus Shimer & Grabau. Bul. Geol. Soc. Amer., 13:184

1903 Gilbertsocrinus spinigerus Clarke & Ruedemann. N. Y. State Mus. Bul. 65, p. 71

1904 Gilbertsocrinus spinigerus Clarke & Luther. N. Y. State Mus. Bul. 63, p. 52

1910 Gilbertsocrinus spinigerus Grabau & Shimer. N. Amer. Index Foss., 2:551

Dorsal cup small; widest at the radials, somewhat constricted at the arm bases and expanding at the upper margin. Cup pentagonal in cross-section, with the angles interradial.

Infrabasals small, hidden within the deep basal pit. Basals comparatively large, hexagonal, forming the sides of the basal pit, and scarcely visible in a side view. Radials heptagonal, slightly larger than the basals and deeply wedged between them. They are of about the same height and width. First primibrachs hexagonal, considerably larger than the primaxils. They are as high, but narrower than the radials. Primaxils heptagonal.

Secundibrachs 2 x 10. The second is axillary, supporting on its inner side an arm and on the outer an interradial appendage. Primary interbrachial somewhat smaller than the radials, hexagonal, resting between the radials upon the truncated basals. It is followed by the series 3, 3, 3, 2, 2 or 3, 3, 3, 3, 2 or 3, 3, 4, 2, 2. The anal interradius gives in one specimen the series 3, 3, 3, 3, 3. It shows a distinct median line of plates decreasing in size upwards and separating the interradial appendages.

Intersecundibrachs three or more, usually one in the first row and two in the second.

Tegmen low, made up of numerous small plates of rather irregular arrangement, nodose in the ambulacral areas and oral region. Interambulacral areas depressed. Anus excentric, opening out directly through the tegmen.

The interradial tubular appendages are composed of a single series of longitudinal, cylindrical joints, perforated by an almost oval canal. The adjacent appendages from the two rays are united up to the sixth plate and then diverge, not recurving, however, as in the later forms. The tubular appendages on the anal side are not confluent, but are simple and separated by the anal plates.

Arms ten, short, uniserial, erect, fairly stout, bifurcating once on the fifth secundibrach. The brachials incline to wedge-form.

Column round, of medium size, nearly filling the basal pit.

Ornamentation. This species is ornamented with prominent spines on the radials, first primibrachs and primary interbrachials. A prominent ridge extends up the radial series, bifurcating on the primaxil. The ornamentation of the tegmen consists in the small nodes on the plates of the ambulacral areas and the oral region.

Horizon and locality. From the Hamilton (Moscow shale) beds, Vincent, Ontario county, N. Y.; Hamilton of Thedford, Ontario, and Clark county, Indiana.

Types. Cotypes in the New York State Museum where they bear the catalog numbers $\frac{4240}{1}$ and $\frac{4240}{2}$.

Remarks. Two species from the Hamilton of Clark county, Indiana, described by Miller & Gurley (1895, pp. 35, 40), G. greenei and G. indianensis, are very similar to G. spinigerus. The former differs from spinigerus in not possessing a spine on the first primibrach, otherwise there is no essential difference. G. spinigerus was figured by Hall (1872, pl. 1 *a*, figure 9) without spines on the primary interbrachial. This specimen, figured on plate 3, figure 1, is crushed in the interradial areas, the spines were broken off and the bases were smoothed down in the cleaning. The second specimen constituting one of Hall's types, number $\frac{4240}{1}$ in the catalog, was not figured. It is figured here (plate 3, figure 2) and shows the spines on the primary interbrachials. This absence of spines on the primary interbrachials was one of the important distinctions between G. spinigerus and G. indianensis. The tegmen of indianensis is described as composed of much more numerous plates. The tegmen was figured from a smaller specimen, possibly a younger specimen of the species. There do not seem to be any essential differences between the two species, and indianensis then becomes a synonym of spinigerus. Specimens from Clark county, Indiana, in the collection of Doctor Springer, are figured here (plate 3, figures 3–6).

Genus SPHAEROTOCRINUS nov.

[Ety. σφαιρωτός, *button;* κρινον, *lily*]

This new genus was created to contain Sphaerotocrinus ornatus sp. nov. The genus which it most resembles is the Silurian genus Lyriocrinus. The calyx is more globose, not flattened at the base, with a strongly arched tegmen. One secundibrach is incorporated in the calyx. The interbrachial areas are wider at the arms showing the series 1, 2, 3. The anal area is distinct, the primary brachial being followed by a median line of hexagonal anal plates with a row of smaller irregular plates on each side. The arm openings are placed at the upper margin of the dorsal cup. The arms are ten in number, of small diameter and abruptly separated from the calyx. The anus is at the end of a tube and central. For further details see the description of the genotype.

Genotype. Sphaerotocrinus ornatus.

Distribution. Lower Devonian (Lower Helderberg, Lewistown limestone) of Pennsylvania.

Sphaerotocrinus ornatus sp. nov.

Plate 3, figures 7, 8; text figure 35

This species is based upon two specimens. The smaller is entirely free from the matrix, and has been used for illustration. The larger specimen is so buried in the matrix and weathered that only the plates of the tegmen can be distinguished. The calyx is subglobose, having in the smaller specimen a height of 9 mm and a width of 8.5 mm; in the larger specimen, a height of 11.7 mm and a width of about 11.4 mm.

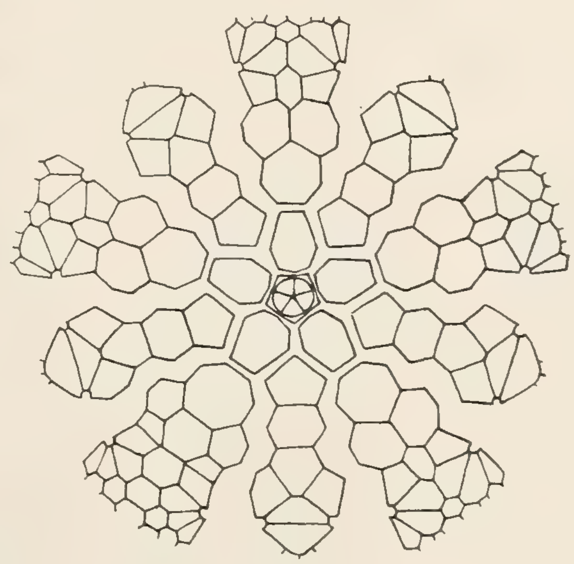


Figure 35 Analysis of the calyx of Sphaerotocrinus ornatus, the genotype.

Dorsal cup decidedly bowl shaped, almost hemispheric, with a height of 6.7 mm and a width of 8.5 mm. Infrabasals very small, scarcely visible, being concealed in the small basal depression into which the column fits. Basals hexagonal, being truncated above for the reception of the primary interbrachials, the two lower lateral faces being about two-thirds the length of the upper lateral faces. The greatest width is at the lateral angles and about equal to the height, and it comes low in the basal. The most proximal parts of the basals are included in the small, shallow depression into which the column fits. Radials pentagonal, wider than high, fitting low into the basal cup because of the deep notch formed by the upper lateral faces of the basals.

Primibrachs two, the first hexagonal, as large as the radials; the second, the primaxils, higher than the first primibrachs, but not quite so wide. The two upper lateral faces are long and slightly concave. Above the primaxil is truncated, making it hexagonal in shape and giving a very short face upon which the intersecundibrach rests.

Secundibrachs two, one to each half ray. They are large and pentagonal, the face supporting the arm being very small and entirely occupied by the curved arm facet.

Primary interbrachial large, heptagonal, slightly wider than high, followed in the second row, in the regular interradii, by two large heptagonal plates, and in the third row by three smaller plates, more than twice as long as wide. These last unite by means of two wedge-shaped plates with the smaller plates of the tegmen. Each of these wedge-shaped plates has its greatest width near the median line of the interbrachial area, where they are united, and tapers rapidly toward the base of the arms where the width is extremely small.

In the anal interradius there is an extra hexagonal anal plate in the middle of the second row which is followed by a median line of hexagonal plates gradually decreasing in size up to the base of the anal tube. This median line of large anal plates is bordered on each side in the cup by a single row of rather irregular, small plates.

There is one large intersecundibrach. It is triangular with the longest side or base of the triangle on a line with the two arm openings in each ray. This triangular plate is slightly truncated at the apex giving an additional very short face which rests upon the short face of the primaxil. This plate meets above a plate of the same size, and, roughly, of the same shape, which connects with the small plates of the tegmen.

Tegmen arched and with a height of about 2.3 mm, which is very nearly one third the height of the dorsal cup. It is composed, for the most part, of numerous small plates. The wedge-shaped plates connecting the regular interradial areas with the tegminal plates and the roughly triangular plate resting upon the intersecundibrach have already been mentioned. Between these in the tegmen are two smaller wedge-shaped plates tapering toward the arm bases. These wedge- and triangular-shaped plates of the tegmen, together with the secundibrachs, intersecundibrachs, and the outer plates of the third row of interbrachials, form around each arm opening a circlet of triangular and wedge-shaped plates with the longer axis directed toward the arm opening. This holds true of the arm opening each side of the anal interradius, though the series of anal plates causes a slight modification.

The tegmen is provided with an anal tube which is central. The median line of hexagonal anal plates, as mentioned above, extends to the base of the anal tube.

Arms. There are ten arm openings, two to a ray. They are very small, so that the arms must have been very slender. The arms themselves are missing in both specimens.

Column missing, but judging by the cicatrix round, fitting into the shallow basal depression. The axial canal is small and round.

Ornamentation. This species is very beautifully ornamented. From the median point of the widest part of each basal a prominent slightly curving ridge extends to the same point on the basal at each side. This forms a pentagonal figure bounding the basal depression. The angle in each basal is marked by a thickening which forms a slight node. From this point in each basal a ridge extends to the center of the radial on each side, forming thus five triangles resting upon the five sides of the basal pentagon. Within each of these triangles is a smaller, rather fragmentary triangle with its sides parallel to those of the larger one. An intermittent ridge extends from the center of the radial up each radial series. Sometimes two or three more or less intermittent longitudinal ridges are shown; but in general plates of the radial series and the interbrachials, especially those of the first two rows, show a number of ridges radiately arranged and crossing the suture lines. Those extending from center of plate to center of plate are slightly more prominent. Sometimes at the center of the plate where the ridges come together there is a small node; again there appears to be no node, but a little to one side of the place where the ridges meet there is a slight pit or depression, not due apparently to the breaking off of one of these nodes.

The plates of the tegmen are not so prominently ornamented. They show, sometimes indistinctly, radiately arranged ridges, rather heavy for the small size of the plates. The ridges are sometimes intermittent.

Horizon and locality. This species was collected from the Lewistown limestone (Lower Helderberg), from the quarry on the summit of the ridge west of the road at Frankstown, Pa.

Types. Genoholotype in the collection of the New York State Museum.

Genus THYLACOCRINUS Oehlert 1878

Thylacocrinus gracilis (Hall) n. comb.

Plate 4, figure 5

1862 Rhodocrinus (Acanthocrinus) gracilis Hall. 15th Ann. Rep't N. Y. State Cab. Nat. Hist., p. 127

1868 Rhodocrinus gracilis Shumard. Trans. Acad. Sci. St Louis, 2:394

1872 Rhodocrinus (Acanthocrinus) gracilis Hall. N. Y. State Mus. Bul. 1, pl. 1, fig. 7. (Photographic plates distributed privately)

1877 Rhodocrinus gracilis S. A. Miller. Amer. Pal. Foss., p. 90

1881 Rhodocrinus gracilis Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 212 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:386

1889 Rhodocrinus gracilis S. A. Miller. N. Amer. Geol. & Pal., p. 277

1903 Rhodocrinus (Acanthocrinus) gracilis Clarke & Ruedemann. N. Y. State Mus. Bul. 65, p. 78

1904 Rhodocrinus gracilis Clarke & Luther. N. Y. State Mus. Bul. 63, p. 52

The description of this species is based upon the type of Hall's Rhodocrinus (Acanthocrinus) gracilis. Although somewhat flattened and imperfectly preserved, the specimen permits of a fairly satisfactory description.

Dorsal cup turbinate with the radial series prominent.

Infrabasals concealed by the proximal columnal which has remained attached to the cup. Basals much crushed and pushed out of place. They are large and heptagonal, and appear to be as large as, if not larger than, the radials. They support the primary interbrachials upon their truncated upper faces and the radials rest between them. The basals are overlapped by the proximal columnal. Radials heptagonal, and, so far as can be ascertained in the crushed condition of the dorsal cup, they are of the same height but slightly narrower than the basals. Primibrachs a little smaller than the radials. The first primibrachs are hexagonal, the primaxils heptagonal or hexagonal. The primaxil is broader than the first primibrach but of about the same height. Secundibrachs two, slightly smaller than the primaxil. The second bifurcation normally gives rise to four arms which are free to a certain extent above the first bifurcation and entirely so above the second.

Primary interbrachial supported by the basal and followed by a series of interbrachials the exact number and arrangement of which are not determinable in the specimen. One interradius seems to have the series 1, 2, 3, 3, 3, etc., another 1, 2, 3, 4, 4, etc.; but this can not be positively stated. Interaxillary plates small and undeterminable. In one ray the intersecundibrachs seem to be in a vertical row.

Tegmen not preserved.

Arms normally four to the ray, so far as the preservation of the specimen has permitted observation. One ray shows an unusual variation.

In this, one of the main forks bifurcates once, the other bifurcates twice, giving five branches. As noted above, the arms are free above the second bifurcation. They are composed of wedge-shaped ossicles, though there is a tendency toward biseriality near the tips. The pinnules apparently were removed in the working out of the specimen. They are shown only in one place, and appear to be fairly long for the size of the specimen.

Column. Only the proximal columnal is preserved. It adheres to the cup, concealing the infrabasals and lapping up on the basals. This, however, shows that the column was stellate in section with deeply reentrant angles. The articulating face of the columnal, though much weathered, is marked with petaloid ridges.

Ornamentation. Hall describes the interradial plates as subnodose or tuberculose, but the specimen does not show this characteristic. There are conspicuous pittings at the angles of the plates which weathering has made more pronounced, giving the centers of the plates an elevated appearance. This is only shown well in one interradius.

Horizon and locality. The single specimen came from the Hamilton (lower Moscow) shales, North Bristol, Ontario county, N. Y.

Types. Holotype in the New York State Museum.

Remarks. In his original description Hall speaks of "second radials two or three below the first bifurcation of the arms." The type shows but two secundibrachs.

There seems to be no doubt as to the generic designation of this species, though the specimen is, I believe, an immature individual. In the Hamilton beds of neighboring localities there occurs another species of this genus, Thylacocrinus clarkei. There are three specimens of this species in our possession, all of which are well-developed adult forms. It is quite possible that gracilis may be found to be an immature form of clarkei. While there are notable differences between the immature and adult forms, particularly as regards the incorporation of the proximal brachials and the biseriality of the arms, the study of immature forms of other species where more of an ontogenetic series has been available, has led to the belief that just such differences are to be expected. There is such a great discrepancy of growth between the two species, however, that it has seemed wiser to keep the species distinct for the present. We have recently acquired new material of clarkei, and it is possible that intermediate forms may yet be found. Should gracilis and clarkei prove to be the same species, the name clarkei should, I think, properly stand for the species as it was based upon adult characters. Likewise, the description of the immature form was unaccompanied by a figure; and a very inadequate figure of the specimen was published in a set of photographic plates distributed privately.

Thylacocrinus clarkei W. & Sp.

Plate 4, figure 1–4

1897 Thylacocrinus clarkei Wachsmuth & Springer. N. Amer. Crin. Cam., 1:248, pl. 13, figs. 11 *a*, *b* (authors' ed.); Mem. Mus. Comp. Zool., v. 20

1903 Thylacocrinus clarkei Clarke & Ruedemann. N. Y. State Mus. Bul. 65, p. 80

1904 Thylacocrinus clarkei Clarke & Luther. N. Y. State Mus. Bul. 63, p. 52

The description of this species is based upon three specimens, one of which (plate 4, figure 2) was used by Wachsmuth and Springer as the type of the species. The second specimen was recently collected by Doctor Clarke at Bethany, N. Y. It is the largest specimen found, being larger than the specimen figured by Wachsmuth and Springer. The third, and by far the finest, specimen (plate 4, figure 1) was found in the New York State Museum where it had been for years. The specimen used by Wachsmuth and Springer is a badly crushed and imperfect adult individual which, though clearly indicating its generic affinities, is in too poor a state of preservation to afford much knowledge of the species. The Bethany specimen is likewise crushed and imperfect. The most perfect specimen, which is somewhat smaller than the one figured by Wachsmuth and Springer, lies upon the rock with the arms outspread in all directions. The base of the dorsal cup is somewhat crushed, but all the essential characters may be observed without difficulty.

Dorsal cup subglobose and apparently somewhat constricted at the base of the arms. Owing to the thinness of the plates, their number and the looseness of the sutural union between them, the theca has a lack of solidity unusual among the Camerata.

Infrabasals small, and as they do not extend beyond the column they have not been observed. Basals large and heptagonal. Between them rest the radials, while upon their truncated upper faces they support the primary interbrachials. The basals are overlapped for a considerable distance by the proximal columnal. Radials heptagonal. They have a height approximately the same as the basals and are somewhat narrower. First primibrachs hexagonal and of approximately the same width as the radials. Primaxils heptagonal or hexagonal. The plate is slightly wider than high and has a height practically the same as the first primibrach.

Secundibrachs two in number and slightly smaller than the primaxil. In the specimen figured on plate 4, figure 1, there are two rays each of which has a series of secundibrachs in which there is but one plate and that an axillary. The second bifurcation gives rise to four arms which are incorporated to a variable extent in the dorsal cup. The tertibrachs are incorporated to the number of from three to six.

Primary interbrachial supported by and somewhat smaller than the basal. It is followed by a series of interbrachials having the following number in successive ranges: 2 or 3, 4, 5, 5, 3, 2, 2, or 1, 1; or 2, 3, 4, 4, 3, 3, 2, 2, 2, 2, 2, etc. In one interradius there are four plates in the second range instead of the two or three noted above. It may be that in this case we have to deal with the posterior interradius. Higher ranges of brachials are incorporated into the dorsal cup, not only by the regular interbrachial series, but also by intersecundibrachs and intertertibrachs as well. The interaxillaries (intersecundibrachs and intertertibrachs) between each half ray have the following number of plates in the successive ranges: 1, 1, 2, 2. In another individual, the type of clarkei, there is the following sequence: 1, 2, 2, 1, . . . ; or 1, 2, 2, 2, . . . The intertertibrachs between the arms of each half ray consist of a vertical row of plates, three or four in number so far as observed in one of the specimens.

Tegmen. The structure of the tegmen is unknown. In the specimen figured on plate 4, figure 1, which was favorably disposed to preserve the tegmen, the theca was removed from the rock. Careful cleaning failed to show any trace of the tegminal plates. It seems probable therefore that the tegmen is made up of very fragile plates.

Arms biserial, long and stout with an almost cylindrical cross-section. They taper rather rapidly distad. In a specimen of average size the maximum length observed is 55 mm. The pinnules are long and slender. The free arms do not bifurcate.

Column. The proximal columnal in all the specimens remains adhering to the cup where it entirely conceals the infrabasals and laps over on the basals. The column is stellate in section with deeply reentrant angles. The fragments of stem shown on the rock (plate 4, figure 1), may pertain to this species and probably to the individual with which it is associated. In this specimen at the angles of the column the ossicles are produced into tubercles. These are much more prominent in certain cases than in others, probably indicating a division of the ossicles into nodes and internodes. Fragments of the column found scattered in the shale at the horizon in which this species occurs have a pentagonal cross-section, as figured on plate 4, figure 4. These columnals evidently represent more distal portions of the stem of this species. The filling out of the reentrant angles is a character to be observed in other genera as, for example, in the case of the recent genus Isocrinus. The articulating faces of the columnals are marked by petaloid ridges.

Ornamentation. The surface of the plates making up the dorsal cup seems to have been covered by a coarse vermicular marking in low relief. Only traces of this ornamentation may be seen on an occasional plate, the plates as a rule appearing quite smooth. Two of the specimens show conspicuous pittings at the angles of the plates, giving the effect of incipient ridges (plate 4, figures 2, 3). This is particularly well shown in the Bethany specimen.

Horizon and locality. Hamilton (lower Moscow) shales. The three specimens figured all come from different localities. The holotype was found on the shore of Canandaigua lake, near Canandaigua, N. Y.; the most perfect specimen came from Vincent, N. Y.; and the third was recently collected by Doctor Clarke at Bethany, N. Y. A fourth specimen, from Menteth's glen, Canandaigua lake, has recently come to our notice.

Types. Holotype and the other figured specimens as well are in the New York State Museum. The fourth specimen is in the collection of Mr Ernest Brown, Rochester, N. Y.

Remarks. See *Remarks* under Thylacocrinus gracilis.

Family MELOCRINIDAE Zittel (em. Wachsmuth & Springer)

Section **MELOCRINITES** Wachsmuth & Springer

In the classification of the Crinoidea used by Wachsmuth and Springer (1897) the family Melocrinidae was divided into two sections: (1) Melocrinites, including those forms in which the symmetry of the dorsal cup is disturbed by one or more anal plates; (2) Dolatocrinites, including those forms in which the symmetry of the dorsal cup is undisturbed by anal plates. In the classification used by Springer in the 1913 edition of Zittel-Eastman no subdivisions of the family were used.[1] I have used the two divisions of Wachsmuth and Springer here. The section Melocrinites includes, among the forms treated here, Mariacrinus, Melocrinus and Melocrinus (Trichotocrinus); the other genera of this family treated here — Clonocrinus, Dolatocrinus, Clarkeocrinus, Craterocrinus, Comanthocrinus and Himerocrinus — belong in the section Dolatocrinites.

[1] Since the completion of this monograph a paper on "The Fossil Genus Dolatocrinus and its Allies" has appeared (1921) in which Springer retains the section Dolatocrinites.

Genus MARIACRINUS Hall 1859 (restr. W. & Sp. 1881, 1897)

Mariacrinus plumosus Hall

Plate 5, figures 1, 2

1859 Mariacrinus plumosus Hall. Pal. N. Y., 3:110, pl. 3, figs. 6–11

1868 Mariacrinus plumosus Shumard. Trans. Acad. Sci. St Louis, 2:380

1877 Mariacrinus plumosus S. A. Miller. Amer. Pal. Foss., p. 83

1881 Mariacrinus plumosus Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 116 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:290

1889 Mariacrinus plumosus S. A. Miller. N. Amer. Geol. & Pal., p. 260

1897 Mariacrinus plumosus Wachsmuth & Springer. N. Amer. Crin. Cam., 1:284, pl. 23, figs. 6, 7 (authors' ed.); Mem. Mus. Comp. Zool., v. 20

1900 Mariacrinus plumosus Schuchert. Bul. Geol. Soc. Amer., 11:279

1903 Mariacrinus plumosus Clarke & Ruedemann. N. Y. State Mus. Bul. 65, p. 73

Dorsal cup small, obconic or turbinate. Basals four, three pentagonal, one hexagonal, about as long as wide. Radials of about the same length and width, or a little longer than wide. Four are heptagonal, the fifth, the one above the hexagonal basal is hexagonal. First primibrachs smaller than the radials; hexagonal, so far as observed, and of about equal length and width. Primaxils smaller than the first primibrachs, of about equal length and width and heptagonal, so far as observed. Secundibrachs 3 x 10, smaller than the primibrachs and gradually decreasing in size upward.

Primary interbrachial hexagonal, probably heptagonal in the anal interradius. It is followed by two plates in the second row, three in the third and two in the fourth. Only a portion of the anal area is visible, and the succession of plates can not be ascertained. The second row probably has three plates. The interradii are widest at the primaxil and then narrow.

Intersecundibrachs few. When there are two they are arranged one above the other in a vertical row; when there are more, there is one in the first row and two in the second. No plates are visible above this.

Tegmen not visible. The proximal portion of the anal tube is visible in one specimen (plate 5, figure 1) and is seen to be composed of small, irregular plates.

Arms. Each secundaxil gives rise to two arms, making four arms to a ray. The arms are simple, rather long, composed of short subcuneiform brachials which bear pinnules alternately on each side of the arm. The pinnules appear to be borne from the second brachial upward. Syzygies are mentioned by Hall (1859, p. 110) and Wachsmuth and Springer (1897, p. 284), but they have not been observed in the material at hand.

Column comparatively large, round, and consisting in the proximal part, which is all that is preserved, of nearly equal columnals.

Ornamentation. The plates of the dorsal cup carry strong, radiating ridges, proceeding from the center of the plates to adjoining ones, crossing the suture lines. These are not well shown on weathered specimens (plate 5, figure 2). The rays from the primaxil up are marked by strong ridges which pass into the arms.

Horizon and locality. Coeymans limestone, associated with Melocrinus paucidactylus, at Wheelock's hill, Litchfield, Herkimer county, and at Schoharie, N. Y.

Type. One of the cotypes (plate 5, figure 1) is in the New York State Museum where it bears the catalog number $\frac{4301}{1}$. The second and poorer cotype has not been located.

Remarks. One of the very young stages of Melocrinus paucidactylus (plate 9, figure 3) bears a resemblance to M. plumosus. It apparently shows in the adult stage, as does M. ramosus, the characters which M. paucidactylus shows in some of its earlier stages. The three secundibrachs of M. plumosus will readily distinguish it.

Mariacrinus ramosus Hall

Plate 5, figures 3, 4

1859 Mariacrinus ramosus Hall. Pal. N. Y., 3:147, pl. 2, fig. 6
1868 Mariacrinus ramosus Shumard. Trans. Acad. Sci. St Louis, 2:380
1877 Mariacrinus ramosus S. A. Miller. Amer. Pal. Foss., p. 83
1881 Mariacrinus ramosus Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 116 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:290
1889 Mariacrinus ramosus S. A. Miller. N. Amer. Geol. & Pal., p. 260
1897 Mariacrinus ramosus Wachsmuth & Springer. N. Amer. Crin. Cam., 1:284 (authors' ed.); Mem. Mus. Comp. Zool., v. 20
1900 Mariacrinus ramosus Schuchert. Bul. Geol. Soc. Amer., 11:279
1903 Mariacrinus ramosus Clarke & Ruedemann. N. Y. State Mus. Bul. 65, p. 73

Dorsal cup urn-shaped. Basal plates small; three pentagonal, the fourth or anterior one, hexagonal. Radials as wide or wider than long, heptagonal, except the anterior one which rests upon the hexagonal basal. First primibrachs smaller than the radials, a little wider than long. Primaxils, the second primibrachs, smaller than the first primibrachs and somewhat wider than long. Secundibrachs 3 x 10, all smaller than the primaxil and gradually decreasing in size upward. Third secundibrach axillary.

Only the anal interradius is well shown. In this interradius there are three plates in the second row, three in the third, four in the fourth and four in the fifth. This would make the primary interbrachial here heptagonal. In the regular interradii they are probably hexagonal, as in similar forms, and followed by two plates in the second row. The intersecundibrachs appear to be three in number in those rays in which they are exposed. They are arranged in a single vertical row.

Tegmen. Only the proximal part of the proboscis-like anal tube is visible. It is made up of hexagonal plates which appear to be arranged in vertical rows.

Arms. Each secundaxil gives rise to two arms, making twenty arms to the calyx. The outer arm of each half ray remains simple; the inner arm bifurcates at least three times at irregular intervals. The bifurcations of the two inner arms of each ray are at the same height. In one specimen (plate 5, figure 3) the right antero-lateral ray appears to have both the inner and outer arms simple, as in Mariacrinus plumosus. The proximal brachials are quadrangular, becoming decidedly wedge-shaped above. In the branches of the inner arms, often the first few proximal brachials are quadrangular followed by the wedge-shaped plates. Pinnules are borne by the brachials alternately on each side of the arms.

Column in the proximal part comparatively large and round and made up of columnals of approximately the same length.

Ornamentation. The rays above the primaxils are marked with strong ridges which pass into the arms. Below the primaxils they are faint and low.

Horizon and locality. Coeymans limestone, Wheelock's hill, Litchfield, Herkimer county, N. Y.

Types. Holotype in the New York State Museum.

Remarks. As pointed out by Hall, this species represents a type of arm structure intermediate between Mariacrinus plumosus and the species of Melocrinus. In each ray the outer arm of the two pairs corresponds to the axillary arms of M. nobilissimus, M. pachydactylus and M. paucidactylus. The two inner arms of each ray correspond to the tubular appendage.

M. ramosus is very much like some of the ontogenetic stages of M. paucidactylus. The stages which M. ramosus resembles represent younger forms, and it seems quite possible that M. paucidactylus passes through in its youthful stages the form which M. ramosus has attained in the adult stage.

M. ramosus differs from M. paucidactylus in having three secundibrachs.

Mariacrinus stoloniferus Hall

Plate 59, figures 1-5

1859 Mariacrinus stoloniferus Hall. Pal. N. Y., 3:112, pl. 3 A, fig. 2; pl. 3 B, figs. 3-7.

1868 Mariacrinus stoloniferus Shumard. Trans. Acad. Nat. Sci. St Louis, 2:380

1877 Mariacrinus stoloniferus S. A. Miller. Amer. Pal. Foss., p. 83

1889 Mariacrinus stoloniferus S. A. Miller. N. Amer. Geol. & Pal., p. 260

1897 Mariacrinus stoloniferus Wachsmuth & Springer. N. Amer. Crin. Cam., 1:282 (authors' ed.); Mem. Mus. Comp. Zool., v. 20

1899 Mariacrinus stoloniferus Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 2, p. 94

1900 Mariacrinus stoloniferus Schuchert. Bul. Geol. Soc. Amer., 11:279

1903 Mariacrinus stoloniferus Clarke & Ruedemann. N. Y. State Mus. Bul. 65, p. 73

Only the columns of this species are known, and because of the general similarity of the columns to others of the genus Mariacrinus Hall referred them here. The species is readily recognizable because of the great uniformity in the columns together with the characteristic appendages.

The column is round, with a large round axial canal which is often excentric, composed of columnals which are thin, nearly equal, with finely striated articulating surfaces. The columns are provided with numerous lateral branches or radical cirri, which in both large and small individuals seem to be given off principally from one side. The mode of occurrence of the columns suggests that they were in a recumbent position, growing irregularly over the surface and conforming to its irregularities. Where the columns are curved the cirri are given off chiefly from the inner side of the curve.

Horizon and locality. New Scotland beds, Clarksville and Schoharie, N. Y.

Types. Cotypes in the American Museum of Natural History numbers $\frac{2298}{1}$, $\frac{2298}{2}$, $\frac{2298}{3}$, and in the New York State Museum, number $\frac{4303}{1}$.

Mariacrinus beecheri Talbot

Plate 5, figure 5; text figure 36

1905 Mariacrinus beecheri Talbot. Amer. Jour. Sci., 20:25, pl. 1, fig. 3

Original description. In rediagnosing 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.

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.

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 (*primibrachs*) two, the first hexagonal, more than half as large as the radials, and the second smaller, pentagonal, and supporting two rows of distichals (*secundibrachs*), three in each row. The last distichal supports two rows of palmars (*tertibrachs*), 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 figure 36). 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.

Figure 36 Mariacrinus beecheri. Anal sac, x $4\frac{1}{2}$. *a, b, c,* are the last of the anal series of plates in the cup. (After Talbot, 1905).

Remarks. There is no specimen of this species in the New York Museum. The illustrations shown here (plate 5, figure 5) are based upon Talbot's types in the Yale University Museum. The resemblance between this species and Melocrinus nobilissimus is very close, and it is possible that it may prove to be a young stage of the latter. The narrower form, the longer ossicles of the main appendages and the incomplete union of the two halves of the main arms into a tubular appendage are all characters to be looked for in younger forms, as seen in the ontogenetic series of M. paucidactylus.

Genus MELOCRINUS Goldfuss 1826 (W. & Sp. 1897)

This genus is described by Wachsmuth and Springer (1897), Bather (1900) and Springer (1913) as having biserial arms. Talbot (1905, p. 27) in a description of some specimens of Melocrinus in the Yale University Museum notes the occurrence of uniserial arms. The specimens there described belong to Hall's species, Melocrinus paucidactylus. Uniserial arms have been found to occur also in

Melocrinus bainbridgensis and clarkei and in the new species, sp. nov., splendens and willetensis *var.* perstriatus. Biserial arms are found in Melocrinus nobilissimus and pachydactylus.

Whether the genus Melocrinus should be made to include species some with uniserial and some with biserial arms or whether this character is to be regarded as a ground for subdividing the genus is a matter for consideration. The genus Ctenocrinus Bronn (1840, p. 542) is regarded by Wachsmuth and Springer (1897) as a synonym of Melocrinus, but is upheld by Jaekel (1895). The characters upon which the genus was based, as pointed out by Wachsmuth and Springer, were not sufficient for generic separation. However, the type of the genus, Melocrinus (Ctenocrinus) typus, figured here on plate 12, figure 1, from a squeeze of the type in the collection of Doctor Springer, shows uniserial arms. This character is also shown by a number of European species. Should a division or subgenus of Melocrinus be founded upon this character it would seem proper that the name Ctenocrinus should be used for the uniserial group.

Such separation has not been made here, for it would only create difficulties. The species vary as to shape and the presence of interaxillaries, and, if the arms are not preserved, they could not be placed in their proper divisions. Thus, while Melocrinus bainbridgensis and clarkei have uniserial arms, none have been found for M. breviradiatus which is closely allied and would seem to belong in the same division. Melocrinus willetensis *var.* perstriatus has uniserial arms; none have been found for M. willetensis. The subgenus Trichotocrinus was founded by Olsson (1912) upon a species showing trichotomous branching of the main trunk or arm. His species, harrisi, has biserial arms; a new species, lutheri, is here described with uniserial arms. If Melocrinus were subdivided upon the character of the arms this subgenus should be subdivided upon the same ground, which would only make more complication; or the subgenus could be raised to generic rank, which I do not think our present knowledge of the subgenus warrants.

The majority of the species of Melocrinus in which arms have been found have uniserial arms; and these species, with the exception of Melocrinus paucidactylus occur in the higher beds of the Devonian.

Melocrinus nobilissimus (Hall)

Plates 6 and 7

1859 Mariacrinus nobilissimus Hall. Pal. N. Y., 3:105, pl. 2, figs. 1–4; pl. 2 A, fig. 1

1868 Mariacrinus nobilissimus Shumard. Trans. Acad. Sci. St Louis, 2:380

1877 Mariacrinus nobilissimus S. A. Miller. Amer. Pal. Foss., p. 83

1881 Melocrinus nobilissimus Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 122 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:296

1889 Mariacrinus nobilissimus S. A. Miller. N. Amer. Geol. & Pal., p. 260

1897 Melocrinus nobilissimus Wachsmuth & Springer. N. Amer. Crin. Cam., 1:295, pl. 22, figs. 1, 2, 3 (authors' ed.); Mem. Mus. Comp. Zool., v. 20

1900 Melocrinus nobilissimus Bather. Lankester's Treatise on Zoology, pt. 3, The Echinoderma, p. 161, text fig. 74

1900 Melocrinus nobilissimus Schuchert. Bul. Geol. Soc. Amer., 11:279

1900 Melocrinus nobilissimus Whitfield & Hovey. Amer. Mus. Nat. Hist. Bul. 11, pt. 2, p. 94.

1903 Melocrinus (Mariacrinus) nobilissimus Foeste. Jour. Geol., 11:712

1905 Melocrinus nobilissimus Talbot. Amer. Jour. Sci., 20:26, pl. 2

1910 Melocrinus nobilissimus Grabau & Shimer. N. Amer. Index Foss., 2:556

This is a rather large and very beautiful species of Melocrinus.

Dorsal cup obconical, higher than wide. In the upper part of each interradial area, except the anal, just above the primibrachs, is a depression which gives it an obtusely pentangular appearance.

Basals four in number; one, the anterior, hexagonal, three pentagonal. They are wider than long and form a small, subcylindrical cup projecting slightly beyond the column. Radials larger than the succeeding primibrachs; of about the same height and width, heptagonal except the anterior one which is hexagonal. First primibrachs smaller than the radials, sometimes longer than wide; hexagonal or heptagonal according to the number of interradial plates with which they come in contact. Primaxils of about the same width and length; heptagonal or sometimes octagonal and giving rise to 3 x 10 secundibrachs.

Secundibrachs about half the size of the primibrachs. The third, the secundaxil, supports on the outer sloping face the lateral or auxiliary arm, the first four or five proximal plates of which are longer and incorporated in the dorsal cup; the inner sloping face supports a series of six, seven or eight tertibrachs which give rise to one-half the tubular appendage. The plates of adjoining divisions are united laterally from the first tertibrach.

Regular interradii long and narrow. Primary interbrachial usually hexagonal, larger than the others, and resting within a deep notch between the two radials. Succeeding interbrachials arranged in two longitudinal rows; generally hexagonal, alternating with one another so that no horizontal rows are formed. The plates decrease in size upward.

Anal interradius flattened instead of being depressed as in the regular interradii, and considerably wider. Primary interbrachial heptagonal, larger than those in the regular interradii, and followed by three plates in the second row and three or four in the succeeding rows.

Intersecundibrachs rather large, three or four in number and arranged longitudinally. Between the auxiliary arm and the tubular appendage of each ray are interposed several intertertibrachs, three or four in a single vertical row or in several rows.

Tegmen not shown in the type. One of the specimens figured by Hall (1859, plate 2 A, figure 1) partially shows the domelike extension of the anal series of plates; but the full length is unknown. This feature is also seen indistinctly in a specimen in the Yale University Museum on a slab bearing the number 2777.

Arms. Brachials not incorporated above the tertibrachs. There are five plates in the fourth and fifth orders, and generally four in the orders above except near the tips where they may be fewer. Brachials short and broad, arranged longitudinally, and connected suturally with the brachials of the adjacent branch so as to form compound, free tubular appendages characteristic of the genus. Approximately thirty pinnule-bearing arms are borne on each side of this tubular appendage, and they all rise to about the same general height. The first two, less frequently the first three, arm plates are quadrangular or wedge-shaped. Above this point the arms are biserial.

Column large, round, made up of columnals of alternating thickness with distinctly wavy suture lines. The columnals have an increasing thickness or length in the distal part of the column. Columns of considerable length have been found on slabs in the Yale University Museum (Talbot, 1905, p. 26), and two of these are shown attached to the crowns in a photographic reproduction (plate 7).

Ornamentation. Plates of the dorsal cup marked with obscure radiating ridges, and a shallow pit at each angle. A low, faint ridge passes up the radial series, bifurcating on the primaxil and scarcely visible above the secundibrachs.

Horizon and locality. Coeymans limestone at Litchfield and North Litchfield, N. Y.

Types. Cotypes in the American Museum of Natural History.

Melocrinus pachydactylus (Conrad)

Plate 8, figures 1–4

1835 Actinocrinus polydactylus (nom. nudum) Bonny. Schenectady Reflector

1841 Astrocrinites pachydactylus Conrad. Ann. Rep't Pal. N. Y., p. 34

1843 Astrocrinites pachydactylus Mather. Geol. Rep't N. Y., p. 246

1859 Mariacrinus pachydactylus Hall. Pal. N. Y., 3:107, pl. 3, figs. 1–4

1868 Mariacrinus pachydactylus Shumard. Trans. Acad. Sci. St Louis p. 380

1877 Mariacrinus pachydactylus S. A. Miller. Amer. Pal. Foss., p. 83

1881 Melocrinus pachydactylus Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 122 (authors' ed.); Proc. Acad. Nat. Sci., 33:296

1889 Mariacrinus pachydactylus S. A. Miller. N. Amer. Geol. & Pal., p. 260

1897 Melocrinus pachydactylus Wachsmuth & Springer. N. Amer. Crin. Cam., 1:296, pl. 23, figs. 4, 5; pl. 24, figs. 4*a*, *b* (authors' ed.); Mem. Mus. Comp. Zool., v. 20

1900 Melocrinus pachydactylus Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 2, p. 94

1905 Melocrinus pachydactylus Talbot. Amer. Jour. Sci., 20:27, pl. 1, fig. 1

1910 Melocrinus pachydactylus Grabau & Shimer. N. Amer. Index Foss. 2:556

Species of medium size. Dorsal cup subturbinate, but so badly crushed in all the specimens observed that its proportions can only be approximately given. The following description is made mainly from the largest specimen (plate 8, figure 1).

Dorsal cup with four basals, one hexagonal, the other three pentagonal. Hexagonal basal with a median height of 2.3 mm and a width of 5 mm; pentagonal basals vary somewhat in size among themselves. An average plate gives the following measurements: height 2.7 mm, width 4.4 mm.

Radials large, four heptagonal, one, resting on the hexagonal basal, hexagonal. Height of this hexagonal radial 5 mm and greatest width 5.4 mm. The other radials vary in size, but seem to average somewhat larger than the one measured.

First primibrachs smaller than the radials, one plate giving 4.2 mm for the height and 4.6 mm for the width. The shape varies according to the number of interradials coming in contact with the plate. Hexagonal and heptagonal plates have been observed, and it is quite possible that octagonal plates occur. Primaxils smaller than the first primibrachs, having a height of 3.6 mm and a width of 3.7 mm. The primaxils support 3 x 10 secundibrachs which are quite large, three of them together measuring 7.8 mm. The brachials are free above the third tertibrach.

Primary interbrachial of about the same size as the first primibrachs and followed, so far as observed, by two plates in the second range. The third range normally contains three plates, and the fourth three. Above this the plates cannot be separated definitely into ranges; the interbrachials become smaller and the interradii narrower. In the area bounded on the sides by the secundibrachs and tertibrachs of each ray, is a variable number of interaxillaries (intersecundibrachs and intertertibrachs). In one ray only one is present, while in another there are four, one in the first, two in the second, and one in the third range. Between an auxiliary arm and the complemental half of the main trunk, there appear to be several quite small irregular plates.

Arms. The auxiliary arm is comparatively slender in the adult, of about the stoutness of one of the proximal ramules. The main trunks or arms are stout. So far as observed, four or five, usually five, brachials intervene between the successive axillaries; higher up in the arms three are found. The brachials of the trunks are firmly united by the interlocking of crenulations in the apposed surfaces of the ossicles. The union of the axillary and the next lower brachial seems especially close, in fact the suture can only be made out by close examination. The union appears to be syzygial.

Ramules or arms long (one, incomplete, is 35 mm long), biserial and fairly stout. The first three or four ossicles at the base of the arms interlock to a greater or less extent, but from that up the arms are strictly biserial.

Column. The column in its proximal, uncrushed portion measures 6 mm in diameter (crushed 8 mm–9 mm).

Ornamentation. This species is well marked by its heavy sculpturing. The radiating ridges are so thick that the surface seems to be deeply pitted rather than ornamented by radiating striae, as in the other closely related species.

Horizon and locality. At the base of the Coeymans limestone, Schoharie, and in the upper third of the same limestone at Jerusalem hill and North Litchfield, N. Y.

Types. Cotypes in the American Museum of Natural History, number 2304 and the Walker Museum, University of Chicago, James Hall Collection, number 10877.

Remarks. For comparison of this species with Melocrinus paucidactylus see *Remarks* under that species.

Melocrinus paucidactylus (Hall)

Plate 8, figure 5; plates 9–11

1859 Mariacrinus paucidactylus Hall. Pal. N. Y., 3:109, pl. 3, fig. 5

1868 Mariacrinus paucidactylus Shumard. Trans. Acad. Sci. St Louis, 2:380

1877 Mariacrinus paucidactylus S. A. Miller. Amer. Pal. Foss., p. 83

1881 Melocrinus paucidactylus Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 122 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:296

1889 Mariacrinus paucidactylus S. A. Miller. N. Amer. Geol. & Pal., p. 260

1897 Syn. Melocrinus pachydactylus Wachsmuth & Springer. N. Amer. Crin. Cam., 1:296 (authors' ed.); Mem. Mus. Comp. Zool., v. 20

1905 Syn. Melocrinus pachydactylus Talbot. Amer. Jour. Sci., 20:27, pl. 1, fig. 1

1911 Mariacrinus paucidactylus Kirk. Proc. U. S. Nat. Mus., 41:43

Specimens are of medium size with the dorsal cup enlarging very gradually.

Dorsal cup with four basals, one hexagonal and the other three pentagonal and smaller.

Radials somewhat longer or at least as long as wide; four of the radials heptagonal, the fifth, that above the hexagonal basal, being hexagonal. First primibrachs smaller than the radials, longer than wide, hexagonal, heptagonal and octagonal in shape, depending upon how many interradial plates come in contact with them. Primaxils smaller than the first primibrachs, slightly longer, or as long as wide. Secundibrachs 2 x 10, large, the first in each series generally quite decidedly longer than wide, the second axillary. Primary interbrachial hexagonal or heptagonal, of about the size of the first primibrach, usually followed by two in the second range, three in the third, three in the fourth. In some specimens there are interradii which show the succession 1, 2, 3, 2 or 1, 2, 2, 2. The anal interradius has the succession 1, 3, 4, 4, etc. Above the fourth range the interradii become narrower, the interradial plates fewer and more irregular. Interaxillaries one or two, usually two. Several small irregular plates lie between the auxiliary arm and the main trunk.

Tegmen. The tegmen, as shown in one of the Yale specimens (plate 9, figure 10), is made up of numerous small, irregular plates.

Arms. In each ray bifurcation takes place upon the second secundibrach, the outer plate on each side giving rise to the auxiliary arm, the two inner ones giving origin to the double series of plates forming the tubular appendage, the main arm. The auxiliary arms are slender, of about the stoutness of the proximal ramules, or even more slender.

The main trunks are stout, made up of a double series of plates; ramules or arms rather stout and either strictly uniserial or they begin with a few quadrangular plates and then are made up of interlocking wedge-shaped plates forming a zigzag. These are given off at the same place on opposite sides of the trunk, usually from every seventh, eighth, or ninth plate, though sometimes they are closer together. This makes the ramules fewer and farther apart than in the case of M. pachydactylus.

Column round; in the proximal portion of the larger specimen measuring 3.5 mm and 4.5 mm in diameter. The stem joints alternate in size near the calyx but in the more distal portions the thin plates are more numerous.

Ornamentation. The surface of the plates is strongly marked with radiating ridges, but not so strongly as to give the pitted effect of the surface of M. pachydactylus. The ridges become fainter in the upper portions of the cup.

Ontogeny. A number of specimens in the State Museum and the Yale University Museum form an ontogenetic series (plate 8, figure 5; plate 9, figures 1–10) which shows very nicely the development of the species from very young forms to the adult. The chief differences between young and adult forms are in the character of the arms, the strength of the ornamentation, and the relative size of the basals. In the youngest individuals, the basals are fairly large and conspicuous, of about the same size as the first primibrachs; in the adults the basals are small compared with the other plates of the dorsal cup with the exception of the hexagonal basal which is often of fair size. The ornamentation in the youngest examples is faint, the radial ridges sometimes only showing at the edges of the plates. In the older forms, the ridges are very pronounced and extend from the centers of the plates. The arms of the young are simple, two to a ray. In two of the examples figured (plate 9, figures 1, 2) the two second secundibrachs of each ray are axillary, giving origin on the outside to the main arm and on the inside to a short armlet. These two inner armlets of each ray correspond to the tubular arm of the adult. Other specimens (plate 9, figures 4, 5) show twenty simple arms, each secundaxil giving rise to two arms of equal size, the two outer arms in each ray corresponding to the auxiliary arms and without armlets, the two inner arms corresponding to the tubular arm and bearing armlets widely spaced and originating at the same place on each arm. One specimen (plate 9, figure 6) shows these two inner arms united to form a main tubular arm in some of the rays, in other rays still separate. The other examples figured (plate 8, figure 5; plate 9, figures 8, 9, 10) have the auxiliary and tubular arms.

Horizon and locality. From the upper third of the Coeymans limestone at Jerusalem hill, Litchfield, and at North Litchfield, Herkimer county, N. Y.

Types. Hypotypes in the Museum of Yale University and the New York State Museum. Hall's type (Pal. N. Y., v. 3, pl. 3, fig. 5) is refigured here on plate 9, figure 11; it has not been located.

Remarks. M. paucidactylus is considered a synonym of M. pachydactylus by Wachsmuth and Springer (1897, v. 1, 296) and it is so described by Talbot (1905, p. 27) following Wachsmuth and Springer. M. paucidactylus can be readily distinguished from M. pachydactylus. The specimen from Yale University, figured by

Talbot (1905, plate 1, figure 1), and the description as well answer to the description of paucidactylus; this same specimen is here figured as paucidactylus in the ontogenetic series.

The calyx of paucidactylus is more slender than that of pachydactylus, the plates of the radial series are longer in proportion to their width, and there are only two secundibrachs, while pachydactylus has three. In paucidactylus, generally, more brachials intervene between the ramules. The ramules in pachydactylus have three or four interlocking plates in their proximal portion and from there on are strictly biserial; in paucidactylus, the ramules are either strictly uniserial throughout or made up of interlocking wedge-shaped plates forming a " zigzag."

Melocrinus nodosus (Hall)

Plate 12, figures 2, 3, 4

1861 Melocrinites nodosus Hall. Rep't Prog. Geol. Surv. Wis., p. 19
1868 Melocrinus nodosus Shumard. Trans. Acad. Sci. St Louis, 2:381
1877 Melocrinus nodosus S. A. Miller. Amer. Pal. Foss., p. 84
1878 Melocrinus nodosus Bigsby. Thesaurus Dev.-Carb., p. 18
1881 Melocrinus nodosus Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 122 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:296
1889 Melocrinus nodosus S. A. Miller. N. Amer. Geol. & Pal., p. 261
1895 Melocrinus nodosus Whitfield. Amer. Mus. Nat. Hist., mem. 1, p. 48, pl. 5, fig. 14
1897 Melocrinus nodosus Wachsmuth & Springer. N. Amer. Crin. Cam., 1:294 (authors' ed.); Mem. Mus. Comp. Zool., v. 20
1898 Melocrinus nodosus Weller. Ann. N. Y. Acad. Sci., v. 11, no. 7, p. 118, pl. 14, fig. 6
1900 Melocrinus nodosus Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 3, p. 198
1911 Melocrinus nodosus Cleland. Wis. Geol. & Nat. Hist. Surv. Bul. 21, p. 38, pl. 3, fig. 4

Dorsal cup pyriform, 27 mm wide by 32 mm total height. Basals fused to four, large, extending far beyond the stem. Radials larger than the basals, wider than high, hexagonal or heptagonal. First primibrachs hexagonal, considerably smaller than the radials, wider than high or of about equal height and width. Primaxils heptagonal (in right posterior radius hexagonal), smaller than the first primibrachs. In the right posterior radius the primaxil is hexagonal and somewhat smaller than the others. Secundibrachs 2 x 10; the first pentagonal, about half the size of the primaxils; the second very small, less than half the size of the first, and axillary.

First tertibrachs incorporated in the cup. There are 1 x 10 tertibrachs on the inner portions of the rays; 2 x 10 on the outer portions. The inner tertibrachs form the bases of the arms.

Primary interbrachial in the regular interradii hexagonal, a little larger than the first primibrachs. It is followed by two plates in the second row, three in the third, and three or four in the fourth.

Anal area distinct. Primary interbrachial larger than in the other interradii, heptagonal, supporting three plates in the second row, three in the third, three in the fourth, three in the fifth. Above this they merge into the plates of the tegmen. A very young individual (plate 12, figure 4) has in the anal area the series 1, 2, 3.

Tegmen low, slightly arched and composed of many small plates. Anus excentric.

Arms. The radial trunks are comparatively very small. The lateral or auxiliary arms are absent even in the very young stage, or represented by one or two plates and incorporated in the vault. In certain rays there are apparently traces of lateral arms, as best shown in the anterior ray; but these are undoubtedly the bases of the first ramules which are partly incorporated into the calyx. A ray (left posterior) which has been weathered shows the true character of the brachials quite well.

Column missing. It is round and deeply inserted.

Ornamentation. The plates of the dorsal cup possess immense protuberances, those on the basals and radials being broad and oval in cross-section, while the others are high blunt nodes. Vault plates bear similar but smaller nodes. The nodes on the young specimens are of the same character, and are as pronounced in proportion to the size of the specimen.

Horizon and locality. The type was found in the drift near Milwaukee, supposed to be from rocks of Hamilton age. Other specimens of Hamilton age have been found in the Milwaukee cement quarry, Milwaukee, Wisconsin (Cleland, 1911, p. 39).

Types. Holotype in the American Museum of Natural History, number $\frac{5579}{1}$.

Remarks. This specimen, described by Hall from the Wisconsin Devonian, is placed here for comparison with the New York Devonian forms. There are several New York forms which show a very spiny or nodose character of the cup plates, but in none is such an extreme condition met with.

Melocrinus breviradiatus Hall

Plate 13, figures 1, 2

1872 Melocrinus breviradiatus Hall. N. Y. State Mus. Bul. 1, pl. 1, figs. 18, 19. (Photographic plates distributed privately)

1875 Melocrinus breviradiatus Hall & Whitfield. Rep't Geol. Surv. Ohio, Pal., v. 2, pt. 2, p. 160

1877 Ctenocrinus breviradiatus S. A. Miller. Amer. Pal. Foss., p. 74

1881 Melocrinus breviradiatus Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 121 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:295

1889 Melocrinus breviradiatus S. A. Miller. N. Amer. Geol. & Pal., p. 261

1897 Melocrinus brevidactylus (incorrectly cit.) Wachsmuth & Springer. N. Amer. Crin. Cam., 1:294 (authors' ed.); Mem. Mus. Comp. Zool., v. 20

Dorsal cup subturbinate, rounding and not pentagonal in cross-section; rendered asymmetrical by a decided bulging of the posterior portion of the theca, such as is shown by many of the Melocrinidae; height to the top of the second secundibrach on the anterior side 21 mm; total height of the calyx to the basal of the anal tube 29 mm; width of cup, measuring in a line from the anterior ray to the posterior interradius, about 26 mm.

Basals fused to three instead of the normal four. Together they form a sharply defined, distinctly projecting disk, 8 mm in width by 2.8 mm in height, with nearly vertical sides. Radials large, hexagonal, an average one having a height of 4.2 mm and a width of 7 mm. First primibrachs hexagonal, an average one having a height of 4.6 mm and a width of 5.8 mm. Primaxils heptagonal, averaging 4.4 mm in height by a greatest width of 5.2 mm.

First and second secundibrachs and first tertibrach incorporated into the cup. First secundibrachs quite large, pentagonal, hexagonal or heptagonal in form, and very variable in size; second secundibrachs comparatively small in most rays, in others nearly as large as the first secundibrachs. First tertibrachs of the inner half of the ray small and facing outward at an abrupt angle, forming the bases of the radial trunks.

Primary interbrachials of about equal height and width; slightly higher than the radials, but somewhat narrower; hexagonal, and in all the interradii followed by two plates in the second range. In the posterior, right posterolateral and right anterior interradii there are three plates in the third and fourth ranges; in the other two interradii there are but two plates in each range. Above, the interradial plates are somewhat irregularly arranged and merge gradually into the tegmen.

Tegmen low, composed of numerous small nodose plates; interambulacral areas quite distinctly depressed; anal tube subcentral.

Arms. Radial trunks not preserved in the type specimen, but were moderately stout. Auxiliary arm entirely suppressed.

Column wanting, but judging from the stem cicatrix was round.

Ornamentation. Unfortunately this specimen has been cleaned with acid, and as a result the exact character of its ornamentation can not be made out. The sutures between the plates in the dorsal cup are marked by well-defined pits, which were undoubtedly formed by short ridges passing from plate to plate, traces of which can still be seen.

The plates of the dorsal cup have well-defined, smooth, rounded bosses of the general outline of the plates themselves. These bosses are separated from the edges of the plates by narrow beveled margins which in turn are traversed by the short, narrow ridges mentioned above.

Horizon and locality. The original label accompanying the specimen reads as follows: "Melocrinus, Hamilton group, Eighteen Mile creek. From Doc. Mayo." The specimen is probably from the Moscow shales.

Types. Holotype in the Jewett Collection, now in the Cornell University Museum, number 7330.

Remarks. This species differs from M. bainbridgensis in its narrower, more elongate calyx, in its rounded instead of subpentagonal cross section, and in the asymmetry of the dorsal cup. In breviradiatus the basals are fused into a sharply projecting, clearly defined, nonlobate disk. In bainbridgensis the four segments of the basal circle are well marked, each projecting in quite a decided lobe. The plates of bainbridgensis are "depressed convex with slightly concave centers," according to the description of Hall and Whitfield (1875, v. 2, p. 159). In breviradiatus, from the beveled edge the plates rise rather abruptly into rounded bosses. This difference seems of no great importance.

One remarkable feature shown by the only specimen of this species known is that instead of the normal four subequal segments in the basal ring there are only three. Two of these are small and of nearly the same size. The third is equal in size to the other two combined. The base is in a very good state of preservation, and if a fourth suture were present, it undoubtedly would show. Whether this is an individual variation or not can not be determined. It is a feature, however, that one would naturally expect to find appearing among the later Melocrinoidea.

No full description has ever been published of this species. In the "Paleontology of Ohio", volume 2, under the description of Melocrinus (Ctenocrinus) bainbridgensis, occurs this passage:

The species bears considerable resemblance to Melocrinus breviradiatus (name issued with explanation of photographic plate, August 1872) from the Hamilton group of New York; but differs in the projecting rim at the base of the cup formed by the basal plates, in the greater inequality of the interradial and anal areas, and also in the surface character and ornamentation of the plates, as well as in the flattening of the surface of the plates themselves, those of that specimen being highly convex, approaching tumidity.

This species is incorrectly cited by Wachsmuth and Springer (1897, v. 1, p. 294) as "Melocrinus brevidactylus". They state that the species can not be regarded as a good one for it "was figured but not described, and the figure not properly published."

Melocrinus bainbridgensis Hall & Whitfield

Plate 12, figures 5-9

1875 Melocrinus (Ctenocrinus) bainbridgensis Hall & Whitfield. Geol. Surv. Ohio, Pal., 2:158, pl. 13, figs. 2, *2a*, 3

1877 Ctenocrinus bainbridgensis S. A. Miller. Amer. Pal. Foss., p. 74

1881 Melocrinus bainbridgensis Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 121 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:295

1889 Melocrinus bainbridgensis S. A. Miller. N. Amer. Geol. & Pal., p. 261

1897 Melocrinus bainbridgensis Wachsmuth & Springer. N. Amer. Crin. Cam., 1:297, pl. 22, figs. 4 *a*, *b*, *c*; pl. 24, fig. 5 (authors' ed.); Mem. Mus. Comp. Zool., v. 20

1910 Melocrinus bainbridgensis Grabau & Shimer. N. Amer. Index Foss., 2:556

This description is based upon a single calyx, a fragment of a radial trunk and several column fragments.

Species above medium size. Height of the calyx to the arm bases 26 mm, to the base of the anal tube 34 mm. Width of the cup, measuring in a line from the anterior ray to the posterior interradius, is about 34 mm.

Dorsal cup as high as wide, very broadly turbinate, spreading rather rapidly from the base of the cup to the arm bases, with somewhat convex sides and pentagonal cross section.

Basals four, forming a low cup which is slightly lobed because of the notching at the interbasal sutures. The cup has a width of 10.1 mm and a height of 2.7 mm. Radials hexagonal, slightly wider than high. An average one has a height of 7.2 mm and a width of 8.2 mm. First primibrachs smaller than the radials, wider than high. An average one measures 5.1 mm in height and 7.7 mm in width. Primaxils heptagonal, smaller than the first primibrachs, averaging 4.6 mm in height and 6.7 mm at the greatest width. First and second secundibrachs and first tertibrachs incorporated in the dorsal cup. First secundibrachs about half as large as the primaxil; variable in shape, being pentagonal, hexagonal and heptagonal. Secundaxils (second secundibrachs) comparatively small. First tertibrachs of the inner side of the half rays small, facing out at an abrupt angle and forming the bases of the radial trunks.

Interradial areas broad. Primary interbrachial hexagonal, of about the same size as the first primibrachs, approximately equal in height and width. In the regular interradii this plate is followed by two in the second row, three in the third and a variable number in the fourth — three, four or five. Above this they gradually intermingle with the interambulacrals.

In the anal interradius the primary interbrachial is larger than the others, equal in size to the radials. It is heptagonal in shape, supporting three plates in the second row, which form an arch, and four in the third and fourth. The arching is characteristic of each range, and continues, though with less distinctness, almost to the base of the anal tube.

Tegmen low, depressed pentapyramidal, surmounted by a subcentral anal tube. It is composed of numerous, more or less uniform, medium-sized plates which are slightly depressed.

Arms. Auxiliary arms entirely suppressed; no radial trunks preserved on the type specimen. A fragment of a radial trunk, supposed to belong to this species, was found associated with the calyx along with several pieces of column. The radial trunk is stout, composed of very short ossicles, and giving off uniserial arms at every third plate on each side. This arm fragment is shown here on plate 12, figure 7.

Column. The columns associated with the calyx are round, pierced by a pentalobate canal, about a quarter of an inch in diameter, composed in some cases of columnals of alternating sizes, in others, of similar-sized columnals. The latter probably occur in the more distal parts of the column. All the columnals have their exterior surfaces longitudinally marked, similar to the plates of the calyx.

Ornamentation. The plates are slightly elevated, with the centers a little depressed, beveled at their margins and with the suture lines giving the appearance of being widely grooved. Except at their margins, the plates of the dorsal cup are marked by a system of confluent granules arranged in concentric circles. The plates of the tegmen are finely granulose. The column is marked longitudinally in a manner similar to the markings on the plates of the dorsal cup.

Horizon and locality. In a limestone layer, 6 inches in thickness, above the base of the Huron shales, Bainbridge, Ross county, Ohio.

Types. Holotype in the Ohio State Collection.

Remarks. This Ohio Devonian form has been introduced here because of its resemblance to the two New York forms, M. bainbridgensis from the Hamilton and M. clarkei from the Genesee and Portage.

This species differs from M. breviradiatus in the shape of the calyx, which is pentagonal in cross-section, in the projecting lobate rim formed by the basal plates, in the greater inequality between the regular and anal interradii, and in the character and ornamentation of the plates. No arms have been found for M. breviradiatus.

The resemblance to M. clarkei is discussed under that species under the heading *Remarks.*

Melocrinus clarkei (Hall Ms) Williams

Plate 13, figures 3–5; plate 14

1882 Melocrinus clarkei Williams. Proc. Acad. Nat. Sci. Phila., 34:31

1885 Melocrinus clarkei Wachsmuth & Springer. Rev. Palaeocr., pt. 3, p. 104 (authors' ed.) Proc. Acad. Nat. Sci. Phila., 37:326

1889 Melocrinus clarkei S. A. Miller. N. Amer. Geol. & Pal., p. 261
1897 Syn. Melocrinus bainbridgensis Wachsmuth & Springer. N. Amer. Crin. Cam., 1:297, pl. 24, fig. 5 (authors' ed.); Mem. Mus. Comp. Zool., v. 20
1903 Melocrinus clarkei Clarke. N. Y. State Mus. Mem. 6, pp. 346, 347, pls. D, E
1903 Melocrinus clarkei Clarke & Ruedemann. N. Y. State Mus. Bul. 65, p. 74
1904 Melocrinus clarkei Clarke & Luther. N. Y. State Mus. Bul. 63, p. 52.
1905 Melocrinus clarkei Clarke & Ruedemann. N. Y. State Mus. Bul. 80, p. 43

All the calyces of this species are in such a crushed condition that it is rather difficult to determine their shape. The specimens are all smaller than M. bainbridgensis, but the shape and number of the plates agree so well with that species that probably the shape was the same — broadly turbinate.

Dorsal cup. Basals forming a low cup, slightly projecting, with nearly vertical sides. The cup has a width of about 5.9 mm and a height of about 2 mm. Radials hexagonal, much larger than the basals. Three average ones give the following measurements: height 4.5 mm, width 5.4 mm; height 4.9 mm, width 5.8 mm; height 3.6 mm, width 5.4 mm. Width usually slightly greater than the height, though sometimes they are about equal.

There is no striking difference in size between the radials and the primibrachs. First primibrachs hexagonal, smaller than the radials, wider than high. Characteristic ones give the following measurements: height 3.7 mm, width 6.1 mm; height 3.9 mm, width 4.8 mm. Primaxils usually heptagonal, though pentagonal ones occur; slightly narrower than the first primibrachs, though often as high or higher.

The two secundibrachs and the first tertibrachs are incorporated in the cup. First secundibrachs smaller than the primaxils and variable in shape — pentagonal, hexagonal, heptagonal; secundaxils usually much smaller, often half the size of the first secundibrachs. The first tertibrachs of the inner half of the ray form the base of the radial trunk or tubular appendage.

Interradial areas broad. Primary interbrachial, in the regular interradii, hexagonal, slightly smaller than the radials; followed in the second row by two, in the third by three and in the fourth by three or four plates. Above this there is a variable number and they merge into the plates of the tegmen. In the anal interradius the primary interbrachial is larger than in the other interradii. It is as large or larger than the radials, heptagonal, supporting three plates in the second row, and apparently four in the third. They have not been determined above this row.

Tegmen. No part of the tegmen is preserved in any of the specimens.

Arms. Radial trunks stout at the base, flattened on the back, and tapering gradually almost to a point; at least 3 times the length of the calyx and composed of very short ossicles. Arms uniserial, long, slender, pinnule-bearing; given off from the main trunk usually from every third plate on each side.

There are no auxiliary arms.

Column round and composed of thick and thin columnals. The thicker columnals project somewhat beyond the others. The thin and thick columnals may alternate or there may be two or more thinner ones between the thick ones. Some of the stems associated with the calyces show all columnals of nearly the same size, and they probably represent more distal parts of the column.

Ornamentation. The plates of the dorsal cup are slightly rounded at the margins and flattened in the middle. In some, the suture lines appear to be grooved and the plates slightly beveled at the margin. The ornamentation is only well shown in one specimen. The plates are marked with granulations over the central portion. There are also rows of fine striae connecting the plates. These fine lines radiate out in groups of three or four from the center, or almost the center, of the plates to all the faces, forming delicate starlike figures. The delicacy of this ornamentation is probably the reason why it is not preserved in all the specimens. It is best shown in one of the Portage specimens (plate 13, figure 5) from the Eighteen Mile creek region.

Horizon and locality. Genesee (West River shale) beds from Bell's gully, Canandaigua lake; Blacksmith gully, Bristol; Bristol Center; Mill gully and Hamilton gully, Honeoye lake, N. Y. Also found in the Portage (Cashaqua shales) at Naples and along Eighteen Mile creek at North Evans, N. Y.; in the Portage (Angola shale) at Fox's point, Lake Erie, near Angola, N. Y.

Types. Cotypes in the collection of the New York State Museum, number $\frac{4340}{1}$.

Remarks. The name Melocrinus clarkei was given to this species by Hall (manuscript) in honor of Noah T. Clarke, father to Dr. John M. Clarke, by whom the original slab was collected in 1870. The species was described by Williams (1882, p. 31) without illustration, and was first illustrated by Doctor Clarke in his "Monograph of the Naples Fauna" (1903, pp. 346, 347, pls. D, E). The illustrations used by Doctor Clarke and those used here, with the exception of figure 5, plate 13, are from the original slab.

This species may be distinguished from M. breviradiatus by the shape of the calyx which in this species is broadly turbinate as in M. bainbridgensis; the interradii are broader and show a different number of plates in the higher ranges; the radials are smaller and there is less difference in size between the radials and primibrachs; the plates of the dorsal cup are low and flattened while in breviradiatus they have well-defined, rounded bosses. No arms have been found for breviradiatus, so no comparison can be made in this respect.

M. clarkei resembles M. bainbridgensis in shape, but it is a smaller species. The basals are smaller and are not lobed. The plates of the radial series are much smaller in comparison with the other plates of the cup in clarkei. Even taking into consideration the difference in size of the cup, the radials are considerably larger in bainbridgensis, and there is a much greater difference in size between the radials and the primibrachs. The radial trunks in bainbridgensis appear to be heavier and less tapering, and the arms are given off from every fourth plate while in clarkei the arms are given off from every third plate. The plates of the cup in clarkei are ornamented with granules and faint radiating clusters of striae, while in bainbridgensis the plates are marked except at the beveled edges with confluent granules arranged in more or less concentric circles. There seem to be enough differences to retain M. clarkei as a separate species. More specimens of the two species may throw further light upon this matter.

Melocrinus gracilis Wachsmuth & Springer

Plate 13, figure 6

1897 Melocrinus gracilis Wachsmuth & Springer. N. Amer. Crin. Cam., 1:298, pl. 22, fig. 5 (authors' ed.); Mem. Mus. Comp. Zool., v. 20

1903 Melocrinus gracilis Clarke & Ruedemann. N. Y. State Mus. Bul. 65, p. 74

1904 Melocrinus gracilis Clarke & Luther. N. Y. State Mus. Bul. 63, p. 52

Calyx of medium size. Dorsal cup pyramidal and sharply pentagonal in cross section owing to the highly arched character of the radial series and the depressed interbrachial areas.

Dorsal cup. Basals forming a low cup which projects slightly beyond the column at the lower edges, while the upper edges are turned abruptly upward. Radials hexagonal and wider than high. First primibrachs smaller than the radials; wider than high. Primaxils pentagonal or heptagonal, smaller than the first primibrachs, and supporting 2 x 10 secundibrachs. Of these the second is axillary, supporting a small arm on the outer and a radial trunk on the inner face. Primary interbrachial in the regular interradii hexagonal, smaller than the radials; followed by two plates in the second row, three in the third, three in the fourth, etc., connecting insensibly with the vault plates. Anal interradius not preserved. There is one small intersecundibrach.

Tegmen elevated and, so far as known, composed of small, smooth plates with a minute tubercle in the center of many of them.

Arms. Radial trunks heavy and bent outwards. The trunks are dreserved only to the fourth plate, so nothing is known of the arrangement of the arms. In addition to the arm trunk there is an auxiliary arm given off in each half ray by the secundaxil.

Column large and round, perforated by a small canal. The nodal columnals are projecting with thinner internodals between.

Ornamentation. The plates of the radial series are strongly arched so as to form a broad conspicuous ridge which extends up to the bases of the arms. There are small tubercles on the first primibrachs and the primaxils, those on the primaxils being stronger and sharper. The plates of the higher orders of interbrachials have each a small, central node, and there are incipient nodes on the plates of the tegmen. The angles of the plates of the dorsal cup are marked with slight pittings, especially in the higher orders of interbrachials.

Horizon and locality. This specimen was collected by Dr John M. Clarke in the Hamilton (Moscow shale) beds, Canandaigua lake, N. Y.

Types. Holotype in the collection of the New York State Museum where it bears the catalog number $\frac{4341}{1}$.

Melocrinus reticularis Olsson

Plate 15, figure 1

1912 Melocrinus reticularis Olsson. Bul. American Paleontology, v. 5, no. 23, pp. 5, 6, pl. 7, fig. 1

Original description. Shape pyriform, spreading rapidly from the narrow base. Basals strongly tumid, only two shown on the specimen, anterior one hexagonal, the other pentagonal in shape. Radials (three shown), anterior one resting upon the hexagonal base, hexagonal in shape, the other two heptagonal, about as wide as high. First costal (*primibrach*) slightly longer than wide and hexagonal in shape. The second costal axillary and heptagonal in shape, supporting upon its two upper sloping sides the distichals. Distichals (*secundibrachs*) 2 x 10 and incorporated in the dorsal cup. Their shape is not easily discernible because their sutures are indistinct.

Arms biserial (one arm is shown lying on its side embedded in the rock); armlets appear to be given off from each third brachial plate.

Commencing on the basals, a groove is continued up through the radials and costals, branches into the distichals on the second costal. Plates with the exception of the basals flat, the radials and brachials only slightly convexed by the longitudinal groove. Plates ornamented with raised lines, radiating in pairs or by threes from, but not showing in the centers of the plates. These lines pass across the sutures of the plates. Sutures distinct only between the lower plates of the dorsal cup, becoming very indistinct on passing upwards. Beyond the third series of interradials the sutures are not visible, the lines of ornamentation on the plates become single, producing a netlike appearance.

First interradials hexagonal in shape, longer than wide, and supported on the upper sides of the radials and first costals. These are followed by the second series of interradials consisting of two plates which are irregularly hexagonal in shape and wider than high. The third series of interradials consists of three plates. Above this series the suture lines become indistinct.

Radials, first costals, first and second interradials have ornamentation lines of three each, the two lateral ones shorter than the middle line and pass nearly to the middle of the plates. Other plates have only one ornamental line passing across the sutures of the plates.

Horizon and locality. From the Portage (Ithaca) beds, McGraw or University quarry, Ithaca, N. Y.

Remarks. It has not been possible to obtain the holotype. Comparisons with other species have been based upon the original description and figure. See *Remarks* under M. (Trichotocrinus) lutheri for comparison with that species.

Olsson's description mentions a groove continuing up over the radial series. From a study of the ornamentation of other species of Melocrinus, it seems likely that this furrow will prove to be a ridge. The radial ridge possibly was broken off and the specimen so weathered as to give it the appearance of a groove.

Melocrinus williamsi Olsson

Plate 15, figure 2

1912 Melocrinus williamsi Olsson. Bul. American Paleontology, v. 5, no. 23, pp. 4, 5, pl. 6, fig. 3

Original description. Specimen about medium size. Dorsal cup higher than wide. Arms five, biserial.

Plates tumid, with the centers of each supporting a conspicuous spiniferous node. This applies not only to the plates of the dorsal cup, but also to the plates of the ventral surface and of the anal tube. The centers of the radials and brachials are connected by a ridgelike elevation, which commencing on the basal plates follows up through the radials and brachials, dividing the dorsal cup into five equal fields. The interradials above the first have their centers connected by a low ridge, which passes from one plate to another, but is much less pronounced. The spiniferous node in the center of the radials and of the first interradial plates is surrounded by a circle of low beadlike elevations.

Basals four, strongly tumid, those shown on the specimen pentagonal in shape. Radials twice as large, those shown on the specimen pentagonal in shape and as wide as high. Costals (*primibrachs*) two of nearly equal size, but much smaller than the radials. First costal hexagonal, second heptagonal in shape and both slightly higher than wide. Distichals (*secundibrachs*) 1 x 10, borne on the inner surface of the second costals, pentagonal in shape and slightly higher than wide.

Interradials 1, 2, 3, 3. First interradial hexagonal, slightly higher than wide, second interradial irregularly hexagonal, as are the remainder of the interradials. Plates of the ventral surface small, apparently of an irregular hexagonal shape. Anal tube long and composed of several small irregular plates.

Remarks. This species is remarkable in its possession of the strongly spiniferous character of its plates. In this respect the species approaches Melocrinus gregeri Rowley (Melocrinus calvini W. & Sp. ?) from the Hamilton of Missouri, which however has the spiniferous nodes confined only to the larger plates of the dorsal cup, as well as lacking the ridgelike elevations extending through the radials and brachials and the circle of beadlike elevations around the spiniferous centers of the radials and the first interradials.

Horizon and locality. From the Portage (Ithaca) beds, near Cortland, N. Y.

Remarks. It has not been possible to obtain the holotype. Comparisons with other species have been based upon the original description and figure. See *Remarks* under M. naplesensis for comparison with that species.

Melocrinus naplesensis sp. nov.

Plate 15, figures 3, 4, 5(?)

Species of medium size. It has been found occurring either in a crushed condition or as molds. A young and a mature specimen are figured here. The larger is quite crushed, so it would be difficult to say what relation the width bears to the height, but in the smaller specimen the calyx is slightly wider than high.

Dorsal cup. Basals four, one hexagonal, the other three pentagonal, thick in their lower portions and projecting out over the column in strong spines or spinelike nodes. Radials wider than high, four pentagonal, one hexagonal, the latter resting upon the hexagonal basal. First primibrachs smaller than the radials, as wide or slightly wider than high, hexagonal so far as any have been observed. Primaxils smaller than the first primibrachs, slightly wider than high, hexagonal or heptagonal, depending upon the number of bordering interbrachials, and giving rise to 2 x 10 secundibrachs which are in contact in each ray. Primary interbrachials smaller than the radials, hexagonal or heptagonal in shape, followed by two plates in the second rank, three in the third, four in the fourth. The anal interradius of one specimen shows the succession 1, 3, 5, 6.

Tegmen composed of many small plates, apparently of irregular hexagonal or heptagonal shape. Anal tube composed of small, irregular, spinose plates; this is not shown in the older specimen.

Arms. Only the bases of the radial trunks are shown, except in one ray of the younger specimen which shows about one-half inch of the proximal portion of a radial trunk. This fragment shows a pair of spines or spinose nodes on the fifth and ninth pair of brachials. A fragment, about one inch in length, of the upper part of a radial trunk lies in close proximity to the younger calyx. It has paired spines every fourth or fifth pair of brachials where the arms are given off. This is very much like the main arm of Melocrinus (Trichotocrinus) lutheri, but may also belong to this species as it has the characteristics which the short piece attached to the calyx would lead one to expect.

Column large and strong compared to the size of the calyx, and made up of thick columnals, the nodals, with one or two thin columnals of smaller diameter between them. In the smaller specimen the thick columnals have a diameter of 6 mm, the thinner ones, about 5 mm; in the larger specimen, the thicker columnals have a diameter of 8 mm and the thinner about 6.2 mm. The heavy columnals are thickened at their edges into nodes which are so strongly developed as to give an almost spinose appearance to the stem.

Ornamentation. The plates of the dorsal cup are tumid, more so in the younger specimen. Each plate bears at the center a conspicuous node or spine. These spines are present on the plates of the ventral surface and anal tube as well; more strongly developed on the plates of the radial series and the primary brachials, and appear much stronger in the younger form. Radiating ridges connect the centers of the plates of the interradial series, even extending up over the tegmen, and are also present on the higher brachials though not so prominent. In the older specimen these ridges are only faintly developed on the primary interbrachials and first primibrachs and do not show on the radials at all; in the younger example the ridges on the primary interbrachials and first primibrachs are more prominent, and ridges may be distinguished on the radials. In the young specimen, in addition to the ridges, the plates show a vermicular marking which in the older specimen is replaced by irregularly scattered small papillae which give a granular appearance to the plates. As mentioned above, the nodal columnals in both the young and mature specimens are ornamented with prominent nodes which give it a spinose appearance.

Locality and horizon. Several specimens of the species were collected by D. Dana Luther in the Portage beds (West Hill flags) from the gully at the head of Italy hollow, near Naples, N. Y.

Types. Cotypes in the collection of the New York State Museum.

Remarks. This species is similar to Melocrinus williamsi described by Olsson (1912, p. 4) from the Portage rocks near Cortland, N. Y., but there are too many differences to permit placing these two together. Melocrinus naplesensis is at least as broad as high, lacks the ridgelike elevations connecting the radials and brachials, the beadlike elevations around the central spines, and has radiating ridges on the radial series as well as on the interbrachials. M. naplesensis has 2 x 10 secundibrachs while M. williamsi has 1 x 10. The heavy nodose stem in M. naplesensis is very characteristic and is not found in M. williamsi.

A very young specimen of a Melocrinus from the same locality and horizon as naplesensis is figured on plate 15, figure 5. It is a sturdy form with a relatively large, strong stem; and when allowances are made for the changes which maturity might bring, it seems quite possible that this specimen may prove to be the young of naplesensis.

The species was named from the locality near which it was collected.

Melocrinus sp. ?

Plate 15, figure 6

Two very young specimens of Melocrinus are shown on a small slab from the Portage beds (West Hill flags) in the vicinity of Naples, N. Y. The larger of the two (plate 15, figure 5) is very suggestive of Melocrinus naplesensis and has been provisionally placed with that species (see *Remarks* under M. naplesensis).

The smaller individual is of particular interest because it shows a parasitic gastropod, a Platyceras, resting over the anal area. It would be rather difficult to say to which species this young form belongs. The basals are very small, much smaller than seen in any of the Portage forms.

Melocrinus sp. nov.

Plate 15, figures 7–9

This species is based upon very fragmentary material, but it is so characteristic that there can be no difficulty in recognizing it when more material is found. The present description is based upon a very beautifully preserved tubular appendage or arm trunk and several pieces of column which apparently belong to this species and are provisionally placed here.

Arms. The tubular appendage preserved measures 10 mm, and even then the tip and most proximal part are missing. It is grooved on the dorsal side and must have been very flexible for as it lies in the rock it is bent over toward the dorsal side in almost a complete circle. The double row of ossicles forming the main trunk are short and broad and have crenulate edges. Arms are given off on each side from every third ossicle, and these arm-bearing ossicles are longer than the others. The arms are uniserial, composed of quadrangular brachials which are broader than long and have crenulate edges. Each bears a pair of long, delicate pinnules. The pinnules are composed of long ossicles and have a dorsal carina which gives them an angular appearance. Both the main trunk and the arms are ornamented with strong spines. On the main trunk they are borne, in each half, usually by every ninth ossicle, but they are not paired. Of each two spines borne by the main trunk the one on the left half is borne by the third ossicle above the one on the right half. The intermediate arm-bearing ossicles sometimes show a faint tubercle. The spines on the arms are borne singly on the backs of the brachials. They are borne at unequal intervals, being closer together nearer the tips.

Column. On the same slab with the tubular appendage is a portion of a column. This same type of column is found on two other slabs from the same locality, and are associated with small arm fragments. It may well be that this is the column of this species, and it is provisionally referred here. The fact that the sutures between the columnals are strongly crenulate, just as in the case of the brachials, is another point in favor of this designation.

The column is composed of nodes and internodes. There are two sizes of nodals. The larger ones project considerably, and are ornamented with strongly developed nodes or tubercles which give an almost spinose appearance to the nodals. The minor nodals are midway between the heavier ones. They project slightly and have a knifelike edge. The internodals are very short. There are three between each minor nodal and the large nodal immediately above and below. The margins of all the columnals are strongly crenulate.

Horizon and locality. Hamilton (Moscow shale) beds, Cashong creek near Bellona, N. Y.

Types. Cotypes in the New York State Museum.

Remarks. The arms of this species in their spinose character resemble the arms of Melocrinus (Trichotocrinus) lutheri more than any other species; but otherwise they are quite different as a reference to the figured arms of that species will show (plate 16, figures 10–12).

Melocrinus splendens sp. nov.

Plate 16, figure 1

This species is described and figured from an excellent gutta-percha squeeze of a single specimen from the Chemung beds. It is a very large specimen, probably the largest described, exceeding M. willetensis in size of calyx and with much heavier arms.

Dorsal cup in a somewhat crushed condition but the normal proportions remain; broader than high, somewhat hemispheric or bowl-shaped. Basal portion crushed and the basals can not be distinguished. Radials large and hexagonal, broader than high, the lower lateral faces being the longer. First primibrachs hexagonal, of about the same size as the radials and of subequal height and width. Primaxils smaller than the first primibrachs and hexagonal so far as known. Secundibrachs 3 x 10 giving rise to the brachials of the tubular arms. First secundibrachs large, in one ray longer than the primaxil; the second and third much smaller, the third being but little longer than the arm brachials. The arms appear to be free at about the fifth secundibrach. Primary interbrachial hexagonal, smaller than the first primibrachs and followed by two plates in the second row, three in the third, three or four in the fourth. Above this they are not distinguishable. Anal interradius not preserved. There is one rather large intersecundibrach.

Tegmen unknown.

Arms. Arm trunks composed of short, heavy brachials and apparently free above the fifth secundibrach; no auxiliary arms. Arms given off at every third brachial on each side, the arm-bearing brachials being wider than the others. Arms long, the proximal ones probably reaching well up toward the tips of the arm trunks. They are composed of quadrangular brachials wider than long and each bearing a pair of fairly long, slender pinnules.

Column not known.

Ornamentation. A strong, rounded ridge extends up the radial series, bifurcating on the primaxil, broadening out on the first secundibrachs and occupying practically the entire width of the second and third secundibrachs. At about the centers of the radials, primibrachs, and first secundibrachs, this ridge is produced into a rounded node. Both the brachials and interbrachials are ornamented with strong, rounded ridges which radiate from the center or nearly the center of each plate to all the faces.

The arms are provided with dorsally situated strong spines, with apparently no regular arrangement. They are best shown on the more distal parts of the arms.

Horizon and locality. From the upper Chemung beds, Binghamton, N. Y.

Types. Holotype in the Walker Museum, University of Chicago, number 12926.

Remarks. This species of Melocrinus is quite distinct from any of the forms described. Perhaps that to which it bears most resemblance is M. pachydactylus from the Coeymans limestone, and from this species it is readily distinguishable. Among the many differences are the larger size and the shape; the arms are heavier, uniserial and spinose, and given off more frequently (every third brachial) from the main trunks; there is no auxiliary arm, and only one intersecundibrach; and the radiating ridges on the plates of the dorsal cup are coarser and rounded.

Melocrinus willetensis sp. nov.

Plate 16, figure 2

A very large species, one of the largest described. Dorsal cup long and turbinate; tegmen slightly convex.

Dorsal cup. Basals four, very long and narrow, the bases rising in abrupt blunt elevations, slightly excavated laterally. Radials large, hexagonal, of the same width and length. First primibrachs slightly longer than wide, and a trifle shorter than the radials. Primaxils heptagonal, as long as wide, somewhat smaller than the first primibrachs, supporting 2 x 10 secundibrachs which in turn support the arm trunks. Primary interbrachial hexagonal (in anal side heptagonal ?), as high as the first primibrachs and of equal width and height, supporting in the higher ranges 2, 3, 5 interbrachials which connect insensibly with the plates of the tegmen. There appears to be one intersecundibrach.

Tegmen slightly convex and composed of numerous medium-sized plates which are tumescent.

Arms. Radial trunks composed of short, wide plates; character of the arm appendages unknown.

Column. Associated with the calyx are two types of large columns with two sizes of thick, projecting nodals and thinner internodals. In one stem the nodals are ornamented with prominent nodes. Either may be the column of this species, but judging from the character of the column of variety perstriatus, that with the nonnodose nodals would seem to be the right one.

Ornamentation. All of the brachials have strong central spines between which run faint, low connecting ridges. The interbrachials of the higher ranges (third, fourth, fifth) have, in addition to the central spines, incipient radiating ridges running from the centers of the plates.

Horizon and locality. Lower Chemung beds near Willet, N. Y.

Types. Holotype in the collection of the New York State Museum.

Remarks. This species most nearly resembles M. calvini Wachsmuth & Springer, from which it differs in its much greater size, in the more elongate, turbinate character of the dorsal cup, in the long, narrow basals with their peculiar lateral extensions, in the greater length of radials and first primibrachs compared with their breadth, in the presence of the radial ridges and in the nodose character of the higher ranges of interbrachials together with the presence of radiating ridges.

Melocrinus willetensis var. **perstriatus** nov.

Plate 16, figures 3–5

Similar to Melocrinus willetensis and from the same locality and horizon is a small Melocrinus which is here regarded as a variety of willetensis. At present only a few fragmentary specimens are at hand.

The exact shape of the calyx can not be determined but it appears to be turbinate. The specimens differ from willetensis in their much smaller size and their less pronounced basals. As in willetensis, the higher plates of the cup, especially the higher orders of interbrachials, show radiating ridges in addition to the spines. These ridges extend well up on the base of the anal tube and as far on the tegmen as can be observed. On the lower plates of the cup, which have only spines in willetensis, there are delicate radiating ridges or striae. They are arranged in clusters, usually of three, which radiate from near the center of each plate to every face. The delicate ornamentation is very faint on two of the specimens, and, indeed, is a character which is likely to grow fainter or even disappear with maturity. This, together with the fragmentary preservation, has induced the writer to make this form a variety.

The column is large and composed of alternating thick and thin columnals. There are two sizes of thick, projecting columnals which alternate, and between these are the thin columnals. There are detached fragments of columns of the same type associated with these fragments of calyces; and there is also another type of column with the thicker columnals nodose.

Horizon and locality. From the lower Chemung beds at Willet, N. Y. A much flattened fragment of a cup belonging to this variety has been collected from Greene, Chenango county, N. Y., and is labelled Ithaca formation.

Types. Cotypes in the collection of the New York State Museum and in the Walker Museum, University of Chicago, number 14240.

Encrinites triciclas Eaton

The name Encrinites triciclas Eaton (Vanuxem: Geol. N. Y., pt 3, 1842, p. 182) has been given to a crinoid column showing three different sized columnals. This column was noted as a characteristic fossil of the Chemung, occurring at Greene, near Binghamton, and many other localities. The column is quite evidently a Melocrinus column; and it is possible that more than one Chemung species could have this same type of stem. Under these conditions it does not seem that the specific name can stand.

Subgenus TRICHOTOCRINUS Olsson 1912

Melocrinus (Trichotocrinus) harrisi Olsson

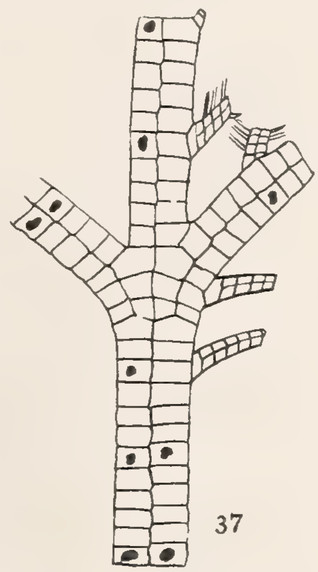
Plate 16, figure 6; text figures 37, 38

1912 Melocrinus (Trichotocrinus) harrisi Olsson. Bul. American Paleontology, v. 5, no. 23, pp. 3, 4, pl. 6, figs. 1, 2

Original description. Specimen about medium size. Dorsal cup as high as wide spreading rapidly. Arms five, biserial and developing three biserial branches, which give off armlets bearing pinnules.

Plates slightly tumid and beautifully ornamented with well-defined ridges, those of the second series of plates passing from one plate to another. From the radials a strong and well-defined ridge is carried up along the brachials, interruptedly at each plate, and dividing the dorsal area into five nearly equal fields. Because of the hexagonal shape of the plates, the ridges tend to be in the form of six-armed stars, all the arms of which seldom join in the center and never do on the radials, but are well marked on the borders of the plates. Between these ridges are situated small beadlike elevations. Suture line deeply grooved.

Basals four, forming a low cup and projecting beyond the surface of the radials. Radials about as wide as high and heptagonal in shape, except the anterior one, which is hexagonal and rests squarely upon the basal plate. Costals (*primibrachs*) about as wide as high, decreasing in size upwards and hexagonal in shape, except the second costal (*primaxil*) which is heptagonal and supports on its inner face the next order of brachial, the distichals (*secundibrachs*). Distichals 2 x 10, those of the same ray in contact laterally. First two rows of distichals pentagonal in shape, elevated in the center and with two small beadlike elevations on the adjacent and opposite extremities, the others much smaller and plain. The trunk tapers upwards and is deeply grooved along the fusion of the rays and this also extends into the branches. Armlets given off at every third, fourth or fifth brachial plate, those of the branches at each fourth brachial plate.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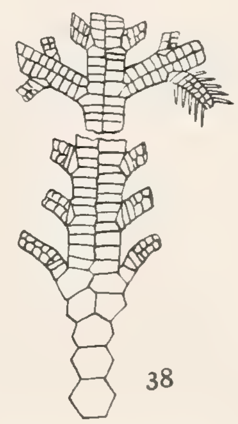
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Figure 37 Melocrinus (Trichotocrinus) harrisi. Portion of an arm showing the trichotomous branching. (After Olsson, 1912).

Figure 38 Melocrinus (Trichotocrinus) harrisi. The branches of its biserial arms. (After Olsson, 1912).

Regular interradials 1, 2, 3, and others above, more or less hexagonal in shape and highly ornamented. The plates rapidly decrease in size on passing upwards towards the ventral surface and the shape varies.

Horizon and locality. From the Portage (Ithaca) beds, McGraw or University quarry, Ithaca, N. Y.

Remarks. It has not been possible to obtain the holotype. Comparisons with the other species have been based upon the original description and figures. See *Remarks* under M. (Trichotocrinus?) lutheri for comparisons with that species.

Melocrinus (Trichotocrinus?) lutheri sp. nov.

Plate 16, figures 7-12

This species is represented by a number of specimens both of the calyx and of the arms. Detached arms or portions of arms are very frequent and in various stages of preservation. Both calyx and arms are usually preserved as sharp, external molds in sandstone or sandy shale. The description here is based mainly upon three specimens. The smallest example (plate 16, figure 9) shows the anal interradius; figure 8, an external mold, shows the calyx, the proximal portions of two arms and about 35 cm of stem. The figure was made from a gutta-percha squeeze. The largest and oldest specimen (figure 7) is imbedded in rock, and shows one side of the dorsal cup, a portion of the tegmen, a considerable portion of one arm trunk and a few joints of the stem. Some of the more perfect specimens of the main arms are also figured (figures 10–12). The species is of medium size.

Dorsal cup as high as wide, spreading rapidly. Basals four, forming a low cup; the largest hexagonal, the other three pentagonal. Radials about as wide or slightly wider than high, four heptagonal, the one resting upon the hexagonal basal hexagonal. First primibrachs hexagonal, smaller than the radials, slightly wider than high. Primaxils pentagonal or hexagonal, supporting 2 x 10 secundibrachs which are in contact in the same ray and give rise to the main trunks or arms.

Primary interbrachial of about the same size as the first primibrach, and, so far as observed, hexagonal. It is followed by two plates in the second range, two in the third, three in the fourth, and in the fifth, five or six small plates which merge into the tegmen. One small specimen shows the anal interradius. In this there are three plates in the second row and apparently three in the third.

Tegmen slightly arched and made up of numerous small irregular plates. Interradial areas slightly depressed.

Arms. The radial trunks branch some distance above the calyx. Usually these branches are oppositely arranged and together with the main trunk form the trichotomy upon which the subgenus is based. One specimen of an arm (figure 10) has been found in which the first division is nearer the calyx, the second division being only a short distance above this. This character of the main arms is shown in the older specimen incompletely (figure 7) and in separate specimens of the arms (figures 11, 12). The main trunk and the branches are deeply grooved along the fusion of the rays, and they bear on each side at every fourth or fifth, usually every fourth, brachial a uniserial arm bearing comparatively long pinnules. There is a strong, rather long, articulated spine on the dorsal side at the place of origin of the branches of the arm trunk and also at the origin of each arm.

The younger specimen (figure 8) shows only a very small portion of the arms, only enough to indicate the character of the main trunk and the uniserial character of the proximal arms. On the same slab with this specimen are detached arm trunks showing the trichotomous branching.

Column. One of the specimens (figure 8) shows about 35 cm of stem. It is stout for the size of the specimen, measuring about 5 mm in the proximal portion and 6 mm in the distal portion. The stem is made up of alternating thick and thin columnals.

Ornamentation. This species is beautifully ornamented. Each plate of the dorsal cup supports a central spine, and, so far as can be ascertained, the plates of the tegmen are also provided with a central spine or tubercle. Prominent radiating ridges connect the centers of the different plates, crossing suture lines. These ridges form six- or seven- sided stars according to the number of sides each plate possesses. In addition to the ridges the plates are ornamented with granules which may be irregularly distributed or more or less fused into delicate ridges parallel to the main ridges. The ridges and granules, as well as the central spines are present on the tegminal plates; the ridges are fainter, but the granules seem to be as well developed.

In the older form (figure 7) the radial ridges are fainter and the papillae form strong vermicular markings over the surface of all the plates.

As noted above, the arm trunks are marked with articulated spines at the place of branching of the main trunk and also at the origin of each arm.

Horizon and locality. From the Portage beds (West Hill flags), Italy hollow, near Naples, N. Y.

Types. Cotypes in the New York State Museum.

Remarks. This new species has been placed under the subgenus Trichotocrinus because it possesses the characteristic branching of the arm trunks. The younger specimen (figure 8) does not show the character of the main arms in this regard; but the calyx shows only those differences which would be found between young and mature forms of the same species, and is therefore referred to this species. On the slab with this younger specimen are detached portions of arm trunks with trichotomous branching. The association of the detached arm trunks here figured with the calyces leaves no doubt as to their connection with this species. The arms in all cases, as far as can be determined, are uniserial. Olsson (1912, pp. 2, 3) states that his subgenus is based on one specimen with only one main arm preserved, and so far as he can ascertain the arms are biserial; and he so figures them. It may be possible that the character of the arms of this genus is variable. Judging by the preponderance of arm trunks with trichotomous branching, it is probable that strictly trichotomous branching is the rule.

A very young specimen referred to this species (figure 9) is of especial interest. As far as preserved, it shows only the Melocrinus type of arm, though in all other respects characteristic of the species. The arms are not preserved to their full length, and it is possible that the trichotomous branching occurs high up on the arm; but, as pointed out in the *Introduction*, page 49, this condition in such a young specimen is very suggestive of an ontogenetic stage repeating the evolution of the subgenus in the development of the individual.

Melocrinus (Trichotocrinus?) lutheri bears a resemblance to two species described by Olsson (pp. 3, 5, pl. 6, figs. 1, 2; pl. 7, fig. 1), Melocrinus (Trichotocrinus) harrisi and Melocrinus reticularis. M. reticularis, when arms are present, is readily distinguished from lutheri. Reticularis has a more elaborate system of ridges, no central spines on the plates, a groove beginning on the basals and continuing up through the radials, primibrachs, and secundibrachs; and the interradial series gives the succession 1, 2, 3, etc. (Olsson, p. 6). These characters make it easily separable from lutheri. There is a closer resemblance between lutheri and harrisi, partly because of the character of the arms. Harrisi lacks the central spines on the plates, the radial ridges seldom join in the centers and have beadlike elevations between them, and the regular radial series gives the succession 1, 2, 3 (ibid, pp. 3, 4), while lutheri has the interradial succession 1, 2, 2, 3, 5 or 6. If harrisi has biserial arms as the description and figures suggest, this is another point of difference. Olsson makes no mention of spines on the main arms, but his figures seem to indicate that they might have been present.

This fine species is named in honor of its collector, D. Dana Luther.

Section **DOLATOCRINITES** Wachsmuth & Springer

Genus CLONOCRINUS Quenstedt 1876

Clonocrinus (?) **macropetalus** (Hall) n. comb.

Plate 20, figure 10

1859 Mariacrinus macropetalus Hall. Pal. N. Y., 3:111, pl. 3 A, figs. 1, 8, 9, 10–12; pl. 3 B, figs. 1, 2

1868 Mariacrinus macropetalus Shumard. Trans. Acad. Sci. St Louis, 2:380

1877 Mariacrinus macropetalus S. A. Miller. Amer. Pal. Foss., p. 83

1889 Mariacrinus macropetalus S. A. Miller. N. Amer. Geol. & Pal., p. 260

1897 Corymbocrinus ? macropetalus Wachsmuth & Springer. N. Amer. Crin. Cam., 1:28 (authors' ed.); Mem. Mus. Comp. Zool., v. 20

1899 Corymbocrinus macropetalus Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 2, p. 88

1900 Corymbocrinus ? macropetalus Schuchert. Bul. Geol. Soc. Amer., 11:279

1903 Mariacrinus macropetalus Clarke & Ruedemann. N. Y. State Mus. Bul. 65, p. 73

The specimen upon which this description is based is very fragmentary: when entire it must have been very large.

Dorsal cup large, probably hemispheric. The specimen consists of the base, a portion of two series of radial plates and one series of interbrachial plates. Basal plates wide and short; one larger than the others and hexagonal. Radials wider than high, the one resting upon the hexagonal basal hexagonal, the other four heptagonal. Primibrachs two, both wider than high; the first quadrangular; the second pentagonal, axillary. Secundibrachs two, shown in the half of one ray, wider than high; the first hexagonal, larger than the primaxil, followed by a smaller pentagonal plate which is axillary. Primary interbrachial very large, ten-sided, and followed in the second row by two smaller hexagonal plates.

Tegmen unknown.

Arms unknown.

Column large, round and deeply inserted into the base of the body.

Horizon and locality. Becraft limestone, Schoharie and the Helderberg.

Types. Two of the cotypes are in the New York State Museum, numbers $\frac{4300}{1}$, $\frac{4300}{2}$. Another is in the American Museum of Natural History, number $\frac{2299}{2}$.

Remarks. Hall (1850, p. 11, pl. 3 A, 3 B) referred to this species fragments of large columns which were associated with it in great numbers. They have not been refigured here.

Mariacrinus macropetalus Hall was designated by Wachsmuth & Springer (1897, v. 1, p. 282) as probably belonging to Corymbocrinus Angelin, and this designation was later accepted by Schuchert (1900, p. 279). Corymbocrinus Angelin proves to be synonymous with Clonocrinus Quenstedt (Bather, 1900, p. 162; Springer, 1913, p. 190), thus changing Hall's Mariacrinus macropetalus to Clonocrinus (?) macropetalus. The species is difficult to place because there is only one specimen and that very fragmentary. It is placed here with its doubtful designation.

Genus DOLATOCRINUS Lyon 1857 (W. & Sp. 1897)

Dolatocrinus glyptus (Hall)

Plate 18, figures 4–7

1862 Cacabocrinus glyptus Hall. 15th Rep't N. Y. State Cab. Nat. Hist., p. 140

1868 Dolatocrinus glyptus Shumard. Trans. Acad. Sci. St Louis, 2:367

1877 Dolatocrinus glyptus S. A. Miller. Amer. Pal. Foss., p. 77

1878 Cacabocrinus glyptus Bigsby. Thesaurus Dev.-Carb., p. 16

1881 Dolatocrinus glyptus Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 125 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:299

1889 Dolatocrinus glyptus S. A. Miller. N. Amer. Geol. & Pal., p. 240

1897 Dolatocrinus glyptus Wachsmuth & Springer. N. Amer. Crin. Cam., 1:317, pl. 26, figs. 2 *a*, 2 *b* (authors' ed.); Mem. Mus. Comp. Zool., v. 20

Syn. Cacabocrinus glyptus *var.* intermedius Hall

Syn. Dolatocrinus ornatus Meek

1900 Dolatocrinus glyptus Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 3, p. 196

1904 Dolatocrinus glyptus Clarke & Luther. N. Y. State Mus. Bul. 63, pp. 49, 52

1910 Dolatocrinus glyptus (ornatus Meek) Grabau & Shimer. N. Amer. Index Foss., 2:557

1921 Dolatocrinus glyptus Springer. U. S. Nat. Mus. Bul. 115, p. 41

Theca of medium size, the dorsal cup of one of the largest specimens examined, the holotype, having a width of 50 mm and a height of 22 mm. Dorsal cup depressed to subglobose; basal region flattened up to the first primibrachs, from there curving rather abruptly upward; periphery in some cases distinctly lobed, in others not. Vault moderately elevated.

Dorsal cup. Basals three, fused into a pentagonal disk, the sutures usually visible. Radials hexagonal, wider than high; plates comparatively narrower at the base, broadening rapidly upward. First primibrachs quadrangular, averaging twice as broad as high, much narrower than the radials. Primaxils pentagonal, supporting 2 x 10 fixed secundibrachs which in turn support the free arms. Primary interbrachial very large, nonagonal, and followed either by a hexagonal or heptagonal plate, depending upon whether or not the plate of the second range has fused with the central plate of the third range. In case of such fusion, the resultant plate is heptagonal, with a broad base and narrowing gradually upward. On its concave upper sides rest two interbrachials.

Tegmen composed of heavy nodose plates; interambulacral areas moderately depressed. Anal tube stout, central.

Arms apparently stout; otherwise their nature is not known.

Column moderately large, only partially concealing the basal disk. Axial canal pentalobate.

Ornamentation. In the adult glyptus the ornamentation consists chiefly of rather regularly arranged elongate nodes and granules. The ridge traversing the radial series is quite distinct, though seldom continuous.

The youngest specimen observed (plate 18, figure 4) has an ornamentation somewhat resembling that of liratus. The carinae forming the triangles characteristic of that species are as a rule incomplete, and at times are indicated merely by faint striae. The radial ridge is represented by elongate nodes at the centers of the plates, which merge into one another more or less completely.

In the next stage observed (plate 18, figure 5) the radial ridge has become practically continuous. All signs of uninterrupted linear ornamentation have disappeared in the interradii, being replaced by a series of elongate nodes ranging from 1 to 4 mm in length.

In the final stage, these elongate nodes are broken up still more completely (plate 18, figures 6, 7).

Horizon and locality. Hamilton (Moscow) shales. Holotype from Pavilion, N. Y.; other specimens from York, Livingston county, and Hopewell, N. Y. Also reported from the Ludlowville shales of the Canandaigua lake region.

Types. Holotype in the American Museum of Natural History, number $\frac{5031}{1}$. The old specimen, figured on plate 18, figure 7, from Hopewell, N. Y., apparently has on it a faded hypotype mark of the Museum, and may be the specimen figured by Wachsmuth and Springer (1897, plate 26, figure 2 *b*).

Remarks. Dolatocrinus glyptus differs from liratus in its somewhat more globose form, its larger basals, and more particularly in its ornamentation. All of these are variable characters, but glyptus, as defined, seems to be a well-marked species.

The fragment of stem attached to the holotype is completely covered with matrix, but was restored by Wachsmuth and Springer in their Monograph, plate 26, figure 2 *a*. The stem is really wider than figured by them, its width being more nearly that given on plate 18, figure 6.

Dolatocrinus glyptus var. **intermedius** (Hall)

Plate 18, figure 8

1862 Cacabocrinus glyptus *var.* intermedius Hall. 15th Rep't N. Y. State Cab. Nat. Hist., p. 141

1868 Dolatocrinus glyptus *var.* intermedius Shumard. Trans. Acad. Sci. St Louis, 2:367

1869 Dolatocrinus glyptus *var.* intermedius Lyon. Trans. Amer. Philos. Soc. Phila., p. 444

1877 Dolatocrinus glyptus *var.* intermedius S. A. Miller. Amer. Pal. Foss., p. 77

1878 Cacabocrinus glyptus *var.* intermedius Bigsby. Thesaurus Dev.-Carb., p. 16

1881 Dolatocrinus glyptus *var.* intermedius Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 126 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:300

1889 Dolatocrinus glyptus *var.* intermedius S. A. Miller. N. Amer. Geol. & Pal., p. 240

1897 Syn. Dolatocrinus glyptus Wachsmuth & Springer. N. Amer. Crin. Cam., 1:318 (authors' ed.); Mem. Mus. Comp. Zool., v. 20

1904 Dolatocrinus intermedius Clarke & Luther. N. Y. State Mus. Bul. 63, p. 52

1905 Dolatocrinus glyptus *var.* intermedius Clarke & Ruedemann. N. Y. State Mus. Rep't for 1904, p. 118

1921 Syn. Dolatocrinus glyptus Springer. U. S. Nat. Mus. Bul. 115, p. 41

This variety differs from glyptus in the character of its ornamentation. In this form, instead of having the linear ornamentation broken up into a series of elongate, sharply defined nodes, the lines remain unbroken, but are very indistinct, in some cases being nearly obsolete. At the center of each primary interradial is a conical protuberance, while near it on the same plate are from one to three irregular nodes. The radial ridge is well defined, and at its bifurcation on the primaxil forms a prominent node. This type of ornamentation differs considerably from that of glyptus, as well as that of liratus — so much so that it seems best to maintain the variety as defined by Hall.

Horizon and locality. Hamilton (Moscow) shales at York, Livingston county, N. Y.

Types. Holotype in the New York State Museum, number $\frac{4141}{1}$.

Dolatocrinus liratus (Hall)

Plate 17, figures 1–13; plate 18, figures 1–3

1862 Cacabocrinus liratus Hall. 15th Rep't N. Y. State Cab. Nat. Hist., p. 139

Cacabocrinus liratus *var.* multilira Hall. 15th Rep't N. Y. State Cab. Nat. Hist., p. 139

1868 Dolatocrinus liratus Shumard. Trans. Acad. Sci. St Louis, 2:367

Dolatocrinus liratus *var.* multilira Shumard. Trans. Acad. Sci. St Louis, 2:367

1869 Dolatocrinus (Cacabocrinus) liratus Lyon. Trans. Amer. Philos. Soc. Phila., 13:443

1877 Dolatocrinus liratus S. A. Miller. Amer. Pal. Foss., p. 77

Dolatocrinus liratus *var.* multilira S. A. Miller. Amer. Pal. Foss., p. 77

1878 Cacabocrinus liratus Bigsby. Thesaurus Dev.-Carb., p. 16
Cacabocrinus liratus *var.* multilira Bigsby. Thesaurus Dev.-Carb., p. 16
1881 Dolatocrinus liratus Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 126 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:300
Dolatocrinus liratus *var.* multilira Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 126 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:300
1889 Dolatocrinus liratus S. A. Miller. N. Amer. Geol. & Pal., p. 240
Dolatocrinus liratus *var.* multilira S. A. Miller. N. Amer. Geol. & Pal., p. 240
Dolatocrinus liratus Whiteaves. Contr. Can. Pal., v. 1, pt. 2, book 2, p. 98
1897 Dolatocrinus liratus (prob. var. of glyptus) Wachsmuth & Springer, N. Amer. Crin. Cam., 1:319, pl. 26, fig. 3 (authors' ed.); Mem. Mus. Comp. Zool., v. 20
1898 Dolatocrinus liratus Bownocker. Bul. Denison Univ., v. 11, art. 2, p. 20
1900 Dolatocrinus liratus Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 3, p. 196
1904 Dolatocrinus liratus Clarke & Luther. N. Y. State Mus. Bul. 63, pp. 49, 52
1905 Dolatocrinus liratus *var.* multilira Clarke & Ruedemann. N. Y. State Mus. Rep't for 1904, p. 118
1910 Dolatocrinus liratus Grabau & Shimer. N. Amer. Index Foss., 2:557
1921 Dolatocrinus liratus Springer. U. S. Nat. Mus. Bul. 115, p. 41

Quite a large species, specimens ranging up to 60 mm in breadth having been found.

Dorsal cup depressed to subglobose; basal region generally flattened, or even somewhat concave up to the primibrachs. From here the plates may turn abruptly upward, giving a subglobose form (plate 17, figure 2) or the flattening may partially include the first primibrach, resulting in a more depressed form (plate 17, figure 1). The dorsal cup varies considerably in its proportions, the chief variations occurring in the adult specimens. Measurements of a number of individuals give the following figures:

Height	Breadth
5.6 mm	12.5 mm
7.3	16.8
(7)	17.9
(abnormal) 12.3	25.
15.5	30.
16.5	41.
17.	36.
23.	38.
(18)	51.
..	60.

The measurements enclosed in parentheses are only approximate, owing to distortion of the specimens.

Basals fused into a tripartite, pentagonal, excavated disk which in adult specimens has a prominent rounded rim which projects beyond the column. Radials hexagonal, nearly twice as broad as high. First primibrachs quadrangular, of about the same height as the radials, but narrower. Primaxils pentagonal, slightly wider than the first primibrachs, supporting 3 x 10 large secundibrachs (fixed), giving two arms to a ray. Primary interbrachial nonagonal, large, reaching to about the middle of the primaxil, usually followed by one plate in the second and three in the third range. Intersecundibrachs one, large, resting on the upper faces of the second secundibrachs and between the third secundibrachs.

Tegmen only slightly elevated with depressed interambulacral areas (plate 17, figure 4). Plates of the tegmen rather heavy and with central nodes; in addition often papillose or with vermicular markings.

Anal tube (plate 17, figure 5) stout and subcentral; length unknown, although it was probably not much longer than that figured on plate 24, figure 3.

Arms only known from fragments; fairly stout, biserial, with rounded backs. In two rays of one specimen (plate 18, figures 2, 3) a bifurcation is shown a short distance above the calyx; whether higher bifurcations occur is not known. This specimen is abnormal.

Column round and fairly stout; central canal large and pentalobate.

Ornamentation. This is the most beautifully ornamented species of Dolatocrinus. Traversing the radial series run low carinae, which rise into tubercles at the centers of the plates. From the center of each radial to the next runs a carina. Proximad in each interradius there is a variable number of carinae parallel to this, the whole forming a series of pentagons surrounding the basal disk. From the center of each primary interbrachial, carinae run to the centers of the adjacent radials, primibrachs, and secundibrachs, and the single large interbrachials of the second range. These carinae form a set of triangles, within each one of which is a group of smaller triangles, more or less perfect, which nest one within the other.

Ontogeny. The changes taking place in the integumentive development of this species are very great. The general proportions of the dorsal cup remain fairly constant. The character of the base and the ornamentation are, however, subject to great modifications.

In the young form, the basal region is deeply excavated, and the basals are deeply sunk in the basal pit (plate 17, figures 6–9). With the growth of the crinoid, this pit gradually becomes filled by a thickening of the basals and the lower portion of the radials, giving a flat or slightly excavated base (figures 1, 2, 11.) The basals become more and more prominent finally projecting in a well-defined rim (figures 1, 3, 10, 12).

In the youngest forms observed (figures 6–8) a prominent ridge runs from the center of each radial to the next, forming a pentagonal, elevated rim about the basal pit. From the center of each primary interbrachial a strong carina runs to the center of each adjacent radial, first primibrach, primaxil, and secundibrach. Between these carinae, the surface of the plates may be somewhat roughened, or there may even be incipient secondary carinae present. Along the radial series extends a prominent ridge which runs into sharp nodes at the center of each plate traversed. The ornamentation in these specimens as in other individuals in various stages of development, varies considerably in the different interradials.

At least up to the stage represented in figure 8, the development of the ornamentation consists in a strengthening of the carinae already formed, and a greater accentuation of the nodes on the plates of the radial series and the primary interbrachials. The only notable addition to the ornamentation is that of the somewhat irregular ridges circumscribed by the carinae passing from the primary interbrachial to the radials, and from radial to radial.

The next stage observed is, unfortunately, considerably older (figure 9). The carinae are much less prominent, and with the widening of the interradii their number has greatly increased. The nodes borne by the primary interbrachials and formed by the intersection of the radiating carinae are scarcely noticeable. The keel traversing the radial series is quite strong, while the nodes are comparatively less conspicuous. The basal pit is quite marked, but has already become much more shallow. In the specimen figured, the basals have been slightly crushed in, making the pit seem deeper than it really is.

With increasing age the basal region becomes more flattened (figures 1, 2), and the ornamentation grows more complex. The radial keels are much less prominent.

In the adult form described by Hall (1862, p. 139) as liratus *var.* multilira (figure 10), the radial keels form a very insignificant part of the ornamentation, in some cases being practically obsolete. The ornamentation of the interradii is highly complex. Having reached this complex stage, there appears to be a breaking up of the carinae caused by a partial resorption (figures 12, 13). The beginning of this process may be seen in figure 11, where in parts the ornamentation has lost its distinctly linear character.

A portion of a very large specimen (figure 13) shows a complete breaking up of the carinae which are now represented by scattered tubercles. Close examination shows that they have a more or less linear arrangement, while on the surface of the plates may occasionally be seen indistinct striae marking the position of the original carinae. The radial ridges alone retain any degree of continuity. Even the projecting basal rim has become partially resorbed, and is marked by a ring of irregular tubercles.

Two abnormal specimens worthy of special mention have been observed. In one (plate 18, figures 1–3) but four rays have been developed, the fifth ray, apparently, being entirely unrepresented. The two primary interbrachials of the interradii that would normally be adjacent to the missing ray are unusually large, and together with an extension of the basals in that area, occupy the space usually filled by two interradii and a radial series. Another peculiar feature possibly induced by the abnormal condition of the dorsal cup is the possession by two of the rays of but one primibrach, being essentially similar in this regard to Stereocrinus.

In the other specimen, one interradius is exceptionally wide, owing to the greater size of the primary interbrachial and of the plates of the adjacent rays. The result of this enlargement is a peculiar change in the character of the ornamentation. This is of the typical *multilira* type, whereas all the other interradii are typically liratus. This fact shows very clearly that the type of ornamentation in liratus depends entirely on the width of the interradius and therefore, in normal individuals, on the age of the animal.

Horizon and locality. From the Hamilton (Moscow) shales of Geneseo; Cashong creek near Bellona; Bellona; Leicester, Livingston county; Menteth's point, Canandaigua lake; near Darien, Geneseo county; in the upper shales of the Livonia salt shaft; and in the Ludlowville shales of the Canandaigua lake region; also found in the Tully limestone near Tully, N. Y.

Types. Cotypes in the New York State Museum where they bear the catalog numbers $\frac{4142\ \mathrm{A}}{1}$ and $\frac{4142\ \mathrm{A}}{2}$; holotype of Dolatocrinus liratus *var.* multilira in the same collection, number $\frac{4142}{1}$.

Dolatocrinus liratus var. **parvulus** nov.

Plate 17, figure 14

From the Hamilton (Moscow) beds of Canandaigua lake comes a Dolatocrinus which resembles Dolatocrinus liratus in form, arrangement of plates and general character of the ornamentation; but differs from that species in its very much smaller size and the delicacy of the ornamentation. The specimen figured has a breadth of about 15.2 mm and a height of about 7.2 mm. The ridges extending up the radial series are very strong, raised into a conspicuous node on each radial and with less prominent nodes on the other plates. A series of three or four delicate carinae or lines extends from radial to radial forming around the base a series of pentagons nesting one within the other. The carinae from the center of the radials to the center of the primary interbrachials are even more delicate, and the carinae within the triangles thus formed are fainter still. There is usually only one carina, sometimes two, from the center of the primary interbrachial to the plates other than the radials. Thus the greater part of the ornamentation is confined to the radials and lower part of the primary interbrachials.

Holotype in the New York State Museum.

Dolatocrinus lamellosus (Hall)

Plate 19, figures 1, 2

1862 Cacabocrinus lamellosus Hall. 15th Ann. Rep't N. Y. State Cab. Nat. Hist., p. 141

1868 Dolatocrinus lamellosus Shumard. Trans. Acad. Sci. St Louis, 2:367

1877 Dolatocrinus lamellosus S. A. Miller. Amer. Pal. Foss., p. 77

1878 Cacabocrinus lamellosus Bigsby. Thesaurus Dev.-Carb., p. 16

1881 Dolatocrinus lamellosus Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 126 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:300

1889 Dolatocrinus lamellosus S. A. Miller. N. Amer. Geol. & Pal., p. 240

1889 Dolatocrinus lamellosus (in err.) Whiteaves. Contr. Can. Pal., v. 1, pt. 2, p. 98

1921 Dolatocrinus lamellosus (?) Springer. U. S. Nat. Mus. Bul. 115, p. 36

It is very probable that Hall's D. lamellosus is not a New York form (*see Remarks* below). The species is here described from specimens in the American Museum of Natural History labeled "Louisville, Kentucky". One of the specimens has the manuscript label "D. lamellosus" and is apparently Hall's type specimen. The description given below is based upon this type specimen (plate 19, figure 1) and the two other large forms, which meet the requirements of Hall's description. A fourth specimen is very small, incomplete and varies somewhat, but it may be a younger stage.

Dorsal cup large and broad and low, spreading horizontally to the top of the primaxil. Basals small, concealed at the bottom of the large, deep, subcircular basal depression into which the column fits. Radials hexagonal with a narrow base, expanding rapidly upward. Lower lateral faces very long and upper lateral faces very short, making the radials over twice as wide at the top as at the base. Lower third of the radials embraced in the basal depression.

First primibrachs short, quadrangular, not as broad as the radials, over one and a third times as broad as high. Primaxils pentagonal, both higher and broader than the first primibrachs, with long upper faces which support 2 x 5 secundibrachs. Secundibrachs large, pentagonal or hexagonal and axillary, supporting on each upper face a series of three tertibrachs which are smaller. This gives 3 x 20 tertibrachs in the dorsal cup.

Primary interbrachial large, the largest plate in the cup; resting between the plates of the adjacent radial series as high as the secundaxils or first tertibrachs; ten- or eleven-sided, depending upon whether or not it touches the first tertibrachs. Usually one plate in the second row, pentagonal, followed by two in the third and apparently two in the fourth; sometimes one plate in the second and one in the fourth, in which case the second plate is quadrangular. In one interradius in the larger specimen there are two plates in the second row, and the first tertibrachs do not rest upon the primary interbrachial; a smaller specimen shows two small plates in the second row and the first tertibrachs bordering the primary interbrachial, which therefore has twelve sides. This may be the anal interradius.

At least one interaxillary (intertertibrach) separating the half rays at the level of the second tertibrachs. It is small and appears to be followed by a second one half its size. This is only shown in one ray, so it can not be further verified.

Tegmen not preserved in any of the specimens.

Arms twenty, four to a ray; apparently heavy, but no part of them preserved.

Column large and round, judging by the stem cicatrix situated at the bottom of the deep basal pit. Axial canal large and pentalobate.

Ornamentation. The plates of the dorsal cup are ornamented with numerous fine radiating striae passing from center of plate to the centers of adjoining plates. This ornamentation is similar to, but more delicate than, the *multilira* type of ornamentation in D. liratus. A strong central ridge passes up the radial series from the edge of the basal depression to about the center of the primaxil. Along the ridge on the radials and first primibrachs are strong rather sharp nodes; particularly strong and sharp on the radials, where they give a pentagonal appearance to the basal depression. The ridges almost die out on the primaxils; but they continue over the secundaxils as rather accentuated striae, which become elevated on the tertibrachs into broad angular ridges which continue to the arm bases.

In the specimen doubtfully referred to a younger stage of this species, the striae are fewer and have more the character of elevated laminae, and the radial ridges are less pronounced. These, however, are all characters which are to be expected in younger forms.

Horizon and locality. Cited by Hall from the Onondaga of western New York, but there seems to be little doubt now that the type, as well as the other specimens in the American Museum, is from the Onondaga of Louisville, Kentucky (*see Remarks* below).

Types. Holotype and the other specimen figured here in the collection of the American Museum of Natural History, number 4167.

Remarks. The specimen figured on plate 19, figure 1, fits the original description and is no doubt Hall's type. It is labeled "near Louisville, Kentucky," and the rock is not the characteristic New York Onondaga. Doctor Springer in writing to me of this species says: "D. lamellosus (which you identified in the American Museum from Louisville specimens) is probably not a New York species at all. The type is there, as I saw it many years ago and made a cast of it; and I noted at the time that it was apparently from Louisville." Through the kindness of Doctor Springer I have a cast from the wax impression of the type, and this cast corresponds with the specimen which I had already judged must be the type.

Miller & Gurley (1894, no. 4, p. 8, pl. 1, figs. 4, 5) described specimens of Dolatocrinus from the Hamilton of Charlestown, Ill., as D. spinosus.[1] In the specimens described the surface ornamentation was not preserved. Outside of this, apparently the only difference between the dorsal cups of the two species is the presence of three plates in the third row of interbrachials in spinosus, which is a variable character anyway. The tegmen is not preserved in the specimens of lamellosus, so no comparison in this respect between the two specimens can be made.

Rowley (in Green, 1903, p. 164, pl. 48, fig. 4) refers an abnormal, four-rayed specimen doubtfully to spinosus. This specimen is from the Middle Devonian, Falls of the Ohio. It shows the ornamentation beautifully, and, so far as preserved, fits the description of lamellosus.

In writing concerning the type of D. lamellosus Springer says:

> It (the type) is incomplete, being minus the tegmen, for which reason the name can not take precedence over Miller & Gurley's D. spinosus, of which the dorsal cup is identical with this, but the tegmen strongly spiniferous. As we do not know whether lamellosus is spiniferous or not, we have to recognize Miller & Gurley's species and leave the earlier one in doubt.[2]

It might be well to retain both species until the character of the tegmen of lamellosus is established. Many fossils have been named from

[1] Shown by Springer (1921, pp. 34, 35) to be Onondaga of Louisville and vicinity.

[2] The same position is held by Springer (1921, p. 36) in his paper on Dolatocrinus and its allies.

incomplete specimens, and a more complete or perfect specimen found later takes the earlier name. Therefore, if only one of the two specific names is to be retained, instead of both, lamellosus ought to stand until further material proves whether its tegmen is or is not identical with that of spinosus.

Dolatocrinus speciosus (Hall)

Plate 18, figures 9–12

1862 Cacabocrinus speciosus Hall. 15th Rep't N. Y. State Cab. Nat. Hist., p. 137

1868 Dolatocrinus speciosus Shumard. Trans. Acad. Sci. St Louis, 2:367

1877 Dolatocrinus speciosus S. A. Miller. Amer. Pal. Foss., p. 77

1878 Cacabocrinus speciosus Bigsby. Thesaurus Dev.-Carb., p. 16

1881 Dolatocrinus speciosus Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 126 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:300

1889 Dolatocrinus speciosus S. A. Miller. N. Amer. Geol. & Pal., p. 240

1897 Dolatocrinus speciosus (in err.) Wachsmuth & Springer. N. Amer. Crin. Cam., 1:323, pl. 25, fig. 4 *a*, *b* (authors' ed.); Mem. Mus. Comp. Zool., v. 20

1905 Dolatocrinus speciosus Clarke & Ruedemann. N. Y. State Mus. Rep't for 1904, p. 119

1921 Dolatocrinus speciosus Springer. U. S. Nat. Mus. Bul. 115, p. 30

Theca of medium size. Dorsal cup in the holotype 33 mm in breadth by 16 mm in height, subglobose; largest specimen observed with breadth of about 38 mm. Basal region somewhat flattened up to the top of the radials. From there the cup curves outward and upward to the top of the primaxil; the sides of the cup above this point become practically vertical. Tegmen only slightly elevated.

Dorsal cup. Basals three, small, completely concealed within a rather deep pit, which is entirely filled by the stem. Radials hexagonal, broader than high; narrow at the edge of the basal pit, widening rapidly upward. First primibrachs quadrangular, about twice as broad as high. Primaxils pentagonal, slightly wider than the first primibrachs and much higher.

Secundibrachs in adult specimens 4 x 10, fixed. Primary interbrachial nonagonal, reaching to about the middle of the primaxil, followed in the second range by one quadrangular plate, and in the third by three smaller plates; occasionally, one, or possibly more, small plates in interradius in addition. Intersecundibrachs one, so far as observed, though there are probably more in older specimens. "Respiratory slits" two for each interradius, and two between the arms of each ray, making twenty in all.

Tegmen made up of heavy, somewhat nodose plates. Anal tube somewhat excentric, large. In the holotype the "obtusely pointed spine" mentioned by Hall, is not a spine at all, but appears to be the result of some abnormal condition of growth. In other specimens such a protuberance is entirely wanting.

Arms two to a ray, given off from sharply defined arm bases; arm bases of each ray separated from one another by a rather broad sulcus. As a result, the free arms of an adult specimen, at their inception, are fully 5 mm apart. This is about one half the interval that separates the arm bases of contiguous rays.

Column of medium size and round.

Ornamentation. The plates of the dorsal cup are heavy, and with the exception of the plates of the radial series, are often smooth and slightly convex. Traversing the plates of the radial series are narrow, rather high keels which at the centers of the plates become somewhat more elevated and thickened. The character of this keel varies considerably, ranging from a sharply defined, elevated carina to a low, broad ridge, rising gradually from the edges of the plates. This variation is one largely due to growth changes. The keel is narrow and well marked at first, but with the subsequent thickening of the plates it becomes broader, finally almost losing its distinctive character as a carina.

In the holotype, the interradii are marked by indistinct sets of parallel lines, radiating from the centers of the primary interbrachials and passing to the adjacent plates in series of four or five lines each. In some specimens even this incipient ornamentation seems to be entirely wanting.

Ontogeny. One interesting change due to growth is the shortening of the radials, owing to the enlargement of the stem. As the stem enlarges, the inner edges of the radials are resorbed, widening the basal pit. In the holotype, which possibly represents the maximum growth of the radials, these plates are 6 mm in height, while in a considerably older specimen (plate 18, figure 11) they average slightly less than 5 mm in height.

Horizon and locality. Onondaga limestone. Holotype from Schoharie county, exact locality unknown; other localities are Cherry Valley, Otsego county, and Thompson's lake, Albany county, N. Y.

Types. Holotype in the collection of the New York State Museum, number $\frac{4143}{1}$.

Remarks. It is very unfortunate that Hall did not figure this species. Wachsmuth and Springer formed an erroneous impression as to the nature of speciosus from the description given by Hall and figured quite a different form in their Monograph, Pl. 25, figs. 4*a*, 4*b*.

See *Remarks* under Dolatocrinus lobatus.

Dolatocrinus ornatus Meek

Plate 18, figures 13, 14

1871 Dolatocrinus ornatus Meek. Proc. Acad. Nat. Sci. Phila., 23:57

1878 Dolatocrinus ornatus Bigsby. Thesaurus Dev.-Carb., p. 17

1885 Dolatocrinus ornatus Wachsmuth & Springer. Rev. Palaeocr., pt. 3, p. 105 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 27:327

1889 Dolatocrinus ornatus S. A. Miller. N. Amer. Geol. & Pal., p. 240

1894 Dolatocrinus ornatus Miller & Gurley. Bul. Ill. State Mus. Nat. Hist., no. 4, p. 18, pl. 2, figs. 7, 8, 9

1897 Syn. Dolatocrinus glyptus Wachsmuth & Springer. N. Amer. Crin. Cam., 1:318 (authors' ed.); Mem. Mus. Comp. Zool., v. 20

1904 Dolatocrinus ornatus Wood. Smith. Misc. Coll., v. 47, no. 1471, p. 76

1921 Dolatocrinus ornatus Springer. U. S. Nat. Mus. Bul. 115, p. 29, pl. 6, figs. 1–4

Theca small, the dorsal cup of the specimen examined having a width of 23 mm and a height of 17.5 mm. Dorsal cup depressed, subglobose, with nearly vertical sides and basal area flattened up to and including the lower part of the first primibrach. Vault moderately elevated with depressed interambulacral areas making the arm bases slightly protuberant. The flattened basal area includes a shallow concavity taking in the radials and basals.

Dorsal cup. Basals small, fused into a pentagonal disk, no suture line visible. Basal plate marked with a rather deeply indented column facet, so that when the column is attached only a very narrow ring of the basals would be visible.

Radials hexagonal, wider than high, with the upper (distad) face the longest; extend out nearly horizontally, in their lower portions curving slightly into the shallow central concavity.

First primibrachs quadrangular, one third wider than high, less broad and less high than the radials. Primaxils pentagonal, as wide as the primibrachs and as high or slightly higher, supporting 2 x 10 secundibrachs which in turn support the free arms. First secundibrach considerably smaller than the primaxil; second secundibrach smaller again and somewhat cuneiform. Primary interbrachial large, nonagonal, above the center as wide or wider than high; followed by a hexagonal plate due to the fact that the plate of the second range has fused with the central plate of the third range. This fusion gives a plate with a broad base and narrowing gradually upward. On its concave upper sides rest two interbrachials, while the short truncate upper side connects with the large cuneiform interambulacral plates of the tegmen. There are no interaxillaries present.

Tegmen composed of large plates ornamented with tubercles which are most numerous in the ambulacral areas and on the plates about the anal tube. Orals large and pushed anteriorly by the subcentral anal tube. In this specimen the anal tube was broken off at the base, but apparently was stout. Two large, cuneiform plates in the interambulacral area connect with the interbrachials of the dorsal cup.

As far as the tegmen is concerned, figure 14 is not entirely accurate. The specimen was weathered so that the small projecting tubercles were not very distinct. They are not shown in the drawing; neither is the broad and rather deeply lobed character of the tegmen brought out. (*See* Springer 1921, pl. 6, fig. 2.)

Arms ten, two to each ray, rather stout and biserial; broken off in the specimen described.

Column moderately large and round, judging from the cicatrix.

Ornamentation. The surface of the dorsal cup is ornamented with radial ridges and radiating costae. A ridge or carina starts at the proximad face of each radial and runs along the radial series, bifurcating on the primaxil and forming a prominent, rather sharp node at the center of each plate, the one on the first primibrach being the strongest. From the upper part of the node of each radial a rather strong curving carina runs to a similar place on the neighboring radials, thus forming a pentagon with slightly curving sides which surrounds a shallow concavity. Within this pentagon is another formed by carinae a little less strong. The primary interbrachial has a small central node from which radiate carinae to the nodes of the radials, first and second primibrachs, and first secundibrachs. Between these are a variable number of fainter radiating ridges, and there are several fainter ridges radiating to the interbrachials above. The surface of the tegmen is ornamented with numerous, small projecting tubercles.

Horizon and locality. The specimen figured here is from the Onondaga limestone, Cherry Valley, N. Y. Holotype and types of Miller and Gurley are from the Onondaga, Columbus, Ohio. It is also doubtfully listed from the Hamilton, Beargrass creek, Ky. (Wood, 1904, p. 76).

Types. Holotype not located.[1]

Remarks. Dolatocrinus ornatus was described by Meek (1871, p. 57) without an illustration. Miller and Gurley in 1894 (pp. 18, 19, pl. II, figs. 7, 8, 9, no. 4) quoted Meek's description and illustrated

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[1] In Columbia University, N. Y. Recently figured by Springer (1921, pl. 6, fig. 1).

it with three views of a specimen from the typical locality, Onondaga formation, Columbus, Ohio. A few years later Wachsmuth and Springer (1897, p. 318) regarded this species as a synonym of Dolatocrinus glyptus (Hall).[1] Wood (1904, p. 76) from a study of some specimens in the U. S. National Museum from the Onondaga, Columbus, Ohio, reinstates Dolatocrinus ornatus as a species. She figures no specimens, but states that her specimens agree with Meek's description and Miller and Gurley's figures and differ widely from Dolatocrinus glyptus. The more mature specimens of glyptus show short discontinuous ridges or "lines of nodes" and are distinctly different from ornatus. The ridges or lines ornamenting the dorsal cup are often more distinct and regular in younger forms; but the younger forms of glyptus with their liratus-like type of ornamentation are decidedly distinct from ornatus.

The specimen figured here (plate 18, figures 13, 14) appears to have stronger carinae forming the basal pentagons and stronger radial ridges than Miller and Gurley's specimen; but the strength of ornamenting ridges varies so considerably within a species, especially in the different growth stages, that this can scarcely be considered an essential difference.

Dolatocrinus marshi var. **glaber** nov.

Plate 20, figures 1, 2

This specimen very much resembles marshi (Wachsmuth and Springer, 1897, pl. 26, fig. 1*a*, *b*, *c*, *d*, v. 1, pp. 312, 313), but shows enough differences to be given varietal value. The calyx of marshi *var.* glaber is more decidedly lobed than marshi, the arm bases are closer together, no interaxillary plates being present, and the interradii are slightly more convex and smooth. The plates of the radial series are without ornamentation except for the sharp keels. In marshi, the primary interbrachial is followed by a good-sized single plate, and this by two ranges of three plates each; in marshi *var.* glaber the

[1] Regarded as a valid species by Springer, 1921, p. 29.

primary interbrachial is followed by a hexagonal plate which supports three others, two small ones on the sloping superior lateral faces, and a fairly large pentagonal plate on the upper face, which joins the two cuneiform plates in each of the interambulacral areas of the tegmen. A single cuneiform plate in the tegmen extends out between the arms of each pair. " Respiratory slits " not visible.

Horizon and locality. From the Onondaga limestone, Cherry Valley, New York.

Types. Holotype in the New York State Museum.

Remarks. See *Remarks* under Dolatocrinus lobatus.

Dolatocrinus insignis sp. nov.

Plate 19, figures 3–6; text figure 39

A very large species, the largest well-preserved specimen observed measuring 55 mm in breadth by about 20 mm in height. Another, fragmentary, specimen would have measured fully 60 mm in breadth. Dorsal cup probably low, with the basal region flattened, or even somewhat concave. Periphery decidedly lobate; tegmen almost flat.

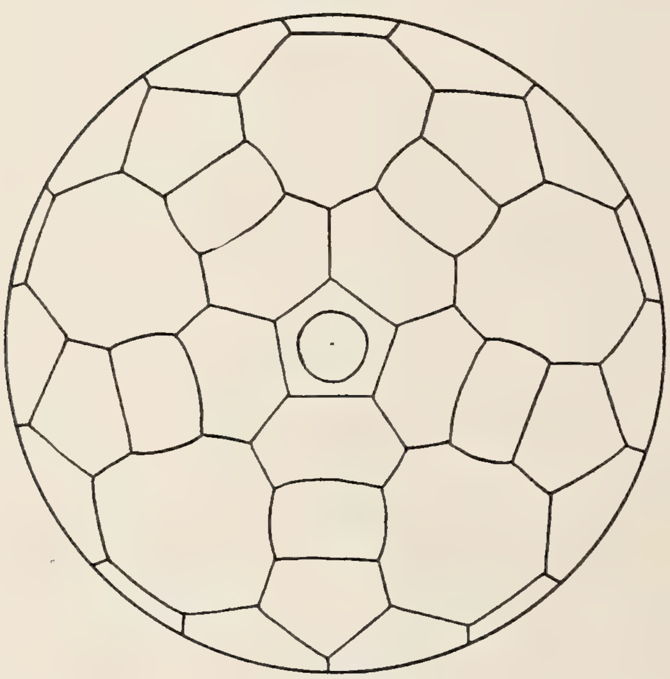

Figure 39 Dolatocrinus insignis. Diagrammatic restoration to show large size attained by this species. Basal view of the dorsal cup of the specimen figured on plate 19, figure 6.

Dorsal cup. Basals three, fused into a large pentagonal disk which projects considerably beyond the column; center of disk deeply excavated. Radials hexagonal, averaging about twice as broad as high. First primibrachs quadrangular, narrower than the radials and not so high. Primaxils pentagonal, of about the same width as the first primibrachs and higher, supporting 4 x 10 fixed secundibrachs. First two secundibrachs very large and massive; the third and fourth much smaller and wedge-shaped.

Primary interbrachial nonagonal. Interbrachials of the second range may or may not be fused with the median plate of the third. In an adult specimen (plate 19, figure 3) fusion has taken place in all but one interradius. In the younger specimen (figure 5) the character of one interradius can not be determined. Of the remaining number, three are not fused. Intersecundibrachs two.

Tegmen composed of massive, irregularly granulose plates (plate 19, figure 4). Interambulacral areas decidedly depressed; anal tube subcentral.

Arms. Arm facets large, indicating massive arms, of which there are two to a ray.

Column round, deeply inset in the basal disk.

Ornamentation rather simple. Each plate of the radial series has a median, longitudinal elevation, a continuous ridge, however, never being formed. From the center of each radial and the other plates of the radial series radiate indefinite ridges, variable in number and length. Each primary interbrachial has a central node from which diverge strongly marked ridges, which, however, seldom pass over to the adjacent plates. Centers of the radials and primary interbrachials somewhat depressed longitudinally, giving a curious pinched appearance to the plates.

Ontogeny. In the youngest specimen observed (plate 19, figure 5) the basal disk is quite small, scarcely extending beyond the column; radials larger than in the older specimens, but this may well be due to individual variation.

Ornamentation in this specimen of the same general character as that of the adult, except that the radiating ridges are prominently developed. Central depressions in the plates, noted above, perhaps more noticeable here, largely owing to the fact that the ornamentation tends to fill them up in the older specimen.

In the largest, fragmentary, specimen (figure 6) the ridges in the interradii form more or less complete patterns, somewhat resembling liratus; the lines are, however, very indistinct.

Horizon and locality. From the Hamilton (Moscow shale) beds. Holotype (plate 19, figures 3, 4) from Bellona, N. Y.; other specimens from Canandaigua lake, Bellona, and Livonia salt shaft (383–387 foot level).

Types. Holotype and paratypes in the collection of the New York State Museum.

Remarks. Dolatocrinus insignis does not particularly resemble any species hitherto described. It is one of the largest species of Dolatocrinus, the fragmentary specimen figured on plate 19, figure 6 (text figure 39), probably exceeding in size the specimen of Dolatocrinus magnificus figured by Miller and Gurley (1894, no. 4, pl. 1, figs. 1–3). This species differs from glyptus, among other things, in size, number of secundibrachs, and the character of the ornamentation of the plates of the dorsal cup.

Dolatocrinus lobatus sp. nov.

Plate 20, figures 3–6

This species is described from two specimens; one a very young individual (plate 20, figures 5, 6), the other an adult (figures 3, 4).

Species of medium size and belonging to the fairly compact, ten-armed group of Onondaga Dolatocrini represented by such forms as speciosus and marshi. Dorsal cup depressed, bowl-shaped, being nearly three times as broad as high. Basal region flattened in a very marked manner, all the plates up to the primaxil taking part in the truncation. Tegmen subconical, as high or higher than the dorsal cup; remarkable preponderance of the vault in the immature specimen. From an oral view the theca is seen to be decidedly lobed, strongly reminding one of certain Actinocrini from the Lower Carbonic. This lobation is almost entirely wanting in the young, and apparently was acquired during the development of the animal.

Dorsal cup. Basals three, very small, forming the bottom of the quite deep basal pit in which they are completely concealed; sides of this basal depression formed by the radials. Radials hexagonal, relatively smaller than in most species of Dolatocrinus. Especially is this true with regard to the width of the plates. In Dolatocrinus lobatus the radials widen but slightly distally, the proximal and distal faces giving very nearly the same measurements. In all the closely related species the widening of the radials is very marked. The following series of measurements gives the width of the proximal and distal faces, and the maximum width of the radials in the type of lobatus:

Proximal face	*Distal face*	*Maximum width*
4.3 mm	5.2 mm	7. mm
3.5	5.	7.3
4.3	5.	7.5
3.6	5.3	7.5
3.8	5.	7.1

The measurements are necessarily somewhat inaccurate owing to the fractured condition of the plates and the difficulty of exactly locating suture lines.

First primibrachs quadrangular, larger than the radials and somewhat narrower. Average height 5 mm; average breadth 6 mm. Primaxils pentagonal, of about the same height as the first primibrach and slightly wider. Average height 5 mm; average breadth 7 mm. These plates, as in the case of the radials and first primibrachs, proportionally narrower than in related species. Secundibrachs 3 x 10, fixed. First secundibrach quite short in the median line of the radial series and widening rapidly toward the interradius, reaching a maximum height equal to that of the primaxil; second and third secundibrachs much smaller than the first.

Primary interbrachial large, as in all the species of Dolatocrinus, and with either nine or ten sides. In the adult specimen, two of the interradii have two plates in the second range, and the other three only one. The small specimen has but one plate in the second series in all five interradii; probably the normal number. Supported by the single plate of the second series are either two or three plates in the third series, which in the adult specimen form the transition from the cup to the tegmen.

Tegmen subconical; formed of large heavy plates which in the young specimen are papillose. Anal tube apparently fairly stout and subcentral. In the small specimen, " respiratory slits " two for each interradius; in the larger specimen slits not visible.

Arms two to a ray, structure unknown. Arm openings diverge at a moderate angle, thus differing in a marked manner from the more globose speciosus.

Ornamentation. The plates of the radial series are marked by lines of heavy nodes. The spaces between the individual nodes are filled more or less completely with calcareous matter, differing from most of the allied species where the nodes are connected by narrow carinae or keels. At the second primibrachs the ridges bifurcate at a very small angle, averaging 60 degrees or less. As a result of the small angle the limbs remain close together, thus bringing the arm bases practically in contact. The nodes are quite prominent on all the plates of the radial series except the radials themselves which are marked by a very slight central elevation. In the interrays, the primary interbrachials are highly nodose, and the other plates tend in the same direction.

Horizon and locality. From the Onondaga limestone, Cherry Valley, New York.

Types. Holotype (plate 20, figures 3, 4) and paratype in the New York State Museum.

Remarks. Dolatocrinus lobatus differs from D. speciosus in the relative size of the dorsal cups and tegmens, in the decidedly lobed character of the calyx, in the flattening of the basal area, in the nodose character of the plates, and in the character of the bifurcation of the radial ridge. In the typical speciosus the ridge upon the bifurcation diverges at an angle as high as 100 degrees or over and the two limbs maintain this angle to the center of the secundibrachs, where they abruptly change and become parallel. This brings the arms quite far apart, about 6 mm.

Lobatus appears from the form of the vault and lobed character to approach Dolatocrinus marshi *var.* glaber, but differs entirely in the structure of the dorsal cup. It seems to form a transitional form between Dolatocrinus speciosus and Dolatocrinus marshi *var.* glaber, as the latter does between Dolatocrinus marshi and Dolatocrinus lobatus.

The specimen figured by Wachsmuth and Springer (1897, plate 25, figures 4*a*, *b*) as D. speciosus appears to belong here.

Genus CLARKEOCRINUS nov.

The specimens of this genus are of rather small size.

Dorsal cup. Basals anchylosed into a pentagonal disk, the sutures occasionally visible. Radials hexagonal. First primibrachs quadrangular; the second primibrachs pentagonal, axillary. Secundibrachs 2 x 10. Primary interbrachial large, reaching well up toward the top of the primaxil in mature specimens, ten- or eleven-sided, supporting two or three plates, as the case may be.

Tegmen slightly crushed, composed of a number of small irregular plates. Anal tube very long, slender and nearly central.

Arms long; provided with long, slender pinnules.

Column round and divided into a series of nodes and internodes. Nodal joints, as far as observed in about 11 cm of the proximal portion of the stem of Clarkeocrinus troosti, all cirrus-bearing, each nodal having a verticil of five cirri. Largest cirri observed about 12.5 cm in length; all below the first two or three nodes extend above the tips of the arms. If the cirri became longer distally, they must have reached a great length. Cirri on the two or three proximal nodes comparatively short. The cirri near their extremities in one or two cases seem to be curved into a hooklike form, but whether they were fitted up as in the modern Pentacrinus can not be determined (Agassiz, 1878, v. 5, p. 296;

Wachsmuth and Springer, 1897, v. 1, p. 42). They seem to have been quite mobile, and probably had properties quite similar to those of Pentacrinus.

Horizon and locality. Clarkeocrinus troosti occurs as a colony in the Hamilton (Moscow) shales of Vincent, N. Y., and is also reported from the Hamilton of the Falls of the Ohio by Lyon (1869, v. 13, p. 443). His identification is, however, extremely doubtful.

Genotype. Clarkeocrinus troosti.

Remarks. The arm brachials of this genus have usually two, sometimes four and six pinnules each — that is, one, two or three pinnules on each side. Bather (1893, p. 36; 1900, p. 116; 1897, pp. 337–345) states that the adjacent right and left ossicles of a biserial arm may fuse forming a compound brachial bearing two pinnules, and that two or more compound brachials may fuse, thus bearing two or three pinnules on a single side. That the two-pinnulid brachials in this genus are not due to fusion is the conclusion reached here:

First. At no point in a perfect arm are there signs of biseriality, as in biserial arms one finds uniserial brachials.

Second. There is no sign of biserial brachials in very young individuals throughout the length of the arms.

Third. No signs of the compound character of the brachials were observed in a number of sections made from various parts of the arms of different specimens.

All the ossicles near the tips of the arms bear two pinnules. Those bearing four have not been observed except in the lower portions of the arms. As one approaches the calyx, the four-pinnulid brachials become more frequent, the usual being two. At times, very near the calyx, there may be as many as two or three or even four out of five bearing four pinnules. The six-pinnulid brachials are very infrequent. In very young specimens the same conditions obtain in regard to the proportion of two- and four-pinnulid brachials as in the upper portions of the older arms. This shows that the four- and six-pinnulid brachials were formed either from the growth of the separate ossicles or, more probably, from the union of two or more ossicles bearing a pinnule on each side.

This genus has been quite misunderstood, owing to the incompleteness of the original description and to the lack of illustration. Wachsmuth and Springer (1897, v. 1, p. 316) have even considered Clarkeocrinus troosti as a possible synonym of Dolatocrinus canadensis Whiteaves, an assignment not in accordance with Hall's description. Hall (1862, p. 138) states that the primary interbrachial supports two or three plates and that the arms are uniserial.

This seems to be the only known genus of the Camerata provided with cirri of considerable development. The stems of the genera Dichocrinus, Camptocrinus, Herpetocrinus, Lenneocrinus (Jaekel 1918) and others are cirriferous, but none compare with Clarkeocrinus in this regard.

Analytic diagrams of the calyces of Clarkeocrinus (text figure 41) and Dolatocrinus (text figure 40) have been added to the description for clearness and comparison. The secundibrachs in Dolatocrinus are two to four when there are two primary arms, one when there are additional bifurcations in the calyx. In Dolatocrinus the interbrachials have the succession 1, 1, variable, usually 3; in Clarkeocrinus, 1, 2, or 3, usually 1, 2.

This genus has been called Clarkeocrinus in honor of Director John M. Clarke of the New York State Museum.

Clarkeocrinus troosti (Hall) n. comb.

Plates 21–24, figures 1–4; plate 25; text figure 41

1862 Cacabocrinus troosti Hall. 15th Ann. Rep't N. Y. State Cab. Nat. Hist., p. 138

1868 Dolatocrinus troosti Shumard. Trans. Acad. Sci. St Louis, 2:367

1869 Dolatocrinus (Cacabocrinus) troosti Lyon. Trans. Philos. Soc. Phila., 13:443

1877 Dolatocrinus troosti S. A. Miller. Amer. Pal. Foss., p. 77

1878 Cacabocrinus troosti Bigsby. Thesaurus Dev.-Carb., p. 16

1881 Dolatocrinus troosti Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 125 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:300

1889 Dolatocrinus troosti S. A. Miller. N. Amer. Geol. & Pal., p. 240

1897 Syn. Dolatocrinus canadensis Wachsmuth & Springer. N. Amer. Crin. Cam., 1:316 (authors' ed.); Mem. Mus. Comp. Zool., v. 20

1903 Dolatocrinus troosti Clarke & Ruedemann. N. Y. State Mus. Bul. 65, pp. 66–68

1904 Dolatocrinus troosti Clarke & Luther. N. Y. State Mus. Bul. 63, p. 52

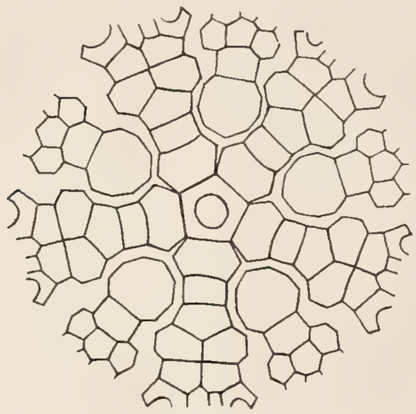

Figure 40 Analysis of calyx of Dolatocrinus. Compare with analyses of Clarkeocrinus, figure 41, Comanthocrinus, figure 44.

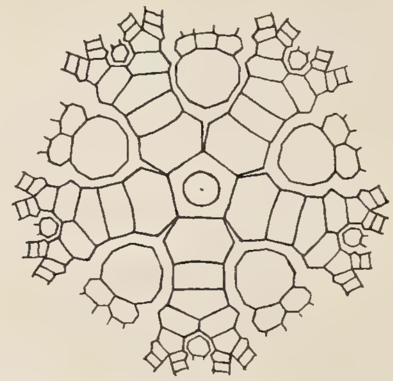

Figure 41 Analysis of calyx of Clarkeocrinus troosti, the genotype.

Dorsal cup. Calyx of rather small size, an average dorsal cup measuring about 1.8 cm by 1.3 cm. Dorsal cup subrotund; distinctly, but not deeply, quinquepartite; basal region somewhat flattened.

Basals three, rather large, subequal, closely anchylosed, but generally showing sutures; together forming an irregularly pentagonal plate which is usually distinctly visible in a side view. Plate about one-third covered by the circular column.

Radials hexagonal, large, more than one-third broader than long, the upper edge somewhat concave. Upper lateral edges shorter than the lower lateral, thus causing a pronounced flaring at the sides.

First primibrach quadrangular, almost appearing pentangular from the convexity of the lower edge; about twice as wide as high. Second primibrach, the primaxil, pentagonal. Secundibrachs 2 x 10.

Primary interbrachial very large, irregularly oval, extending upward to nearly the top of the primaxil; either ten- or eleven-sided, both forms being found in one specimen, depending upon whether there are two or three plates in the second range. The normal number seems to be two, in which case there are three plates in the third range. Intersecundibrachs one.

Tegmen composed of numerous small, light plates, as a result of which no uncrushed examples have been found. Vault probably subconical, rising rather rapidly to the base of the anal tube which was nearly central.

Anal tube long, straight, slender, in a medium-sized specimen measuring 7 cm in its entire length and extending far beyond the tips of the arms. In another specimen the tube, after rising straight upward for 2.3 cm curves outward and extends beyond the arms laterally for some distance (plate 24, figures 2, 3); total length of this tube 6.5 cm. This tendency to curve outward has been observed in another individual, but is not of such a marked character. Tube composed of vertical rows of numerous small quadrangular or hexagonal plates most of which have a single strong tubercle.

Arms four to the ray, uniserial, bifurcating once at about one-third of their length, then a second, and sometimes a third time at more irregular intervals. Pinnules quite long; usually one on each side of every brachial, but sometimes, by the fusion of two or more brachials, there are two and three on each side.

Column rather stout, round and pierced by a circular canal. Columnals arranged in a series of nodes and internodes, the length of the internodes increasing from the calyx downward; greatest number of columnals enclosed by a pair of nodes in 8 cm of the proximal portion of a stem twenty-four. Nodes prominent; each carrying a verticil of extremely long cirri which number five to the node. Cirri borne by the three or four proximal nodes in nearly every instance circinate, the convolutions lying in radial planes, and occasionally completely enveloping the dorsal cup; cirri of the lower nodes remarkably long, in one instance measuring 12.5 cm. The ossicles of the cirri, the cirrals, seem to average about eighteen to 1 cm. The beauty and gracefulness of the crinoid must have been greatly enhanced by the presence of these long, mobile cirri, which were probably in constant motion.

Ornamentation. The plates of the dorsal cup are covered with tuberculous granules, more or less regularly grouped. All the plates have them to some extent, but the radial ridges more particularly. In some cases, the ridges alone show signs of ornamentation. On the primary interbrachial there is a faint arrangement of the granules parallel to the edges of the plate. Besides the calyx plates, the arms, stem and cirri ossicles are granuliferous.

Horizon and locality. The collection of the New York State Museum contains not less than seventy-five specimens of this species, most of them taken from a single locality in the soft shales of the Hamilton (Moscow shale) group, in the northern part of the town of Bristol, Ontario county, not far from the village of Muttonville — now known as Vincent — on land belonging to a Mr Sisson. The greater part of the material was collected in 1860 by Dr C. A. White and Mr C. Van Deloo. Other specimens were found in 1862 at Bristol and Cheshire, not far from the first locality, by Professor R. P. Whitfield and Mr Van Deloo. Since that time no more specimens have been obtained or reported.

The horizon of the Clarkeocrinus-bearing stratum is pretty well defined, lying directly at the base of the Moscow shale in the layer designated by Dr John M. Clarke as the *Encrinal Band.* For further details in regard to the stratigraphic relations of this layer, see Clarke and Luther, "Stratigraphic and Paleontologic Map of Canandaigua and Naples Quadrangle" (N. Y. State Mus. Bul. 63, 1904).

Types. Cotypes in the collection of the New York State Museum.

Remarks. The confusion existing in regard to this species has been referred to under the generic description. The description is based upon the original material used by Hall, and many of the specimens have his manuscript label. These are the specimens indicated in the catalog as "types." There have, then, heretofore, been no specially designated type specimens; therefore the specimens utilized for illustration in the present work will hereafter serve as such.

A slab from Vincent, N. Y., shown in photographic reproduction, about one-half natural size (plate 25), is so fine that it deserves particular mention here. It is a fragment from the largest and finest colony of Devonian crinoids ever found, and shows the most species. Clarkeocrinus troosti occurs most abundantly on this slab, being represented by thirteen specimens. Other species represented are Acanthocrinus spinosus, Gilbertsocrinus spinigerus and Eleutherocrinus whitfieldi (blastoid).

Genus CRATEROCRINUS nov.

[Ety. κρατήρ, *basin, cup;* κρινον, *lily*]

Calyx depressed. Dorsal cup broad and low, two or three times as broad as high; the plates ornamented with low radiating wrinkles. Ventral disk slightly convex with the interambulacral areas slightly depressed. Basal disk pentagonal; composed of three plates or the plates anchylosed showing no line of union. Radials hexagonal and narrow, being over twice as wide as long. Primibrachs two, the first but little narrower than the radials or second primibrachs and about twice as wide as long; the second pentangular, axillary. Secundibrachs two when the first bifurcation begins high up in the cup; followed by one or two tertibrachs. When the first bifurcation takes place low down in the cup, the number of secundibrachs is variable one, two, or three, usually two, and are followed by several series of tertibrachs. Interbrachials few, the primary interbrachial being the largest in the calyx and entirely enclosed by the brachials; higher interbrachials (intertertibrachs) separated from the primary interbrachials by one, two, or three ranks of tertibrachs. Arms biserial.

Horizon and locality. The two species upon which this genus is based are represented in the New York State Museum by one specimen each. Craterocrinus ruedemanni is from the Onondaga limestone, Cherry Valley, N. Y.; Craterocrinus schoharie is from the New Scotland limestone, Schoharie, N. Y.

Genotype. Craterocrinus ruedemanni.

Remarks. Craterocrinus is somewhat similar to Dolatocrinus and Clarkeocrinus, but it differs from them in the shape of the theca and in the arrangement and character of the interbrachials. Dolatocrinus has a greater number of interbrachials, one in the first rank — usually nine-sided — one in the second, variable in the third, but usually three (see plates 17, 18, 19; plate 20, figures 1–4). Clarkeocrinus has one in the first rank, ten or eleven-sided, depending upon whether there are two or three in the second rank (plates 21–25), two or three, usually two, in the second rank, etc. Craterocrinus (plate 20, figure 7) has a twelve- or fourteen- (usually twelve-) sided primary interbrachial, which is entirely enclosed by radials, primibrachs, secundibrachs and tertibrachs. This primary interbrachial is separated from the higher interbrachials (intertertibrachs) by one, two or three ranks of tertibrachs. There is usually one in this higher rank of interbrachials; two occur in one interradius, which may represent the posterior side. Clarkeocrinus has uniserial arms and no tertibrachs in the calyx; Craterocrinus has biserial arms. Both Clarkeocrinus and Dolatocrinus have an anal tube surmounting the ventral disk; Craterocrinus was probably not provided with such a tube. (See *Remarks* under the description of Craterocrinus ruedemanni).

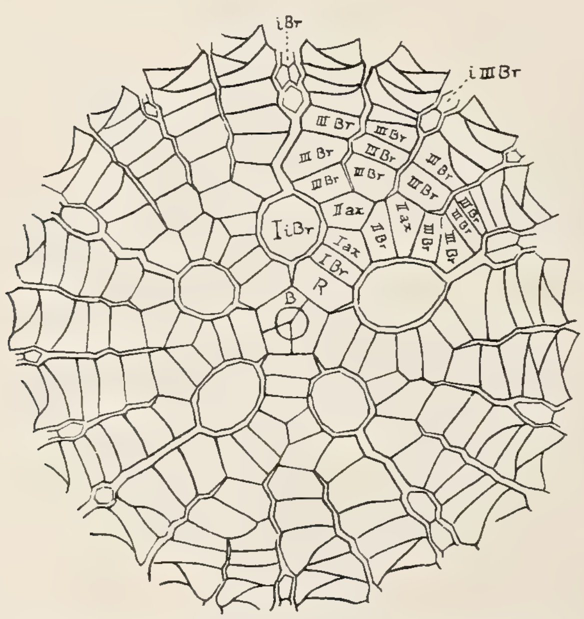

Figure 42 Analysis of calyx of Craterocrinus ruedemanni, the genotype.

Craterocrinus rudemanni sp. nov.

Plate 20, figures 7, 8; text figure 42

Calyx fairly large, broad and low, having the shape of a biconvex lens.

Dorsal cup low and basin-shaped, over three and a half times as broad as high; breadth about 51 mm and height about 14 mm. Basal disk small, pentagonal, apparently composed of three pieces. Radials hexagonal, low and broad, about two and one-half times as wide as long. Primibrachs two, a little less long than the radials. First primibrach quadrangular, about twice as wide as long. Second primibrachs pentagonal and axillary, of the same length as the first primibrachs, but slightly wider in the center. Radials and primibrachs of considerably less height than the following brachials, which brings the primary interbrachial low in the cup and makes it smaller and narrower. Secundibrachs comparatively large, two to each bifurcation; except where a ray gives rise to five arms, in which case there will be three secundibrachs to one of the bifurcations.

Second, exceptionally the third, secundibrachs axillary, giving rise to the tertibrachs; first three usually large and then giving place to small and narrow quadrangular or wedge-shaped plates (variable in number, usually four) which lead to the wedge-shaped plates of the biserial arms.

Primary interbrachial comparatively small and narrow; situated low in the cup; entirely enclosed by the brachials and twelve or fourteen-sided. Twelve-sided plates bordered on each side by two secundibrachs and one tertibrach in addition to the primibrachs and radials. Two interradii (right posterolateral and left anterior) with a fourteen-sided primary interbrachial due to the fact that two tertibrachs of the ray on each side border them; interbrachials larger in these interradii. Two intertertibrachs in the right posterolateral interradius and apparently in the posterior; a single one in each of the others. These first intertertibrachs separated from the primary interbrachial by one, two or three ranks of tertibrachs; followed by one or two plates which merge into the plates of the ventral disk. Higher up in the cup, every pair of arms in each ray is separated by a single interbrachial, and where there are five arms to the ray the fifth arm is also separated from the other two pairs by an interbrachial.

Tegmen low, arched (plate 20, figure 8); interambulacral spaces slightly depressed. Orals rather large, all of about the same size and similar in form. Anal opening subcentral. Two large cuneiform plates to each interambulacral space; abutting upon the orals except on the anal side;

bordered higher up by small plates which merge into the interbrachial plates. Between the arm bases from two to four "respiratory" pores or slits piercing the sides of the small plates.

Arms twenty-one, heavy and biserial. Probably four arms to the ray is the normal number; anterior ray has five. Only the bases of the arms preserved.

Column small and round, as shown by the stem cicatrix.

Ornamentation. The plates of the dorsal cup are ornamented with discontinuous wavy wrinkles which roughly follow the axes of the rays. The primary interbrachials have longitudinal wrinkles in the center, with shorter, roughly radiate wrinkles near the periphery.

Horizon and locality. From the Onondaga limestone, Cherry Valley, N. Y.

Types. Genoholotype in the collection of the New York State Museum.

Remarks. In the posterior region of the ventral disk is a peculiar bulge surrounded by a horseshoe-shaped groove. This marks the attachment of a parasitic gastropod, a Platyceras (Keyes, 1888, pp. 8, 9, plate, fig. 7). The anterior end of the Platyceras was attached over the anal opening and the growth of the shell continued posteriorly, the form of the shell conforming to the irregularities in the surface to which it was attached. Marks of the shell in the earlier stages are not visible. Only two cases have been noted (op. cit., p. 9) in which a Platyceras has been attached to a crinoid with an anal tube. In one case the matrix was too compact to permit of the removal of the Platyceras and study of the attachment; in the second case, the shell was attached at the base of the anal tube which had been injured. Keyes suggested the probability in this case of an additional opening at the base of the anal tube on account of the deformity. The specimen of C. ruedemanni described above has no indication of an anal tube; but if the genus normally had one, the attachment of the Platyceras would most assuredly prevent its growth.

Named in honor of Dr Rudolf Ruedemann of the New York State Museum.

Craterocrinus schoharie sp. nov.

Plate 20, figure 9; text figure 43

This species is described from a single dorsal cup which, though imperfect, is sufficient for purposes of identification.

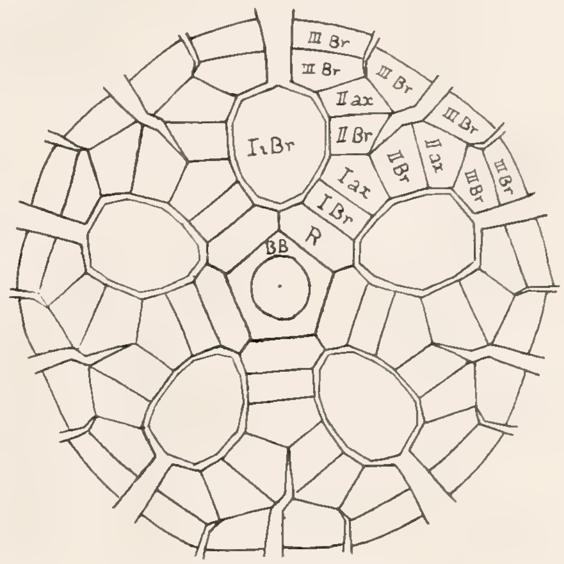

Figure 43 Analysis of calyx of Craterocrinus schoharie.

Dorsal cup broadly shallow, a little more than twice as broad as high. Basal disk pentagonal, slightly projecting at the base and forming a depression into which the column is rather deeply sunk. Plates of the basal disk so anchylosed that the lines of suture are not visible. Radials hexagonal, low and broad, about three times as wide as long. Primibrachs two, a little narrower than the radials. First primibrachs quadrangular, about twice as wide as long. Second primibrachs axillary, of the same width as the first primibrachs but slightly higher. Secundibrachs two, large, the second axillary. Tertibrachs not readily distinguished, due to the weathered and broken character of the rim. One bifurcation, above the secundibrachs, shows two tertibrachs in the outer arm of the bifurcation and one in the inner; decided flaring of the rim in this region indicates that the arms begin here.

Primary interbrachial large, entirely enclosed by the brachials and twelve-sided, being bordered on each side by one radial, two primibrachs, two secundibrachs, and one tertibrach. Higher interbrachials not distinguished.

Tegmen unknown.

Arms wanting; twenty, four to each ray, stout, and probably biserial.

Column small and deeply set in the basal disk; known only from the cicatrix.

Ornamentation. The plates of the dorsal cup are ornamented with discontinuous wavy wrinkles. On the rays they have a roughly longitudinal arrangement, following the ray axis. On the primary interbrachials there are longitudinal wrinkles in the center with shorter, roughly radiate wrinkles near the periphery.

Horizon and locality. From the New Scotland limestone at Schoharie, N. Y.

Types. Holotype in the collection of the New York State Museum.

Remarks. Craterocrinus schoharie differs from Craterocrinus ruedemanni in the smaller size of the dorsal cup and in the greater size of the proximal plates. The radials and primibrachs are so much larger that the first interbrachial is correspondingly larger and reaches two-thirds of the way up in the cup. C. ruedemanni has three or four rows of tertibrachs incorporated in the cup; C. schoharie, one or two. Because of the imperfect preservation of the specimen it can not be stated whether Craterocrinus schoharie has the variations seen in C. ruedemanni, such as five arms to a ray and a fourteen-sided primary interbrachial.

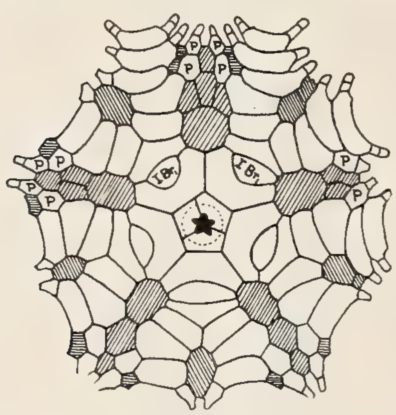

Figure 44 Analysis of calyx of Comanthocrinus. (After Springer 1921, x 2/3). / // = *iBr*; \\\\ = *i II Br*; ≡ = interpinnulars; *P* = pinnulars; *I Br* = first primibrach.

Named from the locality in which the specimen was found.

Genus COMANTHOCRINUS Springer 1921 [1]

I have had at hand, through the kindness of Doctor Springer, a preliminary copy of a paper on Dolatocrinus and allied forms which appeared in the Proceedings of the United States National Museum. In this paper are described a new genus, Comanthocrinus, and two species, one new, belonging to it. Since Springer's observations have been

[1] For full discussion, see paper on Dolatocrinus and allied forms, U. S. Nat. Mus. Bul. 115, 1921, pp. 4–6.

made upon better preserved and more complete series of specimens of both species (material from outside New York), I have based the following generic description largely upon his diagnosis and have also made, from his observations, such additions to my specific description as seemed necessary.

This genus was created to contain the Hamilton species described by Miller and Gurley as Stereocrinus indianensis and a new species, Comanthocrinus priscus, from the Onondaga limestone of New York and Kentucky.

Genus characterized by a practically flat dorsal cup with depressed center, forming a fairly deep, well-defined pit. Composition of dorsal cup is similar to that of Dolatocrinus and Clarkeocrinus gen. nov. Basals fused to three elements, the small plate being in the left posterior position in both species, which is not only different from that of associated genera but is a departure from the rule in monocyclic crinoids generally. Primibrachs two, the first one reduced to a small lunate or elliptic plate occupying a curved socket cut out of the distal face of the radial (or also out of the plate above it), usually less than the width of that plate, but sometimes extending entirely across it.

Dorsal cup marked by sharply defined radiating ridges which follow the radial series, becoming strongly arched on the secundibrachs, which are incorporated into the calyx to a varying extent by means of fixed pinnules, the bases of which are closely united by sutures. Interbrachials few in number. Primary interbrachial large, the posterior one being the largest; followed by one or two (three?) in the succeeding ranges, which are flanked by other plates which resemble interbrachials but which are fixed pinnules.

Tegmen highly arched and composed of a large number of small plates; conspicuous posterior bulging to accommodate the hind gut. Anal side distinguished in the tegmen by a row of large plates, the largest in the tegmen, forming a well-defined median ridge extending to the base of the almost central anal tube. Ambulacral covering plates in double series extend to near the base of the anal tube, and pinnular ambulacra are also present. Incorporated pinnules give rise to the openings or pores through the calyx wall between the bases of the rays, such as are found in Dolatocrinus and other genera (*see* Springer 1917, pp. 40–46).

Arms ten, strong, uniserial; brachials with a pinnule on each side, sometimes even two on one or both sides.

Genotype. "Stereocrinus" indianensis has been chosen by Springer as the genotype. The Onondaga form, C. priscus, in the specimens from the Falls of the Ohio at Louisville shows some structural details, especially the extreme of fixed pinnulation, better than the Hamilton form, but the tegmen is not preserved.

Distribution. Devonian; Hamilton of Indiana and New York; Onondaga of Kentucky and New York.

Comanthocrinus indianensis (Miller & Gurley)

Plate 24, figures 5–8

1897 Stereocrinus indianensis Miller & Gurley. Bul. Ill. State Mus. Nat. Hist., no. 12, p. 38, pl. 3, figs. 13–15

1921 Comanthocrinus indianensis Springer. Proc. U. S. Nat. Mus., Bul. 115, pp. 6–7, pl. 1, figs. 1–6

This species was originally described by Miller and Gurley from the Sellersburg (Hamilton) beds near Charlestown, Indiana. From this general region come silicified thecas which show the general proportions and superficial characters with great clearness. The plates can be made out only with considerable difficulty, owing to the preservation of the material, and this fact led Miller and Gurley into error as regards the number of plates of the radial series, as will hereafter be pointed out. In addition to this material we have specimens from the Hamilton of New York which apparently belong to this species. The best preserved of these (plate 24, figure 5) is in the collection of Doctor Springer. This specimen comes from Canandaigua lake, and shows the structure of the dorsal cup and arms beautifully. A larger specimen from the same locality is in the collection of the New York State Museum, but it is in a badly crushed and fragmentary state; another, likewise poorly preserved, specimen (in the State Museum) comes from Cashong creek, Bellona.

Species a relatively small one; the larger of Miller and Gurley's types, by all odds the largest specimen seen, measuring about 22 mm in diameter. Most of the specimens examined range from 15 mm to nearly 20 mm in diameter; the average specimen, according to Springer, being about 20 mm. A theca about 20 mm in diameter has a height of 17 mm to the base of the anal tube. Almost all this height is that of the tegmen, as the dorsal cup is practically flat. The arms in a specimen of this size attain a probable length of not less than 50 mm, and probably considerably more as indicated by one of the New York specimens.

Dorsal cup practically flat viewed from the side; center depressed, forming a fairly deep well-defined pit. Surface marked by sharply defined radiating ridges, which follow the radial series. Basals fused to three small elements concealed at the bottom of the central depression noted above; the small plate in the left posterior position. The lower portions of the radials form the sides of this pit, but above they reach well out beyond its margin. Radials large and much wider at the top than at the base; one of them giving a maximum breadth of 4.8 mm, and an estimated height of about 2.8 mm.

First primibrach low and considerably narrower than the radial. In the specimens figured here this plate extends entirely across the radials, but Springer has noted that the opposite is usually the case. One of these plates gives a height of 1.8 mm and a breadth of 3.5 mm. Upper face of the radial distinctly concave. In this crescentic margin the first primibrach rests. Union between the two plates intimate, and may as a rule only be seen by careful observation. Fortunately the New York specimen has been somewhat distorted and in two or three rays the sutures between the plates may be clearly seen; in one case the two plates are slightly separated. It was doubtless owing to the close union between these plates, combined with the deceptive preservation of the material, that Miller and Gurley described the species as having a radial immediately followed by the primaxil. Considering this to be the structure they referred the species to Stereocrinus. As a matter of fact, I have been able to locate it in the few specimens that have come under my observation; and Springer has found it in a large series of specimens. In one or two cases there is a marked ridge of silica along the suture.

Primaxil variable in size in the same specimens. In the same ray that furnished the measurements for the first primibrach, the primaxil is 2.1 mm in height. Slightly wider than the first primibrach; upper sloping faces unusually long.

In each half of the ray there are three or four low, broad, incorporated secundibrachs. In this respect Springer points out:

> The species represents a retrogression from the older form in the less extent of incorporation of brachials in the calyx, or a progression in the direction of greater freedom of the arms, whichever way one pleases to consider the case (1921, p. 7).

In C. indianensis from Indiana the first secundibrachs are in lateral contact; in the New York specimen the first two of these plates are in lateral contact with the corresponding plates in the other half ray. Springer states:

> The second secundibrach has an incorporated pinnule on the outer side of the dichotom, the base of which also connects by suture with the third and fourth secundibrachs. The third secundibrach has a free pinnule at the inside of the dichotom, and the fourth bears two free pinnules, one from each side (ref. cit.).

Interradii small and filled mainly by the large primary interbrachial which varies considerably in size in different interradii, the largest being more than twice the size of the smallest. Springer has found that the largest plate invariably occurs in the posterior interradius, which makes the orientation of the figure shown on plate 24, figure 5 incorrect. Primary interbrachial followed in the second range by from one to three plates. Springer gives the plates succeeding the first as one to two, but the New York specimen figured here also shows three.

Tegmen. Owing to the fact that only silicified specimens showing the tegmen are available, it has been difficult to gain an accurate idea as to the exact relationship of the constituent plates of the tegmen. The sutures are in large part obliterated and as a rule it is only when the plates bear short spinous processes that the individual plates can be located. Tegmen composed of a large number of small plates, many of which bear short, sharp spines which are located mainly along the lines of the ambulacra and about the base of the anal tube. Ambulacral covering plates have been found by Springer extending in a double series to near the base of the anal tube, and pinnular ambulacrals are also present. Passing up the middle of the posterior interambulacrum is a line of larger plates traversed by a low but sharply rounding ridge along which are occasional spines.

Tegmen of this species presents unusual and notable characters. Inasmuch as the dorsal cup is flat or even somewhat concave, it follows as a matter of course that in order to provide for the viscera there must be a highly arched tegmen. In a specimen measuring 19.5 mm in diameter the vault has a height of about 16 mm. Tegmen decidedly asymmetrical. Anal opening at the end of a short, stout tube slightly excentric in location. Vault considerably distended at the base of the tube on the posterior side; inflated area for the most part to the left of the median plane of the interradius. The ambulacral ridges running up from the posterolateral rays and bounding the swollen posterior interambulacrum follow a somewhat devious course. After their inception at the arm bases the two branches from each ray pass backward and upward around the swollen area and, uniting, take a more direct course to the base of the anal tube. The ambulacra of the other rays follow the most direct route to the base of the tube.

As the coil of the intestine produces the inflation in the posterior portion of the tegmen, so also do the ambulacra show through the test. Thus the course of the ambulacra may easily be followed, showing as they do on the exterior as raised rounding ridges. From each arm opening a branch of the ambulacrum runs up to about one-half the height of the vault. Here it unites with its mate from the other arm. The main trunk then runs up to the base of the anal tube, where they undoubtedly unite in the circumoral ring.

Pores or openings, formerly termed "respiratory slits", apparently four to each interradius and two between the bases of the arms of each ray It is clearly shown on the surface that each is connected with the branch of the ambulacrum nearest it at from 3 to 4 mm above the arm-opening. These slits have derived their origin from incorporated pinnules, as has been previously proved from other forms by Springer (1917, pp. 40–46).

Arms two to a ray and nonbifurcating; uniserial, stout and fairly long. The arms of the larger specimen in the State Museum measure at least 80 mm in length. Brachials long, only seven or eight in a space of 10 mm. In spite of being uniserial the arms show a considerable degree of specialization; each side of a brachial bears at least one pinnule, and frequently two are borne on a side. Springer notes the occurrence of three and four pinnules to a brachial and that on bipinnulate brachials the outer pinnule is at a lower level than the inner. This multipinnulate condition of the brachials is undoubtedly due to fusion of ossicles. Pinnules fairly stout, and composed of long ossicles. The incorporation of the lower pinnules into the calyx has already been noted.

Column. A few millimeters of column are preserved in two of the specimens. It is round and in its proximal portion measures 3 mm in diameter. Canal small and of indeterminate shape; in one of the type specimens from Indiana apparently pentalobate. Margins of the apposed faces of the columnals crenulate. Column in the proximal portion divided into fairly well-defined nodals, alternating with narrow inconspicuous internodals. In the two specimens in the New York State Museum one of the proximal nodals, about 5 mm from the base of the calyx, shows the bases of a whorl of five rather stout cirri.

Ornamentation. Surface of the plates of the dorsal cup covered with irregularly disposed granules. Upward along the brachial series the granules coalesce, and in both fixed and free brachials form irregular, roughly parallel striae. Along each radial series runs a conspicuous rounding ridge. This has its inception at about one-half the height of the radial, at the rim of the basal depression. It ranges along the median line of the radial series, and bifurcates on the primaxil. Above, the ridges grade insensibly into the rounded backs of the arms.

Horizon and locality. From the Hamilton (Moscow) shales of Canandaigua lake and Cashong creek, Bellona, N. Y., and in the Sellersburg (Hamilton), Clark county, Ind.

Types. Cotypes in the Walker Museum, Chicago University; the other specimens here figured are in the collection of Doctor Springer.

Comanthocrinus priscus Springer

Plate 24, figure 9

1921 Comanthocrinus priscus Springer. Proc. U. S. Nat. Mus., Bul. 115, pp. 7–9, pl. 1, figs. 7–10

The following description was obtained from a preliminary copy of Springer's manuscript description of the species. The description is based upon a series of specimens from the Onondaga of the Falls of the Ohio, Louisville, Ky., in better condition for study than the single, very fragmentary representative from New York State which is referred to the same species. The New York specimen (plate 24, figure 9) loaned to me for study by Doctor Springer, was originally figured only for comparison with the Hamilton form; at the same time, however, though fragmentary, it was recognized as undoubtedly a new species. The general features of size and greater incorporation of the brachials are shown; but the fusion of plates has proceeded to such a degree that suture lines are difficult to distinguish and, therefore, the true nature of the interbrachial plates is not shown.

Original description.[1] A species double the size of the type — an average of eight specimens being about 40 mm in width of calyx at arm bases. As the tegmen has not been found, the comparative height can not be given. The disparity in size evidenced by the wider spread of calyx in this species is correlated with a much greater extent of incorporation of brachials by means of the fixed pinnules. The broadly rounded secundibrachs are transversely ridged exteriorly, and are deeply V-shaped on the ventral side, the wings of the " V " being farther prolonged by the pinnules,

[1] In his recent paper (1921) Doctor Springer has given a fuller discussion of this species.

the lower ossicles of which form a continuous wall in the depressed interbrachial areas. These give the appearance of numerous interbrachial plates above the very large first interbrachial, but in fact the interbrachials are limited to a single narrow plate following the first, while the other rather numerous plates in the area are all pinnulars. In this way secundibrachs to the height of the seventh are incorporated. The second secundibrach has a pinnule to the outside of the dichotom, not showing externally except at the margin, with three pinnule-ossicles incorporated. The third to the seventh secundibrachs have from two to four pinnules per brachial, with two pinnulars incorporated. The reduced first primibrach occupies an oval space between the radial and the axillary primibrach, both of which are more or less excavated for its reception. It is usually small, strongly protuberant, and the radial ridge following the rays begins with this plate. The anal side is scarcely differentiated, two narrow plates tandem succeeding the large first plate and passing toward the tegmen, which is not preserved in any of our specimens.

The inside of the dorsal cup is marked by an extraordinary complex of grooves and ridges from the radials up, some of which are for the lodgment of nerve cords, but the function of so many is not clear. They are comparable in number and position with the ridges seen upon the dorsal side of calyx plates in well-preserved specimens of Himerocrinus plenissimus, but nothing so intricate has been observed upon the inner surface in other forms.

Except for the lack of the tegmen, the specimens in hand are remarkably well preserved for exhibiting the leading characters of the species.

Horizon and locality. From the Onondaga limestone, Falls of the Ohio, Louisville, Ky., and from the same formation, Le Roy, N. Y.

Types in the collection of Doctor Springer. The New York representative figured here is likewise in that collection.

Genus HIMEROCRINUS Springer, 1921

Springer, in his paper on Dolatocrinus and allied forms (1921), describes this new genus with Hadrocrinus plenissimus Lyon as the type and suggests that Hall's Coronocrinus polydactylus may possibly belong to the same genus. The following brief description of the genus is based upon Springer's diagnosis of the genus, obtained from a preliminary copy of the manuscript kindly placed at my disposal.

The genus includes forms of very large size, the largest of the known Camerata. Calyx broad and shallow with a low tegmen composed of innumerable plates; base deeply concave forming an inverted cone. The two special characters upon which the genus is founded are the primibrachs and the enormous brachial extension of the calyx. Primibrachs two, instead of a single axillary plate as in Hadrocrinus. Axillary plate more or less reduced in size, and often singularly changed in shape and proportions; irregularity in the axillary reduplicated to some extent on the succeeding divisions. Arms normally 16 or 17 to the ray, making 80 or more in all; relatively small and biserial. Interbrachiae few and large. Column primarily rounded, but given a sharply pentagonal appearance by the addition of an outer sheath with projecting buttresses at the angles, which is usually broken away and probably does not extend the full length of the column.

The specimen of "Coronocrinus" polydactylus from the New Scotland limestone is only a fragment, showing one-fourth or probably less of the circumference of the calyx at the arm bases. It was listed by Schuchert (1900) under the genus Hadrocrinus; but Springer's recent definition of that genus (ref. cit.) eliminates that possibility. From the characters shown the species might well belong to this genus, and it has been here so placed provisionally.

Genotype. "Hadrocrinus" plenissimus Lyon.

Distribution. Devonian. From the Upper Helderberg group of Indiana and the Falls of Ohio, near Louisville, Ky.; (?) from Lower Helderberg group (New Scotland beds) of New York.

Himerocrinus(?) **polydactylus** (Hall)

Plate 20, figure 11

1859 Coronocrinus polydactylus Hall. Pal. N. Y., 3:124, pl. 6, figs. 4–6
1877 Coronocrinus polydactylus S. A. Miller. Amer. Pal. Foss., p. 74
1889 Coronocrinus polydactylus S. A. Miller. N. Amer. Geol. & Pal., p. 231
1900 Hadrocrinus polydactylus Schuchert. Bul. Geol. Soc. Amer., 11:280
1903 Coronocrinus polydactylus Clarke & Ruedemann. N. Y. State Mus. Bul. 65, p. 66

The specimen upon which Hall based this species is only a fragment, but enough characters are shown to make it distinctive. A portion of the circumference of the body is preserved, and this indicates that the crown at the arms must have had a diameter of nearly three inches.

Dorsal cup. Base of the dorsal cup unknown. Near the base of the arms a few of the small plates of the higher brachial series are indistinctly seen and some of the interaxillary plates between the arm bases.

Tegmen, from the portion preserved, appears to be composed of numerous small, irregularly hexagonal plates; slightly depressed just within the arms and from there slightly convex toward the center. This gives a nearly flat appearance to the tegmen.

Arms proceed abruptly from the margin of the cup; the bases of eleven arms are preserved. Since the fragment is scarcely more than one-fourth the circumference, it can be inferred that the specimen had at least forty arms. Arms biserial.

Horizon and locality. From the New Scotland beds, Schoharie, N. Y.

Types. Holotype in the collection of the New York State Museum.

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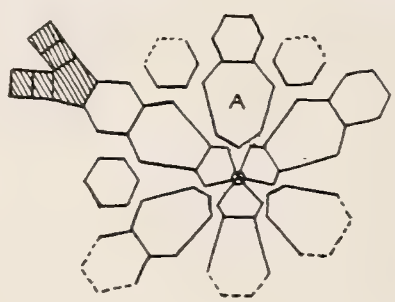

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Figure 45 Acacocrinus pentadactylus. Left posterior view of the type, natural size. For the enlargement of this specimen, see plate 26, figure 1.

Figure 46 Analysis of calyx of Acacocrinus pentadactylus. (After Grabau, 1899).

Remarks. See discussion under genus.

Family BATOCRINIDAE W. & Sp.

Subfamily PERIECHOCRININAE W. & Sp.

Genus ACACOCRINUS W. & Sp. 1897

Acacocrinus pentadactylus (Grabau) n. comb.

Plate 26, figure 1; text figures 45, 46

1898 Habrocrinus pentadactylus (nom. nud.) Grabau. 16th Ann. Rep't N. Y. State Geol. (1896), p. 285

1899 Habrocrinus pentadactylus Grabau. Bul. Buff. Soc. Nat. Sci., v. 6, nos. 2, 3, 4, pp. 143, 144, fig. 25

Two specimens of this species were found by Professor Grabau in the Moscow shale. The figures and description have been made from the originals loaned by Columbia University.

Dorsal cup obconical, uniformly enlarging from the base upward, having a height of about 5 mm and a width of 4.6 mm. Basal plates rather large, three, hexagonal, equal. Radials large, longer than wide; anterior and right and left posterior hexagonal; the right and left anterolateral heptagonal.

First primibrach hexagonal, about half the size of the radial. Second primibrach, the primaxil, smaller than the first primibrach, pentagonal, giving rise to the arms. Primary interbrachial hexagonal, smaller than the first primibrach; plates in the second row not shown. In the anal interradius the heptagonal anal rests between the two posterior radials. It is followed by a second much smaller plate in the median line between two other interbrachials, giving three plates in the second row. No higher rows of interbrachials visible.

Tegmen not known.

Arms two to the ray, ten to the calyx; long, heavy, and simple throughout; composed for the most part of wedge-shaped brachials each bearing a pinnule, the pinnules arranged alternately on each side of the arm. First few brachials of the arms may be more nearly quadrangular.

Column missing. Stem cicatrix round and comparatively small.

Ornamentation. Strong, rounded ridges extend from the base to the ten arms along the five rays. A less prominent ridge traverses the median line of plates of the anal interradius.

Horizon and locality. From the Hamilton beds (Moscow shale) of Eighteen Mile creek, N. Y.

Types. Cotypes in the Museum of Columbia University.

Remarks. Professor Grabau (1899, p. 143) described this species as a Devonian representative of the Silurian genus Habrocrinus (D' Orb.) Angelin (Carpocrinus Müller). Each brachial of Carpocrinus bears two pinnules on the longer face, one on the shorter;

so the species can not belong there. It has been placed here in the genus Acacocrinus W. & Sp., the requirements of which it appears to fulfil in quite a satisfactory manner.

Genus COROCRINUS nov.

[Ety. κόρος *a broom of young trees;* κρινον, lily]

The only species of this genus is Corocrinus ornatus sp. nov., except for "Actinocrinus" calypso Hall provisionally referred to this genus, hence the specific description will serve for the description of the genus. The radiating ridges on the plates of the dorsal cup stand out so prominently that the effect of the calyx with the attached stem is that of a broom of twigs, hence the name Corocrinus.

The genera to which Corocrinus bears the most resemblance are Periechocrinus and Saccocrinus. In Periechocrinus the calyx is more elongate, more of the higher brachials are incorporated, and the brachial series bifurcate two or three times within the calyx. The arms are twenty-five to thirty, biserial beyond the calyx and do not branch after becoming free. In Corocrinus the brachials bifurcate once in the calyx — on the primaxil. Above the secundaxil only a couple of uniserial brachials are preserved in the genotype, and nothing is known of the upper part of the arms. There are twenty arms.

Saccocrinus which was placed as a synonym of Periechocrinus by Wachsmuth and Springer in 1897 (v. 2, p. 520) has been again separated by Springer (1913, p. 194). It is like Periechocrinus; but there are about twenty arms, biserial above and below the bifurcations, in this respect differing from Corocrinus.

Genotype. Corocrinus ornatus.

Distribution. Middle Devonian (Hamilton) of New York.

Corocrinus ornatus sp. nov.

Plate 26, figures 2, 3, 4; text figure 47

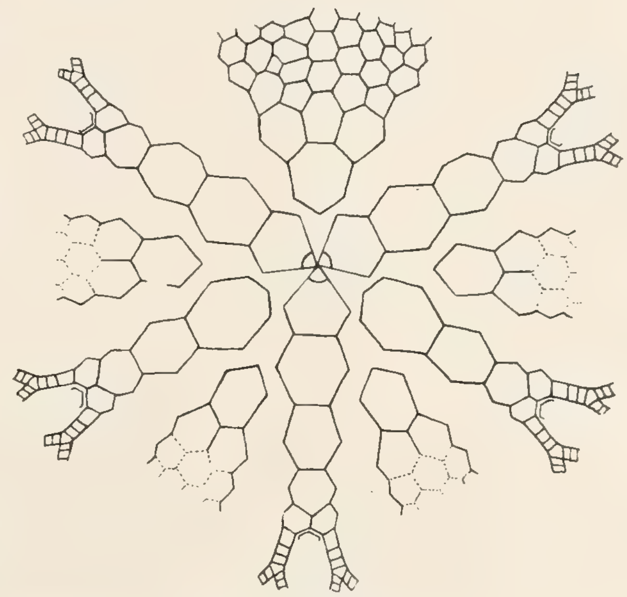

Figure 47 Analysis of calyx of Corocrinus ornatus, the genotype.

This species is represented by five fairly well-preserved thecae. Two of these have about 10 mm of stem attached, and portions of the arms. As the specimens are embedded in soft shale their preservation is excellent. Owing to the thinness of the plates and the delicacy of the cup, all the specimens are more or less crushed.

Dorsal cup urn-shaped; base narrow. The sides extend outward and upward at a low angle to the base of the free arms, with a more or less pronounced outward curvature. One cup somewhat crushed has a height of 22 mm to the tops of the primaxils, and an estimated diameter of about 18 mm at the same level. Basals large and fused to three elements which together form a deep conical cup. Radials hexagonal, large, an average one having a height of about 7 mm and a maximum breadth of about 6 mm. First primibrach with a height of 6 mm and a breadth slightly less than the radial; variable in shape — hexagonal, heptagonal, octagonal. Primaxil slightly smaller than the first primibrach. First secundibrach incorporated and fairly large.

Interradii narrow, with the exception of the posterior, which has about twice the breadth of any of the others. In one specimen examined, the posterior interradius measures about 18 mm in width at the level of the tops of the primaxils. Proximal anal heptagonal, large, being of practically the same size as the radials; three plates in the second range, the median plate being the smallest; in the third range five plates, and in the fourth five or six. Above this level the ranges not well aligned; plates small and numerous. Median line of anals unusually well marked; plates decrease gradually in size upward. Primary interbrachial in regular interradii large and followed in the second range by two relatively small plates; above this level interbrachials not known. Intersecundibrachs one, small.

Tegmen unknown except for a portion of the posterior side; judging by this, composed of numerous small, thin plates. Anal opening situated at the top of a marked protuberance, or possibly a short stout tube.

Arms. Structure of proximal portion alone known; extraordinarily slender, measuring but 1.4 mm in width immediately below the secundaxil. Apparently five secundibrachs to each half ray, the last of which is axillary; rami broken off just above the secundaxils.

Column. Two of the specimens have a portion of the column attached, measuring in each case about 10 mm in length. Immediately below the cup one of these columns measures 3 mm in diameter. For the first 2 or 3 mm it tapers rather rapidly and at a distance of 10 mm measures but 2.2 mm in diameter. Column composed of nodals and internodals; nodals slightly annulate, and not conspicuous. In the proximal portion the nodals and internodals alternate; proceeding distad there is the customary intercalation of secondary internodals. There is so little difference in size between the nodals and internodals that it is almost impossible definitely to fix the limits of the node.

Ornamentation. The dorsal cup is covered with coarse radiating ridges that represent folds in the plates rather than superficial ornamentation. One of these plications runs from the center of a plate to each face. The median elevation running up the radial series is strongly marked, forming a prominent rounding ridge that appears continuous with the free arms. Starting on the proximal anal is a lower but clearly defined ridge that continues up the median line of anals as far as they are preserved. In the interradii the ridges are but faintly developed above the level of the first primibrachs. In addition to the plications, there is a superficial ornamentation consisting of granules which are irregularly and sparsely distributed over the surface of the plates.

Horizon and locality. All the specimens known, three of which are grouped on a small piece of rock a few inches in length, come from the Hamilton (Ludlowville) shales, at Fall brook, near Geneseo, N. Y.

Types. Cotypes in the collection of the New York State Museum.

Remarks. This species does not closely resemble the other species referred to the genus.

Corocrinus (?) **calypso** (Hall) n. comb.

Plate 26, figure 5

1862 Actinocrinus calypso Hall. 15th Ann. Rep't N. Y. State Cab. Nat. Hist., p. 133

1868 Actinocrinus calypso Shumard. Trans. Acad. Sci. St Louis, 2:342

1877 Actinocrinus calypso S. A. Miller. Amer. Pal. Foss., p. 66

1878 Actinocrinus calypso Bigsby. Thesaurus Dev.-Carb., p. 15

1881 Gennaeocrinus calypso Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 161 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:334

1889 Gennaeocrinus calypso S. A. Miller. N. Amer. Geol. & Pal., p. 247

1897 Syn. Aorocrinus cassedayi (Lyon) Wachsmuth & Springer. N. Amer. Crin. Cam., 2:483, pl. 42, figs. 11 *a*, *b*, 12 (authors' ed.); Mem. Mus. Comp. Zool., v. 21

1900 Gennaeocrinus calypso Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 3, p. 196

Under the name "Actinocrinus" calypso Hall described an imperfect, badly crushed crinoid of doubtful affinities.

Dorsal cup. Basals probably fused to three. Radials hexagonal, large, of nearly equal width and height. First primibrachs hexagonal, so far as observed, of about one-half the size of the radials. Primaxils smaller than the primibrachs, supporting 2 x 10 secundibrachs; the second plate again axillary. The upper edges of the first primibrachs, the upper and lower edges of the primaxils and apparently all the edges of the secundibrachs are crenulate. Primary interbrachial larger than the primibrachs, supporting two plates in the second rank, ? in the third. Anal interradius unknown. Intersecundibrachs one, small.

Tegmen unknown.

Arms twenty, long, somewhat slender, biserial, with rounded backs, length about 50 mm. Pinnules slender and in the proximal portion fully 9 mm in length. There are three quadrangular plates in each arm, so far as shown, before the arms become biserial, and they have crenulate margins.

Column comparatively small.

Ornamentation. The radial series is traversed by a low rounded ridge, while the radials, basals, primibrachs and the plates of the interradii are marked by well-defined ridges which radiate from the centers of the plates.

Horizon and locality. From the Hamilton (Moscow shale) beds, Jaycox's run, Genesee valley, N. Y.

Types. Holotype in the American Museum of Natural History, number $\frac{5025}{1}$.

Remarks. This species which was referred to Gennaeocrinus by Wachsmuth and Springer in 1881 (p. 334), and later was referred to by the same authors (1897, v. 2, p. 483) as a synonym of Aorocrinus cassedayi (Lyon), does not belong to either of those genera. It is probably a Batocrinoid, however, and may belong to the genus Corocrinus where it has been provisionally placed.

Genus SACCOCRINUS Hall 1852

Wachsmuth and Springer in their monograph on the North American Crinoidea Camerata placed Saccocrinus as a synonym of Periechocrinus (1897, v. 2, pp. 519, 520), and it is so given by Bather in Lankester's "Treatise on Zoology" (1900, p. 166); Springer separates the two genera (1913, p. 194). Periechocrinus is a Silurian form of England and Gotland. The brachial series bifurcates two or three times within the calyx, leading to twenty-five or thirty arms which are biserial beyond the calyx and do not branch after being free. Saccocrinus, Silurian to Lower Carboniferous (Upper Burlington), North America and (?) Gotland, is like the preceding except as regards the arms. They branch from about twenty openings after becoming free, and are biserial both below and above the bifurcations.

The following new species has been placed with a query under the genus Saccocrinus.

Saccocrinus (?) **hamiltonensis** sp. nov.

Plate 26, figures 6, 7

This species is represented by a single specimen in a somewhat weathered, crushed and broken condition. The arms are missing, and of the calyx the tegmen and the most distal part of the dorsal cup is missing.

Dorsal cup of medium size, somewhat elongate, urn-shaped; pentagonal in cross-section due to the slight depression of the interradii and the ridges extending up the brachial series. Basals three, hexagonal, comparatively large, forming a rather deep cup; greatest width of each basal (about 7.4 mm) nearly twice the height (about 4 mm). Radials large, hexagonal or heptagonal, depending upon their relation to the basals; about equal in height and width, higher than the basals, but considerably less wide. An average one has a height of 5 mm and a width of 5.2 mm.

Primibrachs much smaller than the radials. First primibrach hexagonal, an average one having a height of 3.1 mm and a width of 4.1 mm. Primaxils heptagonal, a little smaller than the first primibrachs, and giving rise to two series of secundibrachs each. The first secundibrach and part of the second are preserved in two rays; nothing is known of the higher brachial series. First secundibrachs large and hexagonal, the second apparently nearly as large.

Primary interbrachial in regular interradii hexagonal, usually as large or larger than the first primibrach, followed by two plates in the second row and two or three in the third. Above this plate not preserved. No intersecundibrachs preserved; first intersecundibrachs apparently large.

Anal plate heptagonal, of nearly the same size as the radials, and followed by a median series of large plates, usually hexagonal, which gradually decrease in size upward and are bordered by smaller plates on each side. Three plates in the second row, five in the third; above this rather irregular in arrangement.

Tegmen unknown.

Arms. The brachial series is not preserved above the proximal part of the second secundibrach. Nothing is known of the arms.

Column missing. The base of the cup is in a fractured condition so that very little of the stem cicatrix can be seen. It apparently had a diameter of 3.9 mm.

Ornamentation. A prominent rounded ridge extends up each radial series branching on the primaxil. Each interbrachial, so far as shown, has a small central node from which fine lines or ridges radiate out to the faces. Between these lines are shorter, more irregular lines or granules. There is a sort of granular or vermicular marking on the plates of the radial series on each side of the median ridge, which has been made rather obscure through weathering.

Horizon and locality. From the Hamilton group (upper Moscow shale), at Bellona, N. Y.

Types. Holotype in the collection of Doctor Springer, now deposited in the United States National Museum, Washington, D. C.

Remarks. Since the arms and the higher brachials of the cup are unknown, this species is referred with a query to Saccocrinus, though so far as preserved it fulfils the requirements of the genus. The species is easily recognized by the large radials and basals together with the prominent ridges on the radial series and the ornamentation, particularly of the interbrachials.

Named from the formation in which the species occurs.

Genus GENNAEOCRINUS W. & Sp. 1881, 1897

Gennaeocrinus kentuckiensis (Shumard)

Plate 31, figures 6, 7, 8

1859 Actinocrinus cornigerus (not Hall, 1858) Lyon & Casseday. Amer. Jour. Sci., 2d Ser., 28:238

1868 Actinocrinus kentuckiensis Shumard. Trans. Acad. Sci., St Louis, 2:345
1877 Actinocrinus kentuckiensis S. A. Miller. Amer. Pal. Foss., p. 67
1878 Actinocrinus cornigerus Bigsby. Thesaurus Dev.-Carb., p. 15
1881 Gennaeocrinus kentuckiensis Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 161 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:335
1889 Gennaeocrinus cornigerus S. A. Miller. N. Amer. Geol. & Pal., p. 247
1897 Gennaeocrinus kentuckiensis (incl. A. nyssa Hall) Wachsmuth & Springer. N. Amer. Crin. Cam., 2:548, pl. 34, figs. 11, 12, 13 (authors' ed.); Mem. Mus. Comp. Zool., v. 21
1904 Gennaeocrinus kentuckiensis Wood. Smith. Misc. Coll., no. 1471, v. 47, p. 80
1910 Gennaeocrinus kentuckiensis (incl. G. nyssa (Hall) Grabau & Shimer. N. Amer. Index Foss., 2:540

Calyx of medium size, wider than high, quite decidedly lobed in the region of the arm bases. Vault low and the interradial spaces broad and well-defined.

Dorsal cup semi-globose.

Basals three, pentagonal, thickened to form a projecting trilobate rim. Base of calyx flat due to the thickening of the basals. Radials five, hexagonal, about as long as wide, bearing 2 x 5 primibrachs which gradually decrease in size until the second primibrachs are about two-thirds or half the size of the radials.

First primibrachs are hexagonal; second primibrachs axillary, hexagonal or pentagonal, depending upon the number of interbrachial plates with which they come in contact. Secundibrachs 1 x 10, variable in shape, pentagonal, hexagonal, or heptagonal.

Tertibrachs 8 x 5. Of the tertibrachs immediately following the secundaxils those nearest the median line are axillary; outer ones followed by two additional tertibrachs, giving 1 x 10 tertibrachs on the inner and 3 x 10 tertibrachs on the outer side of the ray. The two axillary tertibrachs bear on the face near the median line of the ray a series of two quartibrachs (brachials of the fourth order), on the other face an axillary quartibrach bearing a quintibrach (brachial of the fifth order) on each sloping face. In the two outer branches of the ray the third tertibrachs give rise to arms; in the two innermost, the second quartibrachs; between these in each half ray the two quintibrachs. This makes eight arms to the ray (*see* plate 31, figure 7).

Primary interbrachial hexagonal, followed by three in the second range, four or five in the third range. (According to Wachsmuth and Springer (1897, p. 548) the series may also run 1, 2, 4.) These are succeeded by one or two rows of small plates which merge into the plates of the interambulacral areas.

Primary anal plate hexagonal or slightly heptagonal, smaller and narrower than the radials and followed by three large plates in the first row, five in the second and five or more in the third, one specimen showing seven.

Interaxillaries (intersecundibrachs, intertertibrachs, etc.) arranged in a single row or show the series 1, 2, 2, etc. in typical specimens.

Tegmen depressed convex, made up of small plates of nearly uniform size, each one covered with a small central tubercle. Orals small, not much larger than the other plates; ambulacrals in two alternating rows with a larger plate at each bifurcation. Interambulacral areas broad and depressed. Anus located half way between the summit and the periphery.

Arms eight to each ray, close together forming clusters, the clusters of each ray being far apart. This gives forty arms to the crown. Character of the arms not known.

Column occupies two-thirds the width of the base and has a large pentalobate axial canal.

Ornamentation varies considerably, and allowance should be made for variation in this character. It is elaborate, delicate, and sharply defined. The carinae are thin and about one-half a millimeter or more high. A strong carina runs from center to center of the radials and primary anal forming a hexagonal figure. Extending up the middle of each radial series is a strong carina which increases in prominence upward, until at the arm bases it is almost the width of the arms. The radials, primibrachs and the larger plates of the interradii have less strong, but pronounced, carinae running from the center of the plate to the middle of each face. In the angles between the coarser and finer carinae of the brachials and interbrachials broken lines of tubercles of about the height of the carinae extend from the centers of the plates to each angle. On the primary interbrachials two parallel carinae run from the centers to the upper lateral faces and meet two similar carinae from the centers of the end plates of the second range. In older forms (plate 31, figure 8) the ornamentation becomes more elaborate due to increase in number and fineness of the carinae. There are small spines or tubercles on the interaxillaries and on the secundibrachs on the inner side of the carina. Tubercles are borne by the rows of small interbrachials which merge into the tegminal plates. Each plate of the tegmen bears a small central tubercle. In the original description by Lyon & Casseday (1859, p. 239) a long, nearly central spine is noted. This was not noted by Wachsmuth and Springer (1897, p. 548) in their description of the species, and our material is poorly preserved as regards the tegmen.

Horizon and locality. From the Hamilton group, Louisville, Ky., and from the Hamilton (Moscow) shale, Canandaigua lake, New York.

Type figured here (plate 31, figure 7) in the collection of Doctor Springer.

Remarks. In the above description the secundibrachs have been given as 1 x 10. Wachsmuth and Springer (1897, p. 548) give the secundibrachs as 2 x 10, but none of our specimens show this. Kirk (manuscript notes) gives them as 1 x 10 or 2 x 10, stating that "the single secundibrach is probably the result of the fusion of two secundibrachs. In specimens having one, there is a break in the keel showing the position of the former suture." In the specimens in our possession the tegmen is poorly preserved, so that some of the details have been filled in from the description by Lyon and Casseday and the description and figure used by Wachsmuth and Springer.

The species to which G. kentuckiensis bears most resemblance is G. carinatus. It has eight arms instead of six, as in carinatus, and lacks the crescentic ridges on the radials and primary anal. Apparently kentuckiensis lacks the large tegminal spines so conspicuous in carinatus.

Gennaeocrinus eucharis (Hall)

Plates 27–30

1862 Actinocrinus eucharis Hall. 15th Ann. Rep't N. Y. State Cab. Nat. Hist., p. 130

1868 Actinocrinus eucharis Shumard. Trans. Acad. Sci. St Louis, 2:344

1877 Actinocrinus eucharis S. A. Miller. Amer. Pal. Foss., p. 66

1878 Actinocrinus eucharis Bigsby. Thesaurus Dev.-Carb., p. 15

1881 Gennaeocrinus eucharis Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 161 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:335

1889 Gennaeocrinus eucharis S. A. Miller. N. Amer. Geol. & Pal., p. 247

1897 Gennaeocrinus eucharis Wachsmuth & Springer. N. Amer. Crin. Cam., 2:549, pl. 34, fig. 14 (authors' ed.); Mem. Mus. Comp. Zool., v. 21

1898 Gennaeocrinus eucharis Grabau. 16th Ann. Rep't N. Y. State Geol. (1896), p. 285

1899 Gennaeocrinus eucharis Grabau. Bul. Buff. Soc. Nat. Sci., v. 6, nos. 2, 3, 4, p. 142, fig. 24, *e–g*

1900 Gennaeocrinus eucharis (in err.) Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 3, p. 196

1903 Gennaeocrinus eucharis Clarke & Ruedemann. N. Y. State Mus. Bul. 65, p. 70

1904 Gennaeocrinus eucharis Clarke & Luther. N. Y. State Mus. Bul. 63, p. 52

1910 Gennaeocrinus eucharis Grabau & Shimer. N. Amer. Index Foss., 2:540

A large species; dorsal cup broadly turbinate and a little inflated in the lower part.

Dorsal cup. Basals pentagonal, a portion of them thickened into a pronounced trilobate rim. Radials hexagonal, broader than high, the largest plates in the calyx. First primibrachs hexagonal, smaller than the radials and of relatively the same shape. Second primibrachs, the primaxils, in general very small compared with the first primibrachs; variable in shape, pentagonal, hexagonal or heptagonal, as they come in contact with a greater or less number of interbrachials.

Secundibrachs 1 x 10, axillary. On the outer face each supports a series of three tertibrachs; on the inner, one tertibrach which in turn is axillary.

Tertaxils support a variable number, usually three or four, quartibrachs on either face. Last plate of the quartibrachs of the outer series a quartaxil which supports two series; other series support one arm each, which gives eight arms to the ray.

Primary interbrachial large, as large or larger than the first primibrachs; hexagonal, longer than wide, and followed by two plates in the second row, three in the third (in one case a small fourth plate is present), two or three in the fourth and two (?) in the fifth.

Primary anal hexagonal or slightly heptagonal, of about the same size as the radials; supports three plates in the second and five in the third row. Higher plates not observed.

Between the half rays of each ray there is a vertical row of two interaxillaries, one intersecundibrach, one intertertibrach; intersecundibrach not always present. Interaxillaries sometimes present higher up between the minor divisions of the ray.

Tegmen in most of the specimens entirely unknown. In one fragmentary specimen from Cashong creek, just enough of the tegmen in two rays is preserved to show three strong spines (plate 28, figure 5), one, the largest, at the main branching of the ambulacral area and one on each side of this at each minor branching.

Arms eight to the ray, forty to the calyx; biserial, long, slender and flatbacked; may remain simple or branch once again some distance above the calyx (plate 27, figure 1). Pinnules long and slender. On each brachial on the outer side above the place of attachment of the pinnule is a small node or tubercle. On the backs of the arms at irregular intervals are sharp spines, two or three millimeters long, which are either arranged singly or paired. The large, most completely preserved specimens from Vincent show this character of the arms (plate 27, figure 1; plate 28, figure 3; plates 29, 30).

Column round with a large pentalobate canal. The large specimens from Vincent show almost the complete length of the column. Three specimens (plate 27, figure 1; plates 29, 30) are figured with the entire length of the stem preserved; the distal portion of the column of one specimen is shown on plate 27, figure 2. A fourth specimen (plate 28, figure 3) shows very well the characters of the proximal portion. Column composed of thick projecting nodals with sharp edges, between which are thinner, nonprojecting internodals.

The column shows a very peculiar and striking ornamentation. On every other nodal columnal is borne a circlet of three leaflike or petal-like appendages, giving three vertical rows which extend almost down the entire length of the column (plate 27, figures 1, 2; plate 28, figure 3). These appendages are solidly fixed. A thick line, resembling a midrib, extends from the nodal to the tip of the appendage, thinning out at the tip; and on either side are fainter veinlike lines. Each appendage meets, almost meets, or overlaps the appendage next above and below. A specimen of column showing these appendages very beautifully has recently been collected in the Hamilton beds at Canandaigua lake by Roy E. Fowler of Niagara Falls. Natural sections also were found showing the circlet of three appendages. The function, if any, of these appendages has not been ascertained. It seems possible that the purpose might be to give stability to the long stems with their heavy crowns. The appendages certainly are so fixed that they must of necessity curtail the flexing of the stem in any direction.

At the distal end of the column are a number of radical cirri of large diameter, apparently composed of cirrals all of the same size.

Ornamentation of this species on the same plan as that of G. nyssa.

A strong ridge extends up the radial series to the bases of the arms at which place it is of about the width of the arms. Fainter ridges radiate from the center of each plate to the middle of each face. The centers of all the plates are raised into more or less angular elevations or nodes, these being stronger on the radial series, especially upon the primibrachs. Later, between these radiating ridges, numerous faint striae are developed (plate 28, figure 1), and the radiating ridges have become fainter on the radials, first primibrachs and first interbrachials; this gives a more delicate touch to the ornamentation. In more mature forms (plate 27, figure 1; plate 28, figure 3) the ornamentation of all the plates is much fainter; even the ridges on the radial series are much less pronounced, being very faint or not visible on the radials. The radiating ridges, particularly on the lower plates of the cup, are represented by scattered tubercles and the central nodes are less strong.

With the above ornamentation may also be included the sharp spines on the arms and the three vertical rows of leaflike appendages on the column.

Horizon and locality. From the Hamilton (Moscow) shales at Vincent, Cashong creek near Bellona, Bellona, Canandaigua lake, Fall brook near Geneseo, and at Skaneateles lake, three and a half miles below Borodino, N. Y. One specimen from Canandaigua lake, near Cottage City, is a portion of the column which is referred to this species because of the characteristic ornamentation. Also found in the Ludlowville shale, Eighteen Mile creek and Alden, Erie county.

Types. Cotypes in the New York State Museum, numbers $\frac{4220}{1}$, $\frac{4220}{2}$, $\frac{4220}{3}$, $\frac{4220}{4}$, $\frac{4220}{5}$.

Remarks. Wachsmuth and Springer (1897, pp. 548, 549) suggested that G. eucharis and G. nyssa might be synonymous. G. eucharis is a larger form than nyssa and differs from it in the shape of the cup. The branching of the arms in eucharis takes place lower in the cup. The arms of eucharis are ornamented with numerous spines and the column of this species is also characteristically ornamented. Since the column is wanting in nyssa, no weight can be given to this character. Only one specimen of nyssa shows spines on the arms and here they are few and scattered. It might be argued that eucharis is an older form of nyssa, but the forms studied seem to contradict this. In nyssa maturity brings fainter radiating ridges, a strengthening of the ridges on the radial series and a strengthening of the central nodes on the plates, especially on the primibrachs, giving a very spinose effect to the calyx. In eucharis, at first fainter striae are developed between the radiating ridges which are fainter on the lower plates; older forms show the breaking up and disappearance of the radiating ridges and fainter ridges on the radial series. For a fuller discussion see *Ornamentation* under the description of nyssa and eucharis. From a close study of the two species Hall appears to be justified in separating them.

The specimen listed in the catalog of the American Museum of Natural History as the type of Gennaeocrinus eucharis, number $\frac{5026}{1}$, proves to belong to the genus Dimerocrinus; nor does it fit Hall's description of eucharis. For the description of this species see Dimerocrinus whitfieldi, page 85.

Gennaeocrinus nyssa (Hall)

Plate 31, figures 1–5

1862 Actinocrinus nyssa Hall. 15th Ann. Rep't N. Y. State Cab. Nat. Hist., p. 129

1868 Actinocrinus nyssa Shumard. Trans. Acad. Sci. St Louis, 2:346

1877 Actinocrinus nyssa S. A. Miller. Amer. Pal. Foss., p. 67

1878 Actinocrinus nyssa Bigsby. Thesaurus Dev.-Carb., p. 15

1881 Gennaeocrinus nyssa Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 161 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:335

1889 Gennaeocrinus nyssa S. A. Miller. N. Amer. Geol. & Pal., p. 247

1897 Syn. Gennaeocrinus kentuckiensis Wachsmuth & Springer. N. Amer. Crin. Cam., 2:548 (authors' ed.); Mem. Mus. Comp. Zool., v. 21

1898 Gennaeocrinus nyssa Grabau. 16th Ann. Rep't N. Y. State Geol. (1896), p. 285

1899 Gennaeocrinus nyssa Grabau. Bul. Buff. Soc. Nat. Sci., v. 6, nos. 2, 3, 4, p. 141, text-fig. 23, *a–d*

1903 Gennaeocrinus nyssa Clarke & Ruedemann. N. Y. State Mus. Bul. 65, p. 70

1904 Gennaeocrinus nyssa Clarke & Luther. N. Y. State Mus. Bul. 63, p. 52

1910 Syn. Gennaeocrinus kentuckiensis Grabau & Shimer. N. Amer. Index Foss., 2:540

Calyx of this species of medium size; dorsal cup globose.

Dorsal cup. Basals pentagonal and thickened to form a prominent tripartite rim. Radials hexagonal, higher than wide. First primibrachs hexagonal, higher than wide and narrower than the radials. Second primibrachs, the primaxils, much smaller than the first primibrachs and variable in shape; more frequently pentagonal, but may be hexagonal or heptagonal according to the number of interbrachials which border upon them.

Secundibrachs 1 x 10. The outer faces of these bear a series of two or three tertibrachs which give rise to a single arm; the inner faces support 2 x 5 tertaxils, which give rise to two arms, making six arms to the ray at the place where they become free.

Primary interbrachial hexagonal, about as large or larger than the first primibrach; followed in the second row by two plates, in the third by three. One interradius shows three in the fourth and fifth. In one specimen (plate 31, figure 2) the left posterolateral interradius shows two plates in the third row.

Primary anal hexagonal and slightly smaller than the radials; followed in the second row by three plates, in the third by five, in the fourth by five or more.

Tegmen according to Hall, elevated, and each plate bears a spine at the center. No specimen in our possession shows the tegmen.

Arms eight to the ray, forty to the crown, because of the bifurcation near the calyx of the middle arm of each half ray; biserial, long, slender, with flattened backs, as is the case in all observed Gennaeocrinus arms. Brachials bear long, slender pinnules, and there is a small node on the outer surface of each brachial at the origin of the pinnule. A young specimen (plate 31, figure 5) shows the arms rather well. One ray (at the right in the figure) shows additional bifurcations higher up in two arms which do not become biserial until after this higher bifurcation. Another specimen, poorly preserved, shows traces of a few scattered spines on the arms. This is the only specimen of nyssa in which any spines are shown.

Column round and perforated by a pentalobate canal. No columns found attached to the calyces.

Ornamentation. In this species the plates of the dorsal cup are marked by a faint series of low ridges which radiate from a small tubercle in the center of each plate to the middle of each face. A strong ridge extends up the radial series to the bases of the arms. Plates of the radial series up to the secundibrachs bear prominent nodes; those on the first primibrachs usually the most highly developed, being quite spinose. In more mature specimens (plate 31, figures 2, 3) the radiating ridges become much fainter, almost disappearing in some cases; there is a strengthening of the ridge on the radial series and the nodes at the centers of the plates, which resemble small spines. The spinose nodes are still the strongest on the first primibrachs and the primaxil.

Horizon and locality. From the Hamilton (Moscow) shales at Fall brook, North Bristol and Vincent, N. Y.; from the Ludlowville shale at Eighteen Mile creek.

Types. Cotypes in the New York State Museum, numbers $\frac{4221}{1}$, $\frac{4221}{2}$, $\frac{4221}{3}$, $\frac{4221}{4}$.

Remarks. Wachsmuth and Springer (1897, p. 548) placed G. nyssa as a synonym of G. kentuckiensis. It can readily be seen from the illustrations and description that nyssa bears little resemblance to kentuckiensis. G. kentuckiensis has a less globose calyx which is decidedly lobed, the arms being arranged in clusters which are widely separated. The interradii are broader and have three plates in the second row and four or five in the third. The delicate ornamentation of kentuckiensis given by the numerous sharp carinae is quite distinctive.

For comparison of this species with G. eucharis see *Remarks* under that species.

Gennaeocrinus carinatus Wood.

Plate 32, figures 1–7

1901 Gennaeocrinus carinatus Wood. Amer. Jour. Sci., 12:297, pl. 4

1904 Gennaeocrinus carinatus Wood. Smith. Misc. Coll., no. 1471, v. 47, p. 80

1910 Gennaeocrinus carinatus Grabau & Shimer. N. Amer. Index Foss., 2:540

The original description of this species by Miss Wood was based upon a beautifully preserved specimen from the Hamilton, Charlestown, Ind. There are in the New York State Museum three specimens of this species. One is a part of the dorsal cup which has been etched with acid to obtain a mold from which a squeeze could be made; the second is in a fragmentary, crushed condition; the third is an entire specimen which has recently come into the possession of the State Museum. It is smaller and not so well preserved as the type specimen which is also figured here (plate 32, figures 1–3).

Calyx of medium size, subglobose, with a low vault; interradial spaces broad and well defined. Arm regions prominent and projecting due to the deep furrows between them.

Dorsal cup. Basals three, pentagonal. A portion of the basal plates is thickened so as to form a projecting, thin-rimmed cup which is pierced by a quinquelobate canal. Radials five, hexagonal. Primibrachs two, smaller than the radials and decreasing in size upward. First primibrachs hexagonal. Second primibrachs, the primaxils, variable in shape; those of the right and left posterior rays heptagonal, those of the anterolateral rays pentagonal, that of the anterior hexagonal.

Secundibrachs 1 x 10 axillary. They vary in shape as do the primibrachs upon which they rest; secundibrachs resting upon the heptagonal primibrachs are hexagonal; those resting upon the pentagonal primibrachs heptagonal. In the anterior ray, the secundibrach on one side is thus heptagonal, on the other hexagonal.

Tertibrachs 8 x 5; those on the inner side of the ray heptagonal, on the outer side pentagonal. Of the tertibrachs immediately following the secundaxils those nearest the median line of the ray are axillary, giving rise to 3 x 20 radials of the fourth order, quartibrachs; the outer ones are followed by two additional tertibrachs. This makes 1 x 10 tertibrachs on the inner side and 3 x 10 tertibrachs on the outer side of the ray. On the outer side of the ray the third tertibrachs give rise to arms; on the inner side, the third quartibrachs, making six arms to the ray.

Primary interbrachial hexagonal; followed in the second row by two large, hexagonal or heptagonal, plates, in the third row by three smaller plates which are hexagonal or pentagonal. Above the third row the plates are variable in number; interbrachials pass directly into the interambulacrals. The New York specimens show a variation in the number of plates in the interradii. Some of the regular interradii have the succession 1, 2, 3; others, 1, 3, 4 (*see* plate 32, figures 5, 6). The number of interbrachials seems to depend somewhat upon the width of the interradius.

Primary anal heptagonal, followed in the type by three plates in the second row, four in the third. Only the smallest New York specimen shows the anal interradius; primary anal here followed by three plates in the second row and five in the third.

Interaxillaries (intertertibrachs, interquartibrachs) three in number, arranged in a vertical row and decreasing in size upward. The first, the intertertibrach, pentagonal; the second and third (interquartibrachs) respectively hexagonal and roughly pentagonal in shape.

Tegmen moderately elevated and composed of an irregular number of plates. Ambulacral areas elevated and separated by deep depressions which extend at least half way to the summit. At the bifurcation of the ambulacrals is a strong spine which is surrounded by a variable number of low spines or nodes. Anus excentric. In the small New York specimen from Athol Springs there are minute spines scattered over the plates in the region of the anus.

Arms unknown; six arm openings to the ray, giving thirty arms to the crown.

Column wanting. It was circular and pierced by a quinquelobate canal having about one-third the diameter of the column.

Ornamentation of this species perhaps its most striking characteristic. Basals thickened and projecting. Lower half of each radial and the primary anal provided with a crescentic ridge which is thickened at the center and thins out or is terminated with a spine at the sides. This whorl of crescentic ridges, as pointed out by Miss Wood, bears a resemblance to a six-petaled flower. There is a small spine in the center of each of three alternate petals.

From the center of the outer curve of this crescentic ridge, strong, rather sharp, ridges or carinae pass to the centers of the first primibrachs and first interbrachials, and from the centers of these plates to the centers of the adjoining plates forming a series of triangles. Between these carinae are others less strong, directed from the centers of the plates toward the angles but not reaching them. The carinae following the median line of the radial series are the strongest. They increase in prominence up to the arm bases and branch on the primaxils, secundaxils and tertaxils. Sometimes there are minute spines in the angles between the finer and coarser carinae, some of them rather elongated and showing a tendency to form new carinae. Each primaxil bears a spine in the angle of the bifurcation of the median carina; small spines also present on the secundaxils. Interaxillaries bear larger spines, one at the center of each plate, decreasing in size upward.

In the New York specimen showing the anal interradius there is a strong spine on each of the five plates of the third row and smaller spines on the plates of the row above.

More mature specimens show an increase in the minor carinae between the main strong carinae, and they are better developed. This gives a much more beautiful ornamentation (*see* plate 32, figure 7).

Horizon and locality. From the Hamilton of Charlestown, Indiana, and Falls of the Ohio, Louisville, Ky.; from the Hamilton (Ludlowville) shale of Athol Springs, N. Y., and the Hamilton (Moscow) shale of Canandaigua lake, N. Y.

Types. Holotype in the collection of the Boston Society of Natural History.

Remarks. G. carinatus may be easily distinguished from G. kentuckiensis, which it most resembles, by the crescentic, petal-like ridges on the radials and primary anal, together with the numerous carinae. G. kentuckiensis has eight arms to a ray instead of six.

Variations have been noted above in the New York forms as to the number of interbrachials in the interradii and as to the occurrence of spines. The variation in the number of interbrachials seems to depend on the width of the interradius, since the same specimen shows the regular number of the type and the increased number in different interradii. The variations are all of a minor character and are not sufficient to separate the New York forms from the type.

The original figures of the holotype were loaned by Miss Wood for reproduction here.

Gennaeocrinus carinatus var. **crassicostatus** nov.

Plate 32, figure 8

There is in the New York State Museum a specimen and a fragment of a specimen from the Hamilton (Moscow) shale of Cashong creek, Bellona, N. Y., which I have separated from G. carinatus as a variety. It shows the variation in the interradii as do the New York representatives of carinatus, but it also shows other variations. The form is more globose, the carinae are coarser, even the intermediate carinae are stronger and more fully developed. The thick, coarse carinae make the crescentic ridges on the radials less prominent. The spines on the tegmen are longer and much stouter.

At first it seemed as if the variations in the carinae and spines might be due to age. A mature specimen of carinatus is shown on plate 32, figure 7. The delicacy of the ornamentation is not lost, though more carinae are developed, just as age brings on the "*multilira*" type of ornamentation in Dolatocrinus liratus.

Gennaeocrinus decorus sp. nov.

Plate 31, figure 9

The general aspect of this specimen is that of a Gennaeocrinus. There is only a cast of a single specimen which is badly weathered and only fragmentary in preservation. One ray and parts of two others are shown, a complete interradius and part of another, the bases of the arms in two rays and in another ray several millimeters of two arms, and a few millimeters of column. The specimen appears to have been large, though in its state of poor preservation no measurements can be made nor can the shape of the dorsal cup be determined.

Dorsal cup. Basal disk much flattened and suture lines very difficult to distinguish; apparently the disk characteristic of Gennaeocrinus. Radials large, hexagonal, of about equal breadth and height. Primibrachs smaller than the radials; gradual decrease in size of the radial series upward. First primibrachs hexagonal, of about equal height and width; only primaxil shown heptagonal and of about equal height and width.

Secundibrachs 2 x 10, large. Second secundibrachs axillary, giving rise on the outer side in each half ray to two tertaxils, the second of which is axillary giving rise to two series of five or six quartibrachs which pass into the arms. On the inner side in each half ray the secundaxils give rise to a series of five or six tertibrachs which pass into the arms. Just at what point the arms become free can not be ascertained.

Primary interbrachial hexagonal, of about the size of the first primibrach, and followed by two plates in the second row, three in the third;

above this, number of plates indeterminate. Interradii widest at about the top of the primaxils; anal interradius not preserved. Intersecundibrachs and intertertibrachs are present, but can not be distinguished.

Tegmen not preserved.

Arms thirty, six to each ray. The two inner arms in each ray may branch higher up, but this can not be determined. Arms above the fifth or sixth tertibrach (inner arm) and quartibrach (outer arm) biserial and composed of very short brachials. Pinnules appear to be rather long.

Column. About 10 mm of column are preserved. In its crushed state the column has a diameter of about 5 mm which would be somewhat less in an uncrushed state. All the columnals are short. There are projecting nodals with shorter internodals between.

Ornamentation. A low rounded ridge on the radial series which becomes as wide as the arms above the secundaxils. Plates of the radial series and the interbrachial plates all ornamented with rather strong rounded ridges or carinae which radiate from the centers of the plates to the middle of the faces.

Horizon and locality. From the Hamilton beds at Worcester, Otsego county, N. Y.

Types. Holotype in the collection of the New York State Museum.

Remarks. This species bears some resemblance to G. nyssa and, more especially, to G. eucharis; but from both it may be readily distinguished by the number of secundibrachs, which are 2 x 10 in G. decorus and 1 x 10 in G. nyssa and G. eucharis. The bifurcation of the higher brachial series likewise is different. In G. eucharis and G. nyssa the single series of tertibrachs is in the outer arm of each half ray and the tertaxils on the inner side, the middle arm bifurcating again; in G. decorus the single series of tertibrachs is on the inner side of each half ray. There are no spines or nodes on the plates of the dorsal cup of G. decorus, or on the arms so far as preserved. The column in this species is not as large, apparently, as in G. eucharis, and there is no indication of ornamentation.

Gennaeocrinus peculiaris sp. nov.

Plate 31, figure 10

Calyx of medium size. Dorsal cup subturbinate, quite strongly lobed. Vault low with depressed interambulacral areas.

Dorsal cup. Basals raised into a trilobate rim depressed in the center. Radials hexagonal, wider than high. First primibrachs hexagonal, a trifle narrower than the radials but higher. Primaxils are heptagonal, so far as observed.

Higher brachials apparently irregular. In the left posterolateral ray the primaxil supports two secundibrachs on the left and one secundibrach on the right. Each secundaxil supports a tertaxil on the inner side, and a single arm on the outer, giving six arms to the ray. The left anterolateral ray apparently is the same as the left posterolateral. In the right anterolateral ray, however, the primaxil supports two secundaxils. Of these, the right is the same as in the left posterolateral ray, the left supports two arms, giving five arms to the ray. The anterior ray has the appearance of a six-arm ray, but the primaxil supports two secundaxils as in the case of the right anterolateral.

Primary interbrachials about as large as the radials and very low in the calyx, coming nearer the basals than in any other species observed. In the second range are two or three plates, and in the third, four. Anal interradius not preserved. Intersecundibrachs in the series 1, 2, 2.

Tegmen composed of numerous small plates, the surfaces of which are slightly corrugated. At the bifurcation of each ambulacrum stands a rather stout spine.

Arms. The normal number of arms seems to have been thirty, though one ray was noted with five arm bases. Arms wanting.

Column missing; round, with a pentalobate canal, judging from the cicatrix.

Ornamentation of this species quite peculiar and unlike that of any other species of Gennaeocrinus. Traversing the plates of the radial series is a strong continuous carina which, differing from other species, does not rise into nodes at the centers of the plates. On each plate of the radial ring, formed by the radial ridge and the two lateral ridges connecting the center of the plate with the neighboring radials, is a concave faced, three-sided pyramid which attains such a height as to reach beyond the basals. From the center of the primary interbrachial strong ridges pass to the radials and primibrachs. Above the sharply defined lateral ridges to the primibrachs, the ornamentation consists of granules and, exceptionally, incipient vermiculose markings. There is a small node at the center of each plate of the third row of interbrachials.

Horizon and locality. From the Hamilton (Moscow) shales near Moscow, New York.

Types. Holotype and only known specimen in the New York State Museum.

Remarks. This species may be readily recognized by the peculiar ornamentation, by the proximity of the primary interbrachial to the basals, by the relative size and proportion of the radials and primibrachs, and by the obscurity of the basals.

The name pecularis is here proposed for this species because of the peculiar character of the ornamentation.

Genus MEGISTOCRINUS Owen & Shumard 1852 (W. & Sp. 1897)

Megistocrinus depressus Hall

Plate 33

1862 Megistocrinus depressus Hall. 15th Ann. Rep't State Cab. Nat. Hist., p. 134

Actinocrinus pocillum. Op. cit., p. 134

1868 Megistocrinus depressus Shumard. Trans. Acad. Sci. St Louis, 2:380

Actinocrinus pocillum. Op. cit., p. 347

1877 Megistocrinus depressus S. A. Miller. Amer. Pal. Foss., p. 83

1878 Megistocrinus depressus Bigsby. Thesaurus Dev.-Carb., p. 18

Actinocrinus pocillum. Op. cit., p. 15

1881 Megistocrinus depressus Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 137 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:311

Gennaeocrinus pocillum. Op. cit. (authors' ed.), p. 137; v. 33, p. 311

1889 Megistocrinus depressus S. A. Miller. N. Amer. Geol. & Pal., p. 260

Gennaeocrinus pocillum Op. cit., p. 247

1895 Megistocrinus ornatus Miller & Gurley. Ill. State Mus. Nat. Hist. Bul., no. 7, p. 42, pl. 2, figs. 15, 16, 17

1897 Megistocrinus depressus Wachsmuth & Springer. N. Amer. Crin. Cam., 2:540 (authors' ed.); Mem. Mus. Comp. Zool., v. 21

1900 Megistocrinus depressus (in err.) Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 3, p. 198

1903 Megistocrinus depressus Clarke & Ruedemann. N. Y. State Mus. Bul. 63, pp. 73, 74

Aorocrinus ? pocillum. Op. cit., p. 64

1904 Megistocrinus depressus Clarke & Luther. N. Y. State Mus. Bul. 63, p. 52

Aorocrinus pocillum. Op. cit., p. 52

1904 Megistocrinus depressus Wood. Smith. Misc. Coll., v. 47, no. 1471, p. 64

1910 Megistocrinus depressus Grabau & Shimer. N. Amer. Index Foss., 2:538

This is an extremely variable form as regards shape of theca, spinosity of vault, and surface ornamentation. After examining with care a large number of specimens which I refer to this species, I have come to the conclusion that it is impossible to give specific names to the many variations shown by different individuals. It is necessary either to combine all the variants under one specific designation or recognize several distinct species. As any given set of characters that may be chosen varies considerably even within the narrow limits of these greatly restricted species, and are in part held in common by several of the other groups, it has been thought best to recognize but the one species. Wherever possible, closely related species that have sufficiently diagnostic characters are held valid, even though their close affinities to depressus are apparent. Among the large number of specimens examined are many immature individuals which are of great interest as throwing light on the ontogeny of the species.

All parts of the crown have been found in an excellent state of preservation.

The species is a large one, uncrushed dorsal cups 52 mm in diameter having been examined. Undoubtedly the species attains a much greater size, judging by the fragmentary material in the collection. With a proportion of 4 or 5 to 1 expressing the length of the arms to the height of the cup, it will be seen that the crowns were of imposing dimensions. The tegmen is as a rule low, being about one-third the height of the cup.

Dorsal cup. Outline varies considerably. Base always more or less flattened, the flattened area reaching to the tops of the radials; rarely somewhat excavated. Above the level of the radials the average cup rounds outward to the tops of the first primibrachs, above which the sides diverge at a low angle to about the tops of the first secundibrachs where the cup begins to flare outward. Variations from this mean tend on the one hand toward globosity, and on the other, to a low bowl-shaped cup. Many of the specimens have been flattened through vertical pressure and it is such forms that Hall chose as his types. These compressed M. depressus resemble M. abnormis, which is a very closely related species. The fixed secundibrachs and tertibrachs (if present) are laterally produced, forming well-defined lobes. This lobate character is greatly accentuated in specimens that have been subjected to crushing. It is a characteristic and well-marked feature in all the specimens examined, and is very pronounced in immature individuals. With age the lobation becomes less marked.

Basals fused to three elements, the sutures between which are as a rule closely anchylosed; generally covered by the column, but at times extend slightly beyond. In the latter case the basals frequently show their tripartite character, being produced into a trilobate rim. Radials large, having a maximum width slightly greater than the height. First primibrachs of about the same width as the radials and shorter. Primaxils considerably narrower and lower than the first primibrachs.

First secundibrachs large, occasionally comparable in size to the primaxil. In the case of two-arm rays, as a rule, three secundibrachs of fairly large size are incorporated in the cup. In four-arm rays the first secundibrach is nearly always axillary and supports two or three large incorporated tertaxils. Occasionally a variant is seen where the second secundibrach is axillary.

Interradii relatively narrow; posterior the widest, the greatest width being at about the level of the third range. Above this level the area becomes narrower; at the level of the arm bases only slightly wider than the others. Proximal anal as a rule somewhat narrower than the radials, and of the same height; followed by three plates of large size, one or more of them frequently being as high as the proximal anal. The posterior interradius usually attains its maximum breadth at the level of the next range or the one above. Plates in the higher ranges variable in number, depending in large part apparently on the size of the specimen; decreasing gradually in size upward. In the third range four to six plates, four being the usual number, and in the fourth five to seven plates; above this level plates small, irregular in arrangement, gradually merging into interambulacrals. In the regular interradii proximal interbrachial large, frequently exceeding the radials in height; followed by two large plates in the second range, two or three in the third, three or four in the fourth, and two to four in the fifth. This last range lies at the level of the arm bases, and above connects with the interambulacrals.

Intersecundibrachs two or three. Where there are three, two of them rest on the upper sloping faces of the first. In four arm rays a single intertertibrach appears in each half of the ray.

Tegmen well shown in a number of individuals; as a rule low and arching. Interambulacral areas depressed, a character strongly marked in some individuals that have not been subjected to crushing. Tegmen composed of a great number of fairly large, heavy plates. Along the ambulacral ridge there is a more or less regular arrangement of two rows of plates. This biserial arrangement is clearly shown in young specimens, but is more or less broken up in the older crinoids. Anal opening high up in the tegmen, close to the central spine; occasionally lower, approaching the condition found in Megistocrinus abnormis. Anal tube short made up of numerous small plates. As a rule only six spines are borne on the tegmen. One of these is subcentral, and each of the other five lies at the main bifurcation of an ambulacral ridge. Occasionally smaller secondary spines appear, particularly at the points of bifurcation of the ambulacra.

Arms. No adult individual is known in which the arms are preserved. The arms figured by Wachsmuth and Springer (1897, pl. 49, fig. 4*c*) not only do not pertain to this species but are not referable to Megistocrinus. A few of the higher interbrachials are preserved in this individual, and these almost conclusively point to Rhodocrinus nodulosus as the form to which the arms belong. Three young individuals have the arms preserved. Considering the size of the theca, the arms are comparatively slender; compactly biserial with rounding backs and sides. Pinnules long, slender and closely crowded. Branching of arms isotomous. After becoming free there is but a single bifurcation of the arms of these young crinoids. At maturity there are undoubtedly many more, as in the closely allied M. ontario as many as five have been counted. As a rule the species has sixteen free arms, the anterolateral rays bearing two each and the others four. Exceptionally, three free arms are to be found in one of the anterolateral rays.

Column round, stout, and with a pentalobate axial canal. Curiously enough no part of the column has been preserved in all the specimens examined.

Ornamentation. Surfaces of plates of dorsal cup vary from concave through practically flat to decidedly convex; last type probably the result of secondary deposition of stereom, representing gerontic conditions. In one of the specimens here figured (plate 33, figure 1), one of Hall's types, the center of a plate is raised in a sort of tablet which roughly conforms in shape to the outline of the plate, and is separated from the edges of the plate by a narrow beveled area. This condition suggests a cessation of peripheral growth which after a time was resumed. It can not be considered normal for the species as it is the only case observed. A character that shows distinctly in rather old individuals and appears frequently in the material from New York is a rounding elevation along the suture between adjacent radials, (plate 33, figures 12, 13). This is a sort of rounding hump that is highest at about one-half the height of the apposed faces and slopes off in all directions. The radials are somewhat concave and these six radiating ridges give the base of the cup a distinctive and characteristic lobate appearance. Superficial ornamentation of this species very variable within certain limits; in some individuals expressed by fine discrete papillae, with little or no evidence of linear arrangement; in other cases the granules coalesce in places, forming a sort of shagreen ornamentation. Granules may be aligned, particularly in lines near the margins of the plates and parallel to the faces; again, the lines may radiate from the center of a plate, running perpendicular to the faces. The ornamentation of the young will be discussed under the heading *Ontogeny*.

Ontogeny. A very complete series of specimens belonging to the species has been collected, which exhibits a number of interesting developmental features. The dorsal cup of the smallest specimen observed (plate 33, figure 6), one of the types of Hall's Actinocrinus cauliculus, measures only about 4.5 mm in breadth by 2.6 mm in height, while the largest that could be measured with any degree of accuracy measures 52 mm in breadth by 22 mm in height. Much larger specimens occur, however. Four of the most perfect young specimens give the following measurements of the dorsal cup:

	Height of cup	*Breadth of cup*
1	2.6 mm	4.5 mm
2	4.4 mm	9.2 mm
3	4.5 mm	9.6 mm
4	7. mm	14. mm

The breadth in all cases is taken from the anal interradius to the base of the free arms of the anterior radius.

In the smallest specimen, number 1 (plate 33, figure 6), dorsal cup subglobose; arms free from the primaxil up. Radial series marked by a low rounded ridge. Otherwise there appears to be no ornamentation. Basals comparatively large, and extending beyond the stem in a well-defined trilobate rim. Primary interbrachials large; together with the second range of interbrachials filling the interradii. Anal interradius remarkably wide. This specimen, marked $\frac{4020}{2}$ in the type catalog, was one of the types of Hall's *Actinocrinus cauliculus*.

Specimen number 2 (plate 33, figure 7) shows the vault, which is low, in fact almost flat. Interambulacral areas slightly depressed. Tegminal spines represented by nodes, a fraction of a millimeter in height. Arms slender, biserial, about 28 mm in length, probably bifurcating only once.

Specimen number 3 (plate 33, figure 8), although measuring only slightly larger than the preceding specimen, is more globose, and appears to be a considerably later stage. Free arms stouter, and bifurcate twice. Interradii with a third range of plates, and interbrachials comparatively smaller. Anal interradius more constricted at the periphery, and containing more plates. Radial ridge not so well marked; the other plates seem to have an obscure ornamentation. This specimen, number $\frac{4021}{2}$, and the following, number $\frac{4021}{1}$, were Hall's types of *Actinocrinus pocillum*.

Specimen number 4 (plate 33, figure 9) has stouter arms, the groups of which are much nearer together, comparatively. The dorsal cup is flattened in the basal region, and has assumed a more characteristic *depressus* outline.

A fifth young specimen, while not preserving the arms, shows the characters of the theca excellently. This specimen is figured on plate 33, figures 3–5.

Horizon and locality. Found in the Hamilton group (Moscow shale), and has a very extended range. In New York State it has been found most abundantly perhaps on the shores of Canandaigua lake, near Menteth's point. Other localities are Vincent and North Bristol, Ontario county; Geneseo and York, Livingston county; Bellona and Cashong creek near Bellona, Yates county; Livonia salt shaft (385 foot level), Livingston county; and Eighteen Mile creek, Erie county. Also found in the Ludlowville shale at Alden, Erie county. Types from Canandaigua lake. Other localities are Charlestown, Ind.; Louisville, Ky.

Types. Cotypes in the New York State Museum numbers $\frac{4320}{1}$, $\frac{4320}{2}$, $\frac{4320}{3}$. Number $\frac{4320}{4}$ is probably a Rhodocrinus nodulosus.

Remarks. The specimen of depressus marked "type" in the American Museum of Natural History, number $\frac{5029}{1}$, could scarcely have been used by Hall in his description, as it does not show the vault, nor does Hall mention the remarkably excavated character of the plates which is so marked in this specimen (plate 34, figures 6, 7). The specimen has been referred to M. ontario.

M. ornatus Miller and Gurley is regarded as a synonym of depressus (Wood, 1904, p. 64). The differences pointed out are only minor variations that may occur within a species. The ornamentation described as so characteristic of ornatus is shown very beautifully on one of the smaller New York specimens (plate 33, figures 10, 11), and is also well shown on one of the crushed dorsal cups used by Hall as a cotype, number $\frac{4320}{2}$ in the Museum type catalog. I have considered the possibility of making this form M. depressus var. ornatus, but there does not seem to be enough difference even for this as the types of ornamentation in depressus grade into this more elaborate type.

M. depressus undoubtedly is a close ally of two other described species, M. abnormis Lyon and M. ontario Hall. The reasons for keeping depressus and ontario distinct will be given under the description of the latter. The specific distinctions shown between abnormis and depressus appear to be valid. Abnormis is a lower form with much exaggerated lobation of the theca. The anal opening is low, appearing at the level of the arm bases. There is another species intermediate in certain particulars between depressus and abnormis — M. expansus Miller and Gurley. It resembles abnormis in height of cup, but differs from it in the rounded, arched tegmen and the slightly lobate character of the theca. The width of the posterior interradius at the level of the arm bases is narrow. From depressus it differs to a less marked degree. The wide flattening of the level portion of the cup, the less distinct lobation and the character of the tegmen should serve to distinguish it however.

Megistocrinus ontario Hall

Plate 34

1862 Megistocrinus ontario Hall. 15th Ann. Rep't N. Y. State Cab. Nat. Hist., p. 136

1868 Megistocrinus ontario Shumard. Trans. Acad. Sci. St Louis, 2:380

1877 Megistocrinus ontario S. A. Miller. Amer. Pal. Foss., p. 83

1878 Megistocrinus ontario Bigsby. Thesaurus Dev.-Carb., p. 18

1881 Megistocrinus ontario Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 137 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:312

1889 Megistocrinus ontario S. A. Miller. N. Amer. Geol. & Pal., p. 260

1897 Syn. Megistocrinus depressus Wachsmuth & Springer. N. Amer. Crin. Cam., 2:540 (authors' ed.); Mem. Mus. Comp. Zool., v. 21

1903 Megistocrinus ontario Clarke & Ruedemann. N. Y. State Mus. Bul. 65, p. 74

1904 Megistocrinus ontario Clarke & Luther. N. Y. State Mus. Bul. 63, pp. 48, 52

Megistocrinus ontario I was at first inclined to place as a synonym of Megistocrinus depressus Hall. After studying a series of Megistocrinus depressus, however, I came to the conclusion that ontario should be held distinct. But three well-preserved adult specimens of this species have been examined. Two of them are the specimens used by Hall as his types. Another, probably to be referred to this species, is a crushed and imperfect cup that is listed by the American Museum of Natural History as a type of M. depressus (plate 34, figures 6, 7). Of Hall's cotypes, one is an uncrushed theca of which a portion has been broken away. The other is an almost complete crown, the theca of which is somewhat crushed, and the arms in part broken off.

Species large, the specimen preserving the arms probably of average size. With arms expanded this crown would have a height of about 120 mm. Of this amount the dorsal cup contributes about 20 mm. In the theca the vault has a height about one-half that of the cup.

Theca. Dorsal cup low, with strongly rounding sides. Basal region flattened, the flattening extending to the tops of the radials. From this level the sides curve upward gently to the level of the primaxils, above which the sides ascend more steeply to the first secundibrachs where the brachials flare outward rather abruptly. In the interradial areas above the level of the primaxil the cup constricts slightly. Width and length of the posterior interradius greatly exceeds that of the other interradii and gives the cup a distinctly asymmetrical outline. The arm bases do not project strongly and as the interradii at this level are narrow, the theca does not show the marked lobate character characteristic of M. depressus. Tegmen low; interambulacral areas only slightly depressed. Two fairly complete specimens give the following measurements:

Height of theca	*Height of cup*	*Breadth of cup*
33 ? mm	21.8 mm	50 mm
31 mm	19 mm	47 mm

The height of the cup is taken to the bases of the free arms, and the breadth taken at this level from the posterior interradius to the anterior radius. In the larger specimen the tegmen is not shown, so the height of the theca can only be estimated.

Dorsal cup. Basals entirely concealed by the column. Radials large with a width as a rule in excess of the height. First primibrach higher than the radial and somewhat narrower. Primaxil shorter than the first primibrach but of nearly the size of the radial.

First secundibrach large, and in the case of a four-arm ray axillary. In a two-arm ray the first two secundibrachs large. Above them in adult specimens a third brachial is incorporated in the cup. In the four-arm rays two fairly large tertibrachs are incorporated in each division of the ray.

Proximal anal plate of about the size of the adjacent radials. It supports three plates of which the central is the smallest. Lateral plates very large, one or both exceeding the radials in size. Median line of anals distinct to the fourth range, above which the plates are irregularly disposed. In the third range there are five plates; those lying next the radial series the largest, the plates decreasing in size toward the median line. In the fourth range there are seven plates, averaging considerably smaller in size than those of the third range. At the level of the third or fourth range the posterior interradius attains its greatest breadth. Above this level plates smaller in size and fewer in number.

In the regular interradii proximal interbrachial very large, considerably exceeding the radials in size; followed in the second range by three large plates of which the median is the smallest; in the third range four smaller plates, and in the fourth, four or five still smaller. Above this level plates smaller and fewer in number. At the level of the arm bases interradii narrow and of approximately the same breadth; below, interradii unusually wide for the genus, the posterior being notably so. Greatest breadth in interradii at about the level of the primaxils.

In the four-arm rays there is a single large intersecundibrach, followed in the second range by two smaller plates. The same arrangement probably obtains in the two-arm rays. In each half of the four-arm ray is a fairly large intertertibrach, followed by two small plates.

Tegmen relatively low and rather smoothly arched (plate 34, figure 5). Ambulacral areas somewhat elevated, but not conspicuously so; the deep interambulacral depressions so characteristic of many specimens of d e p r e s s u s wanting in this species. Anal tube fairly stout and subcentral. Tegmen bears a number of spines which are much smaller than in the case of d e p r e s s u s and more numerous than is usual in the latter species. There is one nearly central spine just anterior to the base of the anal tube. At each four-arm ray there are three spines, one at the main bifurcation of the ambulacrum, and one at each of the secondary bifurcations. Only one spine at a two-arm ray. Plates of tegmen small and numerous; no regularity of arrangement except occasionally along the ambulacra, where in places there is a more or less well-defined alignment.

Arms four to a ray, except in the anterolateral rays, where there are two to each ray. This gives the species sixteen free arms. Arms long and fairly stout; divisions isotomous. As many as five bifurcations may occur above the point where the arms become free. Rami compactly biserial, with slightly flattened back; sides rounding. Pinnules long and slender.

Column. Only one or two of the proximal columnals are preserved in an adult form. Column stout, having a diameter of nearly 7 mm; circular and perforated by a large obscurely pentalobate canal. Two young forms (plate 34, figures 8, 9) show the column very well, especially the smaller one. The column here is composed of nodals and internodals, the nodals being much thicker and projecting in a striking manner.

Ornamentation. The plates of the cup have concave surfaces. There is a superficial ornamentation of fairly strong ridges of intricate pattern, which varies in different portions of the cup of the same individual. In a general way the ridges radiate from the center of the plate, running perpendicular to the faces. They are more or less wavy, and broken up into dots and dashes. Frequently there are series of irregular ridges which run parallel to the faces of the plate and nest one within the other. This produces a network similar to a spider web (plate 34, figure 2).

Ontogeny. Three young specimens of o n t a r i o are figured here (plate 34, figures 8–10). Two of them show the column attached, and one shows the arms branching at least twice. They show in general the characteristics of the adult forms. The dorsal cup is wider in comparison with the height than in the young of depressus, and there are more plates in the interradii. The ornamentation as shown in the smallest specimen is that of the more strictly ontario type.

One of these specimens (plate 34, figure 10) is doubtfully referred here to ontario. In one anterolateral ray showing the bases of the free arms, there are three of these. If the other anterolateral ray were furnished with an equal number this specimen might constitute a new species, as in these forms the number of free arms is remarkably constant. In a large number of specimens of depressus only one specimen was found which varied from the normal, and that in only one ray.

Anal interradius in this specimen constricted at the periphery much more than in the young of depressus at a similar stage. Dorsal cup wider in comparison with the height, and ornamentation differing essentially from that of the young depressus.

There seems to be little to distinguish this specimen from ontario, other than the possible difference in the arm formula. The ornamentation, though differing considerably from that of the adult ontario, is much as one would expect to find in the young of this species.

Horizon and locality. Hamilton (Moscow) shale. Types from Dresden, Yates county, and Canandaigua lake, N. Y.; specimen in the American Museum, number $\frac{5029}{1}$, from Seneca lake; young specimens from the Livonia salt shaft and North Bristol, Ontario county. Species also found in the Ludlowville shale in the vicinity of Canandaigua, N. Y.

Types. Cotypes in the New York State Museum, numbers $\frac{4321}{1}$, $\frac{4321}{2}$.

Remarks. The arm bases of the specimen figured on plate 34, figure 1, appear to be widely separated and to form a continuous ring about the periphery. As a matter of fact the specimen was probably quite as lobate as the specimen figured on plate 34, figures 3, 5.

In the young specimens (plate 34, figures 8–10) the plates are slightly convex. In both adult specimens, however, they are concave.

The width of the anal interradius at the periphery is comparatively much wider in the young than in the adult, as in the case of depressus.

This species most closely resembles M. depressus from which it might well have been derived. It differs from depressus in a number of characters which may well serve to separate the species. The surface ornamentation in the two species may be very similar. In depressus the ornamentation consists more frequently of fine granules which may or may not have a linear arrangement; but some specimens, otherwise showing all the characters of depressus, have the radiating lines so characteristic of ontario. In the latter, these lines are often so strong as to appear like well-marked ridges, and the ornamentation of the plates sometimes has a spider-web effect. The theca is much lower and broader in ontario with more bulging sides. The disproportion between the posterior interradius and the other interradii in height and inflation is much more marked in ontario. Also the dorsal cup is less distinctly lobed and the corresponding interambulacral depressions much less pronounced. In ontario, however, the interradii are proportionally much wider, particularly the posterior, and contain many more plates than in the case of depressus. The spines in the tegmen are much larger in depressus and as a rule fewer in number. A glance at a dorsal cup is as a rule enough to identify M. ontario. The plates are more numerous and proportionally smaller; instead of being relatively short and broad the plates are relatively long and narrow. This character is particularly well marked in the plates of the radial series.

Genus THAMNOCRINUS nov.

[Ety. θαμνος, *thicket, bush;* κρινον, *lily*]

This remarkable Batocrinoid is represented by two known species in the American Middle Devonian. One species has already been described by Springer (1911) as Dorycrinus devonicus. Of this species the theca alone is known. The new species here described, Thamnocrinus springeri (plate 26, figures 8–10), which has been chosen as the genotype, shows the characters of the arms and stem as well. Thamnocrinus devonicus (Springer) resembles springeri closely, but may be distinguished without difficulty.

The genus contains species of fair size, the crowns so far as known attaining a height of over 70 mm. Arms in length and abundance show a remarkable preponderance over the theca. Dorsal cup subturbinate. Tegmen highly arched and greatly inflated in T. devonicus; interradially sharply depressed.

Dorsal cup. Thamnocrinus is monocyclic. Basals fused to three elements of subequal size. Radials of medium size. The succeeding plates of the radial series gradually decrease in width and height upward. Plates of the radial series incorporated in the rigid cup to the level of the secundaxils or a brachial or so beyond. In the case of T. springeri a lateral union of the main arm trunks, and their incorporation in the theca up to the level of their last bifurcation, is brought about by a large number of small interbrachial plates continuous with those of the cup. In the posterior interradius proximal anal of about the size of the adjacent radials; followed in the second range by the three plates characteristic of the Batocrinidae. Median series of anal plates well marked. Other interradii fairly wide; each with interbrachials ranging in number from six to eleven, to the level of the secundaxils.

Tegmen as known in T. devonicus highly arched and inflated; height approximately that of the dorsal cup; sharply and deeply depressed in the interambulacral areas, giving a strongly lobate appearance; composed of a large number of small plates having for the most part a very irregular arrangement. Plates crossing the ambulacra roughly aligned. Anal opening situated high up in the tegmen. Heavy spines borne on the tegmen. The base of a spine is raised above the general level of the tegmen, arising at the apex of a subconical protuberance made up of a number of small plates.

Arms long, stout and compactly biserial. They divide by unilateral heterotomy, the undivided branches being given off to the inside. Main arm trunk short, uniserial and very heavy. Pinnules long, and lie in apposition.

Column large with a fairly large circular axial canal. Nodals annulate, but not conspicuously so; in the proximal portion of the column some of the internodals slightly annulate.

Ornamentation. The plates of the theca are, so far as known, smoothly rounded with but traces of fine granulation; or they show delicate granulose striae which have a somewhat radial arrangement at the periphery of the plates, particularly the interbrachials. The tegmen bears sixteen heavy spines. One of these is subcentral and situated just above the anal opening. The others are disposed three to the ray; one at the main bifurcation of the ambulacral series; each of the others a short distance from the first, on each fork of the ambulacrum.

Horizon and locality. So far as definitely known, this genus is restricted to the Middle Devonian of North America, being found in the Sellersburg (Hamilton) of Clark county, Indiana, and the Moscow shales (Hamilton) of New York.

Genotype. Thamnocrinus springeri sp. nov.

Remarks. It is possible that Actinocrinus prumiensis Wirtgen and Zeiler is referable to this genus. The structure of the arms is not known in the case of A. prumiensis. The general appearance of the dorsal cup and its structure are strikingly similar to the American species; however, the tegmen is quite different. In A. prumiensis it is low, composed of relatively few and larger plates, and does not bear spines. There is a subcentral node and at times a group of nodose plates at the apex of the tegmen. The differences in tegmen alone would, it seems, be enough to separate the form. Were it considered advisable later to place A. prumiensis in the same genus with the American species, a question would at one arise as to the validity of Thamnocrinus as opposed to Pyxidocrinus Müller.

Wirtgen and Zeiler (1855, p. 82) state in regard to their new species Actinocrinus prumiensis: "Diese devonische Art kann auch zur Aufstellung einer Gattung noch benutzt werden, für welche der name Pyxidocrinus Müller schon in Bereitschaft ist." ("This Devonian form can also be used for the erection of a genus for which the name Pyxidocrinus Müller is already in readiness.") Pyxidocrinus as here mentioned must be taken as a *nomen nudum*. On the following page Ceramocrinus Müller is defined as a new genus, and a species C. eifelensis W. & Z. described under it. So on page 84, Epactocrinus Müller is defined, and on the following page a new species described by Wirtgen and Zeiler. There is obviously no intent here to establish the genus Pyxidocrinus, and the casual reference does not warrant the taking of A. prumiensis W. & Z. as the genotype of Pyxidocrinus. In 1857 Müller himself, under the discussion of the genus Actinocrinus practically repeats the remarks of Wirtgen and Zeiler. On page 254 he states: "Es würden also Pradocrinus und Pyxidocrinus identisch sein." ("Therefore, we consider Pradocrinus and Pyxidocrinus identical.") When he mentions the species prumiensis it is always as Actinocrinus prumiensis. It seems then that Pyxidocrinus should be relegated to the limbo of *nomina nuda*. I can see no reason for following Wachsmuth and Springer (1897, p. 519) in recognizing the genus and quoting it as a synonym of Periechocrinus (in part). It is either a valid genus with Actinocrinus prumiensis as genotype, or a *nomen nudum*.

Thamnocrinus differs from Dorycrinus Wachsmuth and Springer: 1897, p. 454) in several respects. The plates of Dorycrinus are frequently nodose while they are smooth, granulose, or granulose striate in Thamnocrinus and the radial series is ornamented with a low, broad ridge. In the former the first primibrachs are quadrangular, the second usually pentangular, exceptionally hexagonal or heptagonal; in the latter the first primibrachs are hexagonal, the second heptagonal.

The number of interbrachials in Dorycrinus is limited, being rarely more than three in the dorsal cup, the two upper ones at the level of the arm bases. They are more numerous in Thamnocrinus, the species springeri having six rows of interbrachials up to the tertibrachs and a number of small irregularly arranged ones beyond that point. The anus is excentric in Dorycrinus and opens high up in the tegmen. Both genera bear spines on the tegmen — in Dorycrinus the posterior oral and frequently the first radial plates above the ambulacra bear spines; in Thamnocrinus there are sixteen spines, one subcentral and situated just above the anal opening, the others disposed three to the ray.

In Dorycrinus the arms are in groups, rather short, two to four arms to a ray, and more or less spinous; in Thamnocrinus the arms are long and not spinous. There are two main arm trunks to each ray, short, uniserial and very heavy, which divide (four times) by unilateral heterotomy, the undivided branches being given off to the inside.

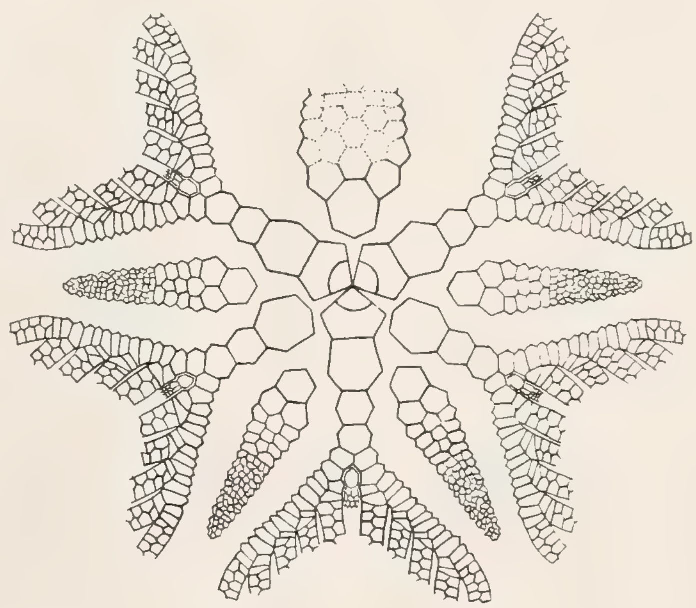

Figure 48 Analysis of calyx of Thamnocrinus springeri, the genotype.

The column in both is round, in Dorycrinus having a small pentangular axial canal, in Thamnocrinus a fairly large round one.

Thamnocrinus springeri sp. nov.

Plate 26, figures 8-10; text figure 48

This handsome species is represented in the collections of the New York State Museum by two splendid specimens. One lying on a block of limestone shows the dorsal cup and the lower portion of the arms. Originally there were some 65 mm of column attached, but most of this has been broken away, leaving but a fragment about 45 mm from the theca. From the impression in the rock, however, it is possible to gain an approximate idea as to the character of the columnals. The other specimen which has been freed from the matrix shows the dorsal cup and arms.

Crown of relatively large size, measuring not less than 65 mm in height with the arms extended. The two specimens show considerable divergence in regard to the relative attitude of the arms and theca. In one specimen (plate 26, figures 9, 10) the arms proceed outward and somewhat downward until the last bifurcation is reached; here they flex abruptly upward. In the other specimen (plate 26, figure 8) the rami, so far as preserved, are directed upward with no indication of lateral extension in a horizontal direction. It appears that the arms were capable of movement at the base to this considerable amount. The two attitudes give widely divergent profiles to the crown.

Dorsal cup. Structure of the dorsal cup alone known in detail; subturbinate in outline. The free specimen with arms is somewhat crushed, and the other partially buried in limestone, so the figures here given are somewhat deceptive as to the true proportions and outline. With a height of 17 mm the cup has an approximate breadth of 20 mm. Cross-section subpentagonal in outline. Interradii narrow, the greatest width coming at the level of the tops of the primaxils; above this level becoming narrower.

Basals fused to three hexagonal and nearly equal elements; slightly excavated for the reception of the column. Radials large, an average plate giving a height of 5.4 mm and a maximum breadth of 6 mm.

First primibrachs considerably smaller than the radials, an average plate having a height of 3.7 mm and a maximum breadth of 4.7 mm. Primaxil slightly smaller than the first primibrach, having a height of 3.6 mm and a breadth of 4.1 mm; heptagonal, coming in contact with two interradials on each side. It bears on its upper sloping face 2 x 2 secundibrachs of which the second two are axillaries.

First secundibrachs fairly large, having a height of 2.3 mm; secundaxil

2 mm high. Secundibrachs as well as the immediately following tertibrach on each side firmly incorporated in the cup. Above this level is a type of incorporation apparently peculiar to this species which is described in detail under the discussion of the interradii.

Proximal anal of about the size of the radials; followed in the second range by three relatively small plates of which the median is the smallest; higher ranges not known. In the regular interradii, primary interbrachial large; followed by two somewhat smaller plates in the second range; in the third range either three or four plates; in the fourth three or four; in the fifth three; and in the sixth two. Above this level interradial plates irregular in number and arrangement; in one ray no clear alignment beyond the fourth range. Plates of the second range laterally abut against the first primibrach and primaxil, fitting in the angles between the two plates of the radial series. Terminal plates of the third range fit between the primaxils and first secundibrachs; those of the fourth between the first secundibrachs and secundaxils; those of the fifth between the secundaxils and first tertibrachs; while, finally, those of the sixth abut against the sides of the first tertibrachs. An arbitrary line is drawn between the plates of the sixth range and those following. In the specimen in which the arms assume a horizontal position the point of flexure lies at the level of the first tertibrachs. Above this level also the interbrachials are irregular in number and arrangement and apparently form a part of a formerly pliant integument. The space between adjacent arms filled by this integument lies between the first tertibrach and the last bifurcation of the arms. As the main arm trunks of adjacent rays converge until they come in contact, or practically so, the area thus filled has the form of an isosceles triangle. The width of the triangle at the base is about 5 mm and the height 10 mm. Within this area lie a large number of small plates, irregular in size and shape. Their number is not less than sixty in one space where an approximate computation could be made. These series of small plates obviously are continuous with the interbrachial series below. Laterally they abut against and fit into the angles between the higher series of brachials. That the integument of which these plates formed a part was flexible is clearly shown by the two specimens where there is clear evidence of infolding. The ability on the part of the crinoid to change the attitude of the arms to such a marked degree in itself indicates great flexibility and adaptability on the part of this interbrachial series. It is evident that when expanded, that is, in a procumbent position, the triangular area between adjacent rays would be of maximum size. When the arms assumed a semivertical position the area would become narrower. In the specimen with the arms closed the main trunks of adjacent rays when undisturbed lie in contact below the quintaxil. In the specimen with expanded arms we find the interbrachial integument well stretched with a shallow median depression running down to about the level of the tertaxil. In the other specimen up to the level of the tertaxil the interbrachials form a smooth slightly concave surface. Above this level the arm trunks come closely together and the interbrachial integument practically disappears in a deep infold. In each ray the brachials toward the inner side of the ray are incorporated by interaxillaries (intersecundibrachs and intertertibrachs). The first of these plates is large, reaching practically to the tops of the secundaxils. It supports two small plates which are followed by at least two ranges of irregularly disposed plates. Above the first, the interaxillaries seem to connect laterally the rami first given off from the main arm trunk.

Tegmen unknown except for the remarkably heavy spines, described later.

Arms, as noted under the description of the genus, a most characteristic and remarkable feature. Each secundaxil bears a free ramus on the sloping face toward the inner portion of the ray. On the other face it supports a series of four tertibrachs, the fourth being an axillary. To the inner side the axillary again gives off a ramus, and on the outer face rests a series of three quartibrachs, the last of which is axillary. This again gives off a ramus to the inner side and a series of three brachials to the outer; the last of these being an axillary gives the final normal division.

In one case the last ramus given off bifurcates about 12 mm above its point of inception. The heterotomous type of arm-branching may clearly be seen in plate 26, figure 9, and the interrelations of the ossicles taking part in the division in figure 8, plate 26. Rami with smoothly rounding backs and sides, compactly biserial and tapering gradually distad. Pinnules long and slender and in close lateral contact.

Column. One of the specimens originally had some 65 mm of column attached. Unfortunately all of this has been broken away except about 20 mm which represent the distal portion of that originally preserved. It is possible to make a squeeze of the impression left in the rock, however, and gain a fair idea as to the structure of the column. At its point of union with the cup it measures (somewhat flattened) 5.5 mm in diameter. At about 10 mm from the cup an internodal has a diameter of 3.5 mm, while in the most distal portion preserved the diameter is about 3.2 mm. Column divided up into nodes and internodes. Nodals not conspicuous, being but slightly greater in diameter than the internodals; internodals slightly annulate. Length of internodes increases rapidly proceeding distad. The first internode that can clearly be distinguished, lying about 3 mm from the cup, is about 4 mm in length; the next 5 mm, the next 11 mm and the next 16 mm. Length of the succeeding internode not ascertained as no nodal appears in the portion preserved. Length of the columnals increases considerably proceeding distad. In the fragment of column preserved the columnals are slightly arched and smooth. Axial canal fairly large, and seems to be circular.

Ornamentation. Plates of dorsal cup covered with fine granules; in places more or less confluent. Toward the periphery of the plate may be noted a general alignment of the granules, forming fine parallel lines perpendicular to each face and running over on the adjacent plate. Traversing the radial series and passing up to the secundaxil is a rounding ridge. This ridge on each plate really involves the entire breadth of the plate, the slope being gradual in the case of the radials and gradually increasing in intensity upward. In the lower part of the cup, therefore, the ridge is broad, narrowing distad until at the secundaxil it has the contour and size of the main arm trunk above. It is the elevation of the plates of the radial series that gives the cup the subpentagonal cross-section.

The tegmen, as noted above, bears heavy spines; probably sixteen in number, three to each ray and one subcentral in location. Spines stout, measuring nearly 4 mm in diameter at the base. They taper but slightly, a spine probably not over 2 mm or 3 mm from the tip measuring 2 mm in diameter. It is difficult to compute the length of the spines, but the marginal ones probably run from 15 mm to 20 mm in length.

Horizon and locality. From the Hamilton (Moscow shales), Cashong creek, near Bellona, N. Y.

Types. Cotypes in the collection of the New York State Museum.

Remarks. Thamnocrinus springeri differs in several important particulars from T. devonicus. The dorsal cup in devonicus is narrower and more bell-shaped. The radials and first primibrachs are comparatively longer and narrower. The basals are narrower and comparatively smaller. The space between the secundaxils of adjacent rays is much wider in devonicus. In springeri the interradii become narrower proceeding upward; in devonicus they become broader. In devonicus the remarkable interbrachial integument reaching up to the last bifurcation of the arms is absent. In this species the incorporation of the brachials scarcely extends above the secundaxil; the intersecundibrach alone firmly incorporates the adjacent brachials.

This beautiful species has been named in honor of Dr Frank Springer of the United States National Museum.

Subfamily BATOCRININAE W. & Sp.

Genus AOROCRINUS W. & Sp. 1897

This genus is considered by Bather (1899, p. 922; 1900, p. 167) as synonymous with Coelocrinus Meek and Worthen. Coelocrinus antedates Aorocrinus and hence would stand.

Springer (1913, p. 196) separates the two genera. They are very similar, but differ in the character of the base.

Aorocrinus cauliculus (Hall)

Plate 35, figures 1-3

1862 Actinocrinus cauliculus Hall. 15th Ann. Rep't N. Y. State Cab. Nat. Hist., p. 132

1868 Actinocrinus cauliculus Shumard. Trans. Acad. Sci. St Louis, 2:342

1877 Actinocrinus cauliculus S. A. Miller. Amer. Pal. Foss., p. 66

1878 Actinocrinus cauliculus Bigsby. Thesaurus Dev.-Carb., p. 15

1881 Gennaeocrinus cauliculus Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 161 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:335

1889 Gennaeocrinus cauliculus S. A. Miller. N. Amer. Geol. & Pal., p. 247

1897 ? Syn. Aorocrinus cassedayi Wachsmuth & Springer. N. Amer. Crin. Cam., 2:483 (authors' ed.); Mem. Mus. Comp. Zool., v. 21

1903 Aorocrinus (?) cauliculus Clarke & Ruedemann. N. Y. State Mus. Bul. 65, p. 64

1904 Aorocrinus cauliculus Clarke & Luther. N. Y. State Mus. Bul. 63, p. 52

In the New York State Museum are three specimens listed as cotypes of this species. One of these, number $\frac{4020}{2}$ of the type catalog is, I think, a very young Megistocrinus depressus. Of the other two, one is a young individual, the specific relationships of which are uncertain at best. The other is a badly crushed more mature specimen. Both these specimens show the dorsal cup and arms. Another specimen acquired by the Museum subsequent to Hall's original description is here referred to the species. This specimen is badly crushed and a portion of the dorsal cup broken away. It varies in certain respects from Hall's type, but such differences as appear may, I think, be explained as due to growth changes. With such poor material it is impossible to give an adequate description of the species. There are, however, certain features by which the species probably can be recognized in the future when more perfect material is available. The description of the species is based in the main on the larger type specimen which is here chosen as the lectotype. Such differences as are to be seen in the largest specimen examined will be noted, and the structure of the young individual will be described under the heading *Ontogeny.*

The species is a small one. A striking feature of the crown is the relatively great length of the arms. With a crown measuring about 40 mm over all, with the arms extended, the dorsal cup has a height of less than 5 mm to the base of the free arms. As the species has twenty arms the preponderance of the arms over the theca is marked. In the largest specimen, the observed length of arms is but slightly greater than that just given. However, the arms are strongly incurved in their distal portion, and their actual length is, therefore, considerably greater. In this specimen the cup has a height of about 7 mm.

Dorsal cup uncrushed, probably rather narrowly obpyramidal; in cross-section pentagonal outline given by the elevated character of the radial series. Interradial areas not flattened; without the strong radial ridges the cup would be distinctly more rounding. Width of uncrushed cup at the base of the free arms would be not far from 8.5 mm, with a height of about 4.5 mm. Thecal plates remarkably thin, which accounts for the crushing of the dorsal cup. It is the most delicate theca in the genus, as far as I know.

Basals, so far as may be seen, relatively large and projecting well beyond the stem in a sharply trilobate rim. Radials large and either hexagonal or heptagonal, depending upon their relations to the basals; wider than high. First primibrach hexagonal and of about one-half the height of the radial. Primaxil a trifle lower than the first primibrach. Upon the shoulders of the primaxil are borne 2 x 2 small secundibrachs, the second of which in each case is an axillary. Brachials incorporated at least to and including the secundaxils.

Of the interradial plates nothing can be determined other than that the proximal interbrachial is of fairly large size; followed by two plates in the second range, above which level the plates are tegminal. In the posterior interradius anal undoubtedly followed by three plates in the second range.

Tegmen unknown.

Arms four to a ray. It is in the arms that the greatest differences are to be noted between the lectotype and what is here considered the mature specimen. In the smaller specimen arms long and relatively slender; broad and almost flat with a barely perceptible rounding; sides flat. Arms become biserial within five or six ossicles of the secundaxils; biserial ossicles rather wide for the genus. In their distal portions the arms curve inward and their backs become broader, tending toward spatulation. In the larger specimen arms proportionally somewhat heavier than in the other individual; fairly narrow at the base, the increase in breadth taking place rapidly; in their distal portions strongly incurved, and distinctly spatulate. At a distance of about 20 mm above the cup, pairs of spinous processes are borne by the arms at intervals of about 4 mm. Spines sharp, slender, with a maximum length of about 2 mm. Pinnules very long and slender, as in the smaller specimen.

Column not known.

Ornamentation of the species seems to be very simple. Along the radial series runs a carina which culminates at the center of each plate in a laterally flattened node. Above the primaxil each of the fixed brachials marked by a similar but less conspicuous node. Surface of all plates of the cup marked by irregularly dispersed granules. On the arms are similar granules and irregular wavy lines apparently formed by the coalescence of numerous granules; lines roughly parallel and running parallel to the long axis of the arm; as a rule confined to the dorsal surface.

Ontogeny. The small specimen constituting one of the types of A. cauliculus may well belong to the same species as the lectotype. Both specimens come from the same locality, and there is enough resemblance between the two to warrant placing the younger specimen in the species. The preservation of the older individual is so poor that detailed comparisons are out of the question. In the young individual brachials apparently incorporated only to and including the primaxil; secundibrachs relatively much larger, being approximately the size of the corresponding primibrachs. It is interesting to note that the sutures between the radial and the first primibrach, and the first primibrach and primaxil, have the same crenulate character shown by the free brachials. Pinnules relatively much stouter, as are the arms. Proximal brachials of the arms long and quadrangular; above, arms biserial. In the cup interradial spaces probably more depressed, the radial series standing out very prominently and giving a distinctly pentalobate cross-section. There is a hint of low radiating ridges connecting the radials and the plates of the interradii. Surface of the plates irregularly granulose with some fusion of the granules.

The differences to be noted between the lectotype and the large specimen referred to this species may well be due to ontogenetic changes. As noted above, the chief differences lie in the character of the arms. The arms of the larger specimen differ in being relatively stouter, spatulate, and spiniferous. All these characters are such as might well be acquired with age, and indeed are just the characters one would expect to develop.

Horizon and locality. From the Hamilton (Moscow) shale. Types from Vincent, Ontario county; the third specimen from Canandaigua lake, N. Y.

Types. Lectotype and cotype in the New York State Museum, numbers $\frac{4020}{1}$ and $\frac{4020}{3}$; third specimen in the same collection.

Remarks. As noted above there are three specimens in the New York State Museum which are listed as cotypes of Aorocrinus cauliculus. Number $\frac{4020}{2}$ I consider the young of a Megistocrinus, probably M. depressus. This specimen bears a manuscript label, apparently in Whitfield's writing, of "Actinocrinus cauliculus." It was, therefore, probably part of the originally described material.

Aorocrinus cauliculus may be distinguished from the other known species of the genus by the marked preponderance of the arms over the theca, the simple ornamentation, the fragility of the cup, due to the thinness of the plates, and the shape of the cup. I believe it to be a good species.

Aorocrinus praecursor (Hall)

Plate 35, figure 4

1862 Actinocrinus praecursor Hall. 15th Ann. Rep't N. Y. State Cab. Nat Hist., p. 131

1868 Actinocrinus praecursor Shumard. Trans. Acad. Sci. St Louis, 2:347

1878 Actinocrinus praecursor Bigsby. Thesaurus Dev.-Carb., p. 15

1889 Dorycrinus praecursor S. A. Miller. N. Amer. Geol. & Pal., p. 241

1903 Aorocrinus (?) praecursor Clarke & Ruedemann. N. Y. State Mus. Bul. 65, p. 64

1904 Aorocrinus praecursor Clarke & Luther. N. Y. State Mus. Bul. 63, p. 52

The species described by Hall as Actinocrinus praecursor falls within the genus Aorocrinus. The species is represented by a single specimen, the holotype, which has the dorsal cup and a portion of the arms well preserved. It lies on a slab of rock with the dorsal cup up and the arms passing down into the rock. The surface of the cup, either as the result of cleaning or weathering, has been considerably damaged.

Species of medium size and with remarkably stout arms for the size of the cup. Unfortunately, the greater portion of the arms lies buried and it is impossible to gain an idea as to the relative proportions of the crown.

Dorsal cup low, having a height to the primaxil of only about 5 mm. At the same level the cup has a diameter of about 13 mm measuring from the top of the primaxil of the anterior radius to the posterior interradius. Basal portion of the cup up to about the center of the radials flattened. Above this level the sides of the cup diverge widely, with the suggestion of a rounding contour. Basals relatively inconspicuous and probably extended but little beyond the stem. Radials large, one of them having a height of 3.4 mm and a maximum breadth of 3.8 mm; either hexagonal or heptagonal, depending on their attitude with respect to the basals.

First primibrachs quadrangular, one of them having a height of 1.4 mm and a width of about 3 mm. Primaxils low and pentagonal. They vary in size but the average height seems to be only about 1.3 mm. On one side the primaxil bears two secundibrachs, the second of which is axillary; on the other side an undivided ramus is given off. Abnormally, apparently, but two free rami are borne by the right anterolateral ray.

Anal plate narrower but of about the same height as the radials; three relatively large plates in the second range. Plates of the third range can not be distinguished. Primary interbrachial large, reaching at least to the top of the first primibrach; apparently followed by two plates in the second range, but the structure can not be made out with certainty.

Tegmen buried; impossible to determine its structure.

Arms. Free rami, as noted above, three to a ray, except in the right anterolateral ray where there are only two; probably a sporadic variation, the normal number being three. If two is the normal number, the other anterolateral ray is the variant, and should have but two rami. Rami remarkably stout. A short distance above the primaxil they begin to curve upward. Change in direction gradual; rami do not assume their final vertical direction until about 10 mm from the primaxil. Arms of this species probably more spreading than in any other known species of the genus; so far as observed with rounding backs and sides; compactly biserial a short distance above the last bifurcation. Pinnules unknown.

Column not preserved.

Ornamentation. Owing to the fractured condition of the plates, and their poor preservation, it is impossible to give an accurate idea as to the ornamentation of the dorsal cup. The plates are roughly nodose, and there seems to be a complete lack of radiating series of ridges. Over the surface of the plates of the cup, and extending up on the arms, is a coarse vermicular marking apparently not unlike that found in A. armatus to which this species seems nearly related. The back of each biserial arm ossicle is pinched up in an irregular ridge which culminates in an irregular node near the point of contact with the opposed ossicles.

Horizon and locality. From the lower Moscow shales (Hamilton group) on the shore of Canandaigua lake, probably near Tichenor's point, south of Canandaigua, N. Y.

Type. Holotype and only known specimen in the New York State Museum, number $\frac{4023}{1}$.

Aorocrinus armatus sp. nov.

Plate 35, figures 11–12

This beautiful little species is represented by the greater portion of a crown and some 50 mm of stem. Unfortunately the side of the crown lying uppermost on the rock surface has been badly weathered and practically all structure obliterated so far as the dorsal cup is concerned. The specimen as here figured shows the stem in its normal position, while the crown has been freed from the matrix and turned over. As a result of the weathering some of the structural characters can not be made out with certainty.

Species a small one, the crown having a height over all of but 26 mm. This measurement does not take in the entire length of the arms, the tips of which are deeply incurved. Of the height as given the dorsal cup constitutes not more than 4 mm.

Dorsal cup the only part of the calyx known. It possesses characters which sharply distinguish the species from all other known members of the genus. Cup remarkably low and broad; height 4 mm and breadth 11 mm. Base of the cup nearly flat. Above the flattened area to the level of the primaxil the sides of the cup diverge rapidly. Above this level the superior brachials abruptly change direction, standing out at practically right angles to the longitudinal axis of the cup. This gives the cup a general aspect quite at variance with that shown by any other species of the genus. Next to this character the most notable features of the cup are the very large size of the radials and the insignificance of the interradii.

Basals small and inconspicuous extending slightly beyond the column in a low trilobate rim. Radials, as noted above, proportionally large; in one case height of 2.7 mm, maximum breadth of 3.8 mm. Line of contact of two adjacent radials 2.4 mm in length. With a breadth of 2.5 mm at the base the sides of the radial diverge at a low angle to the level at which the plate attains its greatest breadth. From here the sides of the plate converge sharply, the line of contact of the first primibrach being but 2.2 mm in length.

First primibrach quadrangular, having a maximum breadth of about 2.6 mm and a height of about 1 mm. Primaxil apparently with about the same breadth as the first primibrach, and a maximum height of 1.3 mm.

Higher ranges of brachials fairly well shown in the anterior radius. In this ray two secundibrachs are borne on each face of the primaxil, the second plate being an axillary in each instance, thus giving four arms to the ray. Secundibrachs somewhat smaller than the primibrachs. In the right and left anterolateral rays only three free arms. It is impossible definitely to state the degree of incorporation of the higher order of brachials. It seems certain that the secundaxils at least form a part of the cup, and it may be that one or two brachials of the higher series are more or less loosely incorporated. This is suggested by the way in which the arms in the anterior ray bend abruptly upward at about the level of the second tertibrachs.

Anal plate somewhat smaller than the radials and followed by three plates in the second range; impossible to determine the character of the posterior interradius above these plates.

Interradii inconspicuous; only part of the primary interbrachial seen in each interradius. The outward inclination of the secundibrachs brings the base of the free arms only slightly above the level of the base of the primary interbrachial, and the remainder of the interradius is concealed when the arms are preserved as in the present case. So far as may be seen, the primary interbrachial is relatively large and must practically fill the entire interradius in the dorsal cup. In one interradius where the arms have been broken away it seems to reach a level well up on the primaxil, almost at the top of the plate. Apparently two plates in the second range in this interradius; of fairly large size and probably serve to incorporate the adjacent secundibrachs. Structure of the interradius can not be made out with certainty as the plates are weathered and somewhat fractured.

Tegmen. Structure unknown.

Arms. According to the evidence of the rays as preserved the species has eighteen free arms; of these three lie in the right and left anterolateral rays, respectively, while the other rays have four each. Arms at first have the horizontal position given by the higher orders of brachials, but about the second tertibrach they bend abruptly upward. Arms stout and strongly incurved in their distal portions; compactly biserial, with a well-defined furrow down the median line where the two series imbricate; in their proximal portions with rounding backs and sides. Proceeding distad the arms tend to flatten out. At the point where the arm curves inward the flattening is quite marked, while farther on a spatulate character seems to be assumed. Beginning at from 8 to 10 mm above the point where the arms bend upward a pair of unusually heavy spines is borne. These paired spines are repeated at intervals of about 5 mm proceeding distad. They are lateral prolongations of arm ossicles, and attain an average length of about 3 mm. Pinnules known only from dissociated ossicles; relatively slender judging by these.

Column preserved to a length of some 50 mm. The most striking feature of the column is the strongly marked nodals which in the proximal portion of the stem have a diameter of 3 mm. Proceeding distad the nodals gradually increase in diameter reaching a maximum of 3.4 mm in the portion of the column preserved. Next the crown two nodals are separated by a single columnal; proceeding distad the usual course of columnal intercalation may be observed. In the last unit shown one nodal of the second order, two of the third, and four columnals of the fourth order are to be found between a pair of primary nodals. Nodals relatively thin and with smoothly rounded edges. There is a marked disparity in diameter between the nodals and the columnals of the internodes. For instance, a nodal with a diameter of 3 mm has an internodal of but 2.3 mm in diameter lying adjacent. Sutures between the columnals finely crenulate. Axial canal small and round.

Ornamentation. Radials, which are notable for their large size, made more prominent by being strongly nodose; whole plate highly elevated; slight indentations at the corners of the plates. The high elevation attained by the radial is continued in one ray across the first primibrach in a broad smoothly rounded ridge. In the other rays examined a furrow separates the first primibrach from the radial. Similar furrows separate the brachials so far as incorporated. The center of the primary interbrachial rises in a peak from which sharply defined ridges run perpendicular to the faces of the plate. Surface of all the plates of the theca as well as the arm ossicles coarsely pustulose; pustules either separate or coalesced, forming an irregular vermicular ornamentation.

Horizon and locality. From the lower Moscow shales (Hamilton group), Cashong creek near Bellona, New York.

Type. Holotype and only known specimen in the collection of Doctor Springer, now deposited in the United States National Museum.

Remarks. Although small for the genus, this is, I believe, an adult individual. There are no signs of immaturity, while the length of the spines on the arms and the ornamentation of the cup seem to be adult characters. The nodosity of the radials is not due to a simple central node, or a general elevation of the plate, but rather to a fusion of radiating ridges with the intervening spaces filled by a secondary deposit of stereom. This seems to be indicated by the notches or indentations at the angles of the plates.

The short, stout, sharply infolded arms with their long spines are characteristic of the species. Even more striking is the depressed dorsal cup with its large radials, unimportant interradii, and horizontally expanding brachials.

Aorocrinus formosus sp. nov.

Plate 35, figures 5–9

This species is represented by two well-preserved specimens showing the theca and arms. The larger and more perfect crinoid has been broken but fortunately the break enhances rather than impairs the value of the specimen as it permits the theca to be separated from the arms and adherent shale matrix, thereby exposing the tegmen. The description is based on the larger specimen which is taken as the holotype. The smaller individual adds little to our knowledge of the species, and is of interest chiefly in showing the more youthful character of the form. A discussion of this specimen will be found under the heading *Ontogeny*.

Theca. Dorsal cup broadly turbinate with its greatest diameter considerably in excess of its height. Tegmen low with sharply depressed areas in the interambulacra. The theca is slightly crushed but, making allowance for this, it gives the following measurements: total height, about 16 mm; height of cup to base of free arms about 11 mm; diameter of cup at base of free arms about 16 mm. Interradii in this species relatively narrower, even in the case of the posterior. A notable feature is the decided narrowing and closing in of the areas at the arm bases. Posterior interradius gives a measurement of 11.6 mm from point to point of adjacent primaxils, and a breadth between the last incorporated brachials of 4.3 mm. Corresponding measurements of an ordinary interradius (rt. post. interradius) follow: breadth at primaxil 9 mm; breadth at second tertibrach 2.2 mm.

Dorsal cup. Basals fused to three elements which are large and project beyond the stem, forming a thick tripartite base. Radials hexagonal or heptagonal in shape, depending upon their relation to the basals; of medium size and with a width greater than their height. First primibrach considerably lower and narrower than the radial, and with but a single exception hexagonal in outline; odd plate pentagonal. Primaxils pentagonal as a rule; slightly lower and considerably narrower than the first primibrachs; supporting 2 x 10 secundibrachs, each of which supports in turn two series of tertibrachs, thus giving four arms to the ray. Brachials become progressively smaller distad; incorporated in the cup at least to and including the second tertibrach.

Anal plate slightly smaller than the adjacent radials and heptagonal in outline. Above it supports three subequal plates, the central one of which is considerably narrower than the flanking plates. In the third range five plates; in the fourth apparently only four; and in the fifth three plates, above which the plates are poorly shown and are perhaps better classed as pertaining to the tegmen. Above the second range plates small and in the main irregular as to shape. Central median line of anal plates clearly differentiated from the other plates in the area; uniformly hexagonal in outline, higher than broad, and decreasing progressively in size upward.

In the other interradii primary interbrachial somewhat smaller than the anal; followed by two smaller plates in the second range; in the third range three plates, which together have a width slightly less than that of the combined plates of the second range. The three plates of the fourth range very small; followed by two plates in the next range, which may be referred either to the cup or tegmen. At this level fixed tertibrachs separated by a space of not more than 2 mm.

Intersecundibrachs in each ray one, very small.

Tegmen very well shown; no essential features which cannot be readily seen in spite of a slight amount of crushing. As noted elsewhere, interambulacral areas sharply depressed, giving the vault a decidedly lobate appearance. Tegmen composed of a large number of small, sharply nodose plates, which must have formed a somewhat pliant structure judging by the way it has folded and bulged as a result of slight crushing of the specimen. Anal opening small and situated at the summit of a protuberance made up of numerous small plates; faces laterally.

Arms. The incorporation of the brachials up to and including the second tertibrachs results in the giving off of four free arms from the theca in each radius. Arms moderately stout and closely biserial; not preserved to their full length, but probably relatively short. Dorsal surfaces rounded; sides practically flat and vertical. In the more distal portion of the arms, so far as preserved, a slight flattening is to be observed indicating that near the tips the arms are spatulate, or approach that form. Pinnules long and slender; ossicles long and, so far as observed, nonspiniferous. Beginning at about 18 to 20 mm from the incorporated brachials, pairs of spines are borne by the arms. They are laterally produced brachials and attain a length in some cases of not less than 2 mm. Pairs of spines continue as far distad as the arms are preserved, being spaced at intervals of approximately 5 mm.

Column unknown; fairly small, however, having a diameter at its junction with the theca of but 3 mm.

Ornamentation. Plates of the dorsal cup strongly nodose; radiating ridges connecting the nodes poorly developed. As noted above basals produced into three petaloid lobes which project for some distance beyond the stem; a strong central node on each radial. The tendency seems to be to connect these nodes laterally by means of ridges. Ridges low and inconspicuous where present; in places represented merely by subsidiary nodes. Running up along the radial series is an equally variable ridge. In one ray it is continuous with no nodes rising above the general level; in another ray practically obsolete. Other rays present gradations between these two extremes. Ridges better developed among the fixed brachials above the primaxil; interradial plates marked by simple sharp nodes, with no evidence of radiating ridges except in the posterior interradius. Here from the primary anal diverges a series of low ridges, one running perpendicular to each face and passing to the center of the apposed plate. This system of inconspicuous radiating ridges continues toward the upper portion of the posterior interradius, progressively becoming more obscure. Each of the tegminal plates produced into a sharp node; at the points of division and subdivision of an ambulacral ridge nodes larger and more prominent than the average on the tegmen. At the center and apex of the vault is a spine or large node. Unfortunately in this specimen the process is broken off near the base, so it is impossible to give an idea as to its height.

Ontogeny. The younger specimen mentioned above does not differ widely from the adult. Dorsal cup proportionally somewhat lower and the outline more bowl-shaped. Interradial areas proportionally broader, and the spaces between the bases of the free arms proportionally wider. The most striking difference in the cup is to be found in the ornamentation. In the younger specimen there is a well-defined series of radiating ridges in the interradii; in the older crinoid these ridges are much less prominent, and in places have become obsolete. The ridge connecting the centers of the radials and anal is a sort of casual affair in the older specimen, while in the other it is a strongly marked character. The same may also be said in regard to the ridges running from the centers of the radials and anal to the basals. In the small specimen the radial and incorporated brachials of each ray are traversed by a practically unbroken ridge. In the adult, one ray is like this; in the others, however, each plate is nodose, and the connecting ridge is largely lost sight of. In the arms of the young individual the spines which are not strongly developed in the adult show as slight excrescences. They would not be noticed if not specially looked for.

Horizon and locality. From the Hamilton (Moscow) shales, Cashong creek, near Bellona, N. Y.

Types. Holotype and paratype in the New York State Museum.

Aorocrinus longidactylus sp. nov.

Plate 35, figure 10

This species is represented by one well-preserved specimen that shows the dorsal cup, a portion of the tegmen, and portions of the arms. Two of the arms are preserved almost to their distal extremities. It is a large species, the crown measuring more than 70 mm in height. Of this height the arms contribute in the neighborhood of 60 mm.

Theca. Dorsal cup broadly turbinate. Tegmen low, smoothly arching, with well-marked interambulacral depressions. Height of the cup to the base of the free arms only 11 mm; average breadth nearly 20 mm. Interradial areas wide, as might be expected with a dorsal cup so low and broad; wide space between the arm clusters of adjacent rays particularly notable. Posterior interradius with a breadth of 13.5 mm from primaxil (center) to primaxil, and a breadth of 6.5 mm at the base of the free arms. An ordinary interradius gives 10.5 mm and 6 mm for the same measurements respectively.

Dorsal cup. Basals fused to three elements and apparently projected beyond the stem in a pronounced tripartite rim; lobes broken off in this specimen.

Radials large and averaging somewhat wider than high; hexagonal or heptagonal, depending on their relation to the basals.

First primibrachs hexagonal, relatively low and broad; as a rule, considerably narrower than the radials. Primaxil pentagonal; as a rule lower than the first primibrach and appreciably narrower. On each of its sloping surfaces it bears two secundibrachs, the second of which is axillary.

From the preservation of the specimen it is somewhat difficult to judge the degree of fixation of the higher ranks of brachials. One can be certain only of the incorporation of the secundibrachs. It is possible that there is a certain amount of fixation in the case of the first tertibrachs, but if so it is but a casual occurrence and of no special significance.

Anal plate heptagonal, only slightly smaller than the adjacent radials; followed by three plates in the second range, five in the third, and five or six in the fourth. Above this level the plates can not be distinguished clearly and may well be considered as belonging to the tegmen.

In the other interradii primary interbrachial followed by two plates in the second range, three or four in the third. Above this the plates are tegminal. Intersecundibrachs to each ray one, small.

Tegmen, so far as observed, composed of numerous small, irregular, smooth plates.

Arms. Free arms four to each ray. At the base the ramus is relatively slender; proceeding distad it widens until it becomes comparatively stout, and having reached its maximum thickness at about one-half the length of the arms, it gradually becomes smaller again. Although one of the arms is preserved for a length of 55 mm it is still fairly thick, indicating that the break is still some distance from the tip. No evidence of flattening near the distal portion of the arms as is commonly observed in other species of the genus. Throughout the length as seen, arms with flat, vertical sides and low rounded backs; beginning about 5 mm above the secundaxil compactly biserial. No spinous processes borne by the arms. Pinnules long and slender, composed of long ossicles. Arms of this species remarkable for the genus in their length and apparent lack of spatulation.

Column unknown; judging from the cicatrix somewhat small for the crown, the cicatrix having a diameter of only a trifle over 3 mm.

Ornamentation of this species very simple, consisting chiefly of nodes. Each of the plates in the dorsal cup is produced into a node, those of the radial series being particularly high and prominent. Nodes rise sharply from the center of the plates; particularly marked in the case of the plates of the radial series, where the portion of the plate surrounding the node rises slightly from the margin toward the base of the node. Cross-section of the node on a radial oval in outline, with the long axis coinciding with the line of the radial series. Node on the primaxil of approximately the same shape as that on the radial, but with the long axis at right angles to the vertical; node on the first primibrach round in cross-section. Strongly produced nodes on the secundibrachs. Higher up first tertibrachs alone show any evidence of nodosity, and in their case it is merely a slightly more pronounced convexity than is shown by succeeding brachials. Plates of the tegmen smooth, so far as observed. Entire surface of dorsal cup papillose. This ornamentation is much coarser than ordinary, and may even be seen with the naked eye. In places papillae coalesce and form irregular, subvermicular markings. On the arms papillae much smaller and more scattered. In places, particularly on the upper third of the arms, there are crenulations or crinklings along and perpendicular to the apposed margins of the ossicles.

Horizon and locality. From the top of the Moscow shales (Hamilton group) near Cascade Mills, three miles west of Dundee, N. Y.

Type. Holotype and only known specimen in the collection of Doctor Springer, now deposited in the United States National Museum.

Remarks. The species to which A. longidactylus bears the closest resemblance is A. formosus from the Hamilton, Cashong creek, Bellona, N. Y. It is a larger form than A. formosus with longer arms which are not flattened and lack spines. The plates of the dorsal cup show no radiating ridges.

Family PLATYCRINIDAE Roemer

Genus CYTTAROCRINUS nov.

[Ety. κύτταρος *a hollow cavity, a cup;* κρινον, *lily*]

This genus is established to include certain small Devonian crinoids of the family Platycrinidae. It is based primarily on Platycrinus eriensis Hall, inasmuch as the holotype of that species is in a splendid state of preservation, and clearly shows the characters differentiating the genus from other members of the family. A new species, based upon the specimen erroneously used by Hall (1872) to illustrate his previously described species Platycrinus eboraceus, is doubtfully referred to the new genus, although the confirmatory evidence of arm structure is wanting.

Dorsal cup. Basals fused to three elements, the simple basal lying in the left anterolateral interradius. Stem cicatrix as observed in C. (?) jewetti sp. nov. peculiar and distinctive; circular with coarsely crenulate periphery. Inasmuch as the cicatrix is obscured in the case of C. eriensis it is impossible to determine whether it has a crenate margin or not.

Radials spade-shaped, longer than wide, and notched in the interradii for the reception of a single interradial tegminal plate. This plate does not abut against the proximal brachials. Posterior interradius more deeply notched than the others.

Tegmen unknown. From such evidence as we have it seems probable that the interradial tegminal plates form a considerable portion of the vault, agreeing well with the more primitive genera of the Platycrinidae where the five orals play a role of great importance. It is probable however that the tegmen is not rigid or very strong, as shown by its destruction in the case of C. eriensis. In this specimen, although preserved in soft shale under the most favorable conditions, the tegmen is missing. Lack of stability in the tegmen points, I think, to the presence of a number of small interambulacrals.

Arms. Primibrachs two; the first relatively large and quadrangular; the second pentangular, supporting two rami neither of which bifurcates. Arms relatively short, stout, uniserial and composed of long stout ossicles which bear pinnules on alternate sides. Apposed surfaces of brachials with sharply crenate margins reminding one of the structure noted in the case of the stem cicatrix of C. (?) jewetti sp. nov. Pinnules stout, composed of remarkably long ossicles. From the radial up the arm is entirely free from the theca, there being no beveling or other evidence on the sides of the brachials of lateral union with tegminal plates.

Column unknown. Cicatrix on basals round; but it is also round in species of Platycrinus with elliptic columnals in the greater portion of the stem. The entire absence of oval columnals in the Hamilton, or elsewhere in the Devonian, argues strongly for the possession of circular columns by members of the Platycrinidae antedating the Mississippian.

Horizon and locality. Only known as yet from the Middle Devonian (Hamilton) of New York. It is possible that the genus may be represented in the Mississippian by Platycrinus truncatulus Hall.

Genotype. "Platycrinus" eriensis Hall.

Remarks. The peculiar and diagnostic characters of Cyttarocrinus so far as known are those shown by the arms. Cyttaorcrinus differs from all known Platycrini except P. truncatulus Hall in normally possessing two primibrachs. Wachsmuth and Springer (1897, v. 2, p. 676) state that if they were sure the charactre of the stem and relation of interradial tegminal plates to radials in *eriensis* agreed with *P. truncatulus*, they would propose a new genus for the reception of the two species. As a matter of fact *C. eriensis* apparently has a circular column, and has but one tegminal plate in contact with the radials in any given interradius, agreeing perfectly with *P. truncatulus* in these particulars. Although agreeing in these characters I should not go so far as to make *eriensis* and *truncatulus* congeneric. *P. truncatulus* probably is not a true *Platycrinus*, but until the arm structure is known I should be equally hesitant in referring it to *Cyttarocrinus*, a genus that precedes it by such a considerable period of time. It probably will be found that the arms of *P. truncatulus* are biserial.

Cyttarocrinus in the possession of uniserial arms with but a single bifurcation is in a sense more primitive than the earlier forms, as *Cylicocrinus* and *Hapalocrinus*. At the same time the arms with their curiously modified brachials show a degree of differentiation and specialization that is quite comparable with these types. There is but one genus with which *Cyttarocrinus* may prove to have close affinities. That is *Coccocrinus*. Unfortunately, the arms of the latter genus are unknown except in the most proximal part, and anything but a general comparison is impossible. It is probable that the tegmen of *Coccocrinus* differs widely from that of *Cyttarocrinus*. In the former genus the vault is rigid and firmly bound together, while in the latter, as argued above, the tegmen is probably much less strong, and has a different type of structure.

Cyttarocrinus (?) *jewetti* sp. nov. has been placed in this genus provisionally, largely for want of a better place for its reception. It has, however, a certain unity of structure with *C. eriensis*, and it may well prove that the two species are congeneric when better material is available for study.

Cyttarocrinus with its curiously specialized arms, may, like

Cordylocrinus, be considered a divergent off-shoot from the main platycrinoid stock. The two primibrachs found regularly in C. eriensis and Platycrinus (?) truncatulus occur as a sporadic character in one or more rays of various species of Platycrinus. In Cyttarocrinus and P. (?) truncatulus the two primibrachs probably indicate the retention of a primitive character, while in the case of the sporadic occurrences a partial reversion to type is probably indicated.

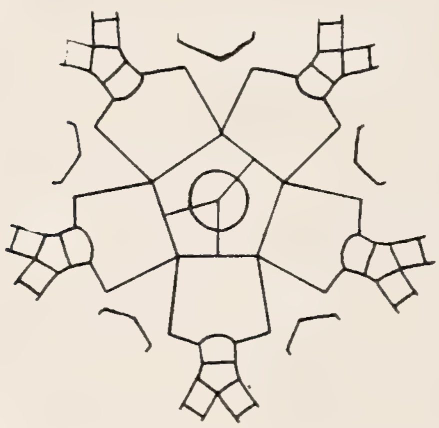

Figure 49 Analysis of calyx of Cyttarocrinus eriensis, the genotype.

Cyttarocrinus eriensis (Hall) n. comb.

Plate 36, figures 1, 2; text figure 49

1862 Platycrinus eriensis Hall. 15th Ann. Rep't N. Y. State Cab. Nat. Hist., p. 119, pl. 1, fig. 1

1868 Platycrinus eriensis Shumard. Trans. Acad. Sci. St Louis, 2:388

1877 Platycrinus eriensis S. A. Miller. Amer. Pal. Foss., p. 87

1878 Hexacrinus eriensis Bigsby. Thesaurus Dev.-Carb., p. 18

1881 Platycrinus (Cordylocrinus?) eriensis Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 71 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:245

1889 Platycrinus eriensis S. A. Miller. N. Amer. Geol. & Pal., p. 270

1897 Platycrinus eriensis Wachsmuth & Springer. N. Amer. Crin. Cam., 2:676 (authors' ed.); Mem. Mus. Comp. Zool., v. 21

1899 Platycrinus eriensis Grabau. Bul. Buff. Soc. Nat. Sci., v. 6, nos. 2, 3, 4, p. 144, text fig. 26 (after Hall)

1900 Platycrinus eriensis Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 3, p. 198

The type and only known specimen of the species though imperfect is in a remarkably fine state of preservation, so far as it goes. The specimen apparently lay on the surface of a piece of limestone, and in freeing the crinoid that portion of the crown embedded in the rock was lost. Half of the basal cup, two whole radials, the greater part of a third, and a small portion of a fourth are shown. The remainder of the cup and the tips of the arms have been broken off. Portions of the arms are shown in all five rays being especially well preserved in three of them.

Species a small one, judging from the type which appears to be an adult individual. Crown when complete probably measured little more than 10 mm in height.

Dorsal cup somewhat narrowly bowl-shaped; height to the radial facets 3 mm, breadth at the base of the arms 3.5 mm. The cup is asymmetrical in that the posterior interradius is appreciably swollen. This interradius is considerably wider than any of the others. Basals forming a low broadly expanding cup with a height of about one-third that of the dorsal cup; probably fused to three elements. Only one of the sutures may be seen which apparently marks one side of a large segment. The suture limiting the segment on the other side perhaps is coincident with the line of fracture which divides the dorsal cup. Along the suture shown is a low rounded ridge.

Radials spade-shaped, little difference in the width of the plate at the top and bottom except in the case of the right and left posterior radials. What is here considered the left anterolateral radial has a height of 2.6 mm to the facet; width at the top 2.5 mm, at the bottom 2.2 mm; radial facet in this plate with a breadth of approximately 1.5 mm and centrally located. Left posterior radial with a height to the facet of 2.8 mm; breadth at the top 3.3 mm, at the base 2.3 mm; radial facet of approximately the same breadth as in the other plates. Here, however, it is excentric in location, lying considerably nearer the left margin of the plate. The facet of the right posterior radial lies toward the right margin of the radial. The result is to give the included interradius nearly twice the width of the others. On this account it is assumed that this represents the posterior interradius, a supposition that is strengthened by the relative degree of notching of the radials for the reception of the interradial tegminal plates. Interradii, with the exception of the posterior, slightly notched for the reception of the interradial tegminal plates; posterior interradius more deeply and widely incised. Radials smoothly rounded, the right and left posterior radials being more highly arched in the posterior interradius, giving the cup an asymmetrical outline as noted above. The radial facet projects in a narrow rim and slopes but slightly from the horizontal; articulating surface nearly on the level with the upper surface of the plate.

Tegmen. Structure unknown. Judging from the size of the tegmen, however, and the interradial notches, it would appear that a considerable portion of the tegmen is made up of five large oral plates.

Arms. Tips of the arms wanting but the remaining portions in a splendid state of preservation; relatively short and stout, uniserial and bifurcating only once. Primibrachs two; the first rectangular with a height but slightly in excess of one-half its breadth. Brachials stand out sharply from the radials. Primaxil wider and higher than the first primibrach, although owing to a curious wrinkling of its surface it appears much lower on casual inspection. This wrinkling, or constriction of the plate, on either side makes the ossicle appear to consist of a low axillary to which on each upper sloping face is fused a low secundibrach. Secundibrachs remarkable and, so far as I know, unique in aspect among crinoid arms. Ossicles long and roughly hour-glass shaped on the back although the outline of the entire brachial is approximately rectangular. A very good idea of the secundibrachs may be had from an examination of plate 36, figure 2, which shows several ossicles enlarged fifteen times. This figure gives a better idea of the character of the ossicles than any description. The attachment of the pinnule is peculiar. It will be noted that the portion of the brachial supporting the pinnule is considerably produced upward and outward. The round ridge which is continuous and of equal width with the pinnule is actually separated at the top from the main body of the brachial by a sharply incised notch. First pinnules borne by the second secundibrachs; given off at the outer side of the arms; stout with rounded backs, and composed of ossicles of remarkable length. Articulating faces of the brachials marked on the margin by a coarse crenulation.

Column not preserved. As noted in the description of the genus, it is inferred that the column of this genus is round.

Ornamentation. The surface of the plates of the dorsal cup under a lens of low power appears to be covered with an exceedingly fine ornamentation. Under a higher power lens the nature of this ornamentation may clearly be seen. The surface is thickly covered with papillae of minute size, these becoming confluent in a surface covered with innumerable pits of polygonal or nearly round outline. Seen at certain angles the plates appear pitted, at others finely granulated. This type of ornamentation is to be found on brachials and pinnules as well, though in the latter case the pitting is somewhat less obvious and the granules tend to align themselves in irregular rows.

Horizon and locality given by Hall as Hamilton group, near Hamburg, Erie county, N. Y. Judging from the preservation it seems reasonably certain that the specimen was found on the surface of the Encrinal limestone band of that region. It is somewhat pyritized and seems to have been embedded in a dense, impure limestone. The upper surface of the crinoid is covered by a dark soft calcareous shale. This preservation is precisely that characteristic of the upper surface of the Encrinal band.

Type. Holotype and only known specimen of this species in the American Museum of Natural History, number $\frac{5023}{1}$.

Cyttarocrinus (?) **jewetti** sp. nov.

Plate 36, figures 3–5

1872 Platycrinus eboraceus (in err.) Hall. N. Y. State Mus. Bul. 1, pl. 1, figs. 16, 17. (Photographic plates distributed privately.)

The description of this species is based upon a specimen formerly in the Jewett collection and now in the museum of Cornell University. The specimen is a complete, but badly crushed, dorsal cup. Tegmen, arms and stem of the species unknown.

Dorsal cup has a somewhat broadly expanding sharply conical base formed by the basal plates; radials diverge but slightly from the vertical as evidenced by their practically parallel sides. Height of cup 13 mm; breadth at arm bases about 12 mm.

Basals fused to form three elements, the sutures between which are clearly marked. Two of the basal elements subequal, hexagonal; the third and smallest plate pentagonal. Stem cicatrix round and somewhat excavate, with a peripheral ring of fine notches or ridges; crenate character clearly shown.

Radials long and comparatively narrow. One of them gives the following measurements: height to the facet, 8 mm; breadth at the top, 6.5 mm; breadth at the base, 6 mm; breadth of the facet, 3.7 mm. One of the radials has the appearance of being slightly wider at the base than at the top. Surface of a radial almost flat along the lower margin, becoming more elevated and rounded toward the upper portion. This makes the center of the facet rim the most elevated portion of the plate, from which point the surface of the plate slopes gradually to the sides and bottom giving a smooth rounded contour. Radials sharply notched interradially for the reception of the interradial tegminal plates; one interradius more broadly and deeply notched than either of the others shown, probably indicating the posterior interradius. According to this the small unfused basal lies in the left anterior interradius. Arm facet sharply produced into a sort of lip in its median portion. This part of the facet is practically flat and lies at a low angle to the horizontal, giving but a slight outward inclination to the arms. Laterally the sides of the facet rise somewhat abruptly, a character that must have let the first primibrach well down into the radial. As shown by the measurements given above, the arm facet occupies nearly two-thirds of the upper face of the radial.

Column round judging from the cicatrix. Diameter of cicatrix 2.7 mm.

Ornamentation. Surface of the plates upon superficial examination apparently smooth, but under a high magnification found to be finely granular.

Locality and horizon. From the Hamilton at Bloomfield, N. Y.; probably collected by Jewett in 1885.

Type. Holotype in the Jewett collection, Cornell University Museum, number 7329.

Remarks. Hall in 1862 (p. 119) described the species Platycrinus eboraceus. This species was founded on isolated radials and a basal disk. The original specimens used by Hall and bearing his manuscript label are extant and are described under Arthracantha eboracea. In 1872 a figure was published by Hall of the specimen forming the type of the present species under the name Platycrinus eboraceus Hall. There can be no doubt but that the material originally used by Hall for his description of Platycrinus eboraceus differs not only specifically but generically from the specimen which he subsequently figured and which is here used as the type of Cyttarocrinus (?) jewetti sp. nov.

The species is referred to Cyttarocrinus with some degree of doubt inasmuch as so little of the form is known. It agrees however with the type species in a number of minor characters and may well fall within the genus. It might of course be referred to Platycrinus, but such a reference would involve as much uncertainty as that here made.

Genus CORDYLOCRINUS Angelin 1878

Cordylocrinus plumosus (Hall)

Plate 36, figures 6–13

1859 Platycrinus plumosus Hall. Pal. N. Y., 3:113, pl. 4, figs. 1–5
Platycrinus parvus Hall. Pal. N. Y., 3:114, pl. 4, figs. 6–9
1868 Platycrinus plumosus Shumard. Trans. Acad. Sci. St Louis, p. 388
Platycrinus parvus Shumard. Trans. Acad. Sci. St Louis, p. 388
1881 Cordylocrinus plumosus Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 61 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:235
Cordylocrinus parvus Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 60 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:234
1889 Cordylocrinus plumosus S. A. Miller. N. Amer. Geol. & Pal., p. 234
Cordylocrinus parvus S. A. Miller. N. Amer. Geol. & Pal., p. 234

1897 Cordylocrinus plumosus (syn. Cordylocrinus parvus) Wachsmuth & Springer. N. Amer. Crin. Cam., 2:737, pl. 75, fig. 20 (authors' ed.); Mem. Mus. Comp. Zool., v. 21

1899 Cordylocrinus plumosus Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 2, p. 88

Cordylocrinus parvus Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 2, p. 88

1900 Cordylocrinus plumosus Schuchert. Bul. Geol. Soc. Amer., 11:279

1905 Cordylocrinus plumosus Talbot. Amer. Jour. Sci., 20:28–30, pl. 3, figs. 2, 4.

1911 Cordylocrinus plumosus Kirk. Proc. U. S. Nat. Mus., v. 41, no. 1846, p. 58

This is a small species, which appears to have been very abundant at the Litchfield localities. The species described by Hall as parvus is here treated as synonymous with plumosus (discussed under *Remarks*).

Dorsal cup, cup- or bowl-shaped, rounded at the base, expanding to the arm bases and subpentangular. Basals three, two hexagonal, one (the left anterior) pentagonal, broader than high, with a small column facet. Radials broader than high; two, the left posterior and right anterolateral, hexagonal with nearly straight lower edge; the other three heptagonal, meeting an interbasal suture. Radial facet curved, sometimes rather deeply indented for the reception of the first primibrach, and occupying a little more than half the width of the radial. The upper faces of the right and left posterior radials form a deep notch into which fits the first plate of the anal series.

Tegmen composed of numerous plates and prolonged into a proboscis-like anal tube or sac (plate 36, figure 9). First anal plate pentagonal, resting in the notch formed by the upper faces of the right and left posterior radials; succeeded by a quadrangular plate. Plates of the anal sac hexagonal and irregular; smaller towards the summit. Length of the sac a little over that of the crown.

Arms. Two primibrachs, both short; the first very short, quadrangular; the second, the primaxil, pentagonal giving rise to two arms to the ray, ten for the calyx. Arms simple; composed of quadrangular brachials, wider than long, giving off long, strong pinnules, a pair to each brachial. Pinnules angular and made up of long ossicles. Syzygies have not been found in the New York State Museum material; but their occurrence has been noted in several of the specimens in the Yale University Museum by both myself and Miss Talbot (1905, p. 29), giving brachials bearing two pinnules on each side (plate 36, figure 7). In such cases the brachials are longer. This fusion was found to occur as frequently as every other joint in parts of the arm; in other places every third joint showed this characteristic. Joints near the base normal, one-pinnuled on each side.

Column round, made up of nodes and internodes. Internodes lengthen proceeding distad. Nodal columnals provided with whorls of unusually long cirri which are arranged interradially. Cirri composed of short ossicles, the cirrals. Frequently the most proximal cirri are so long that they extend to or beyond the tips of the arms.

Ornamentation. Surface of dorsal cup finely granulated.

Horizon and locality. Upper third of the Coeymans limestone at Jerusalem hill, Litchfield; Days Corners near Litchfield, North Litchfield; and Schoharie, N. Y.

Types. Cotypes in the American Museum of Natural History.

Remarks. Wachsmuth and Springer in their *Revision of the Palaeocrinoidea* (1881, p. 234) retained Cordylocrinus plumosus and Cordylocrinus parvus as separate species. In their later work (1897, v. 2, p. 737) they regard the two species as synonymous. C. parvus appears to be a younger form of plumosus. In the Yale University Museum there are many hundreds of specimens of this species (Talbot, 1905, p. 29). The North Litchfield material shows large and small forms, the large forms being confined to the lower beds and the small ones to the upper, a few of these latter having the calyx gibbous, not flattened. The Jerusalem hill specimens are uncompressed and small. Miss Talbot suggests that these small uncompressed specimens from the upper crinoid bed might be the forms Hall had under observation when he described C. parvus; and, if so, since they occur at a slightly higher geological horizon, C. parvus might well be regarded as a variety of C. plumosus. The form is here included with C. plumosus. The types of C. parvus have been refigured on plate 36, figures 12, 13.

Cordylocrinus (?) **ramulosus** (Hall)

Plate 36, figures 14–17

1859 Platycrinus ramulosus Hall. Pal. N. Y., 3:115, pl. 4, figs. 10–13

1868 Platycrinus ramulosus Shumard. Trans. Acad. Sci. St Louis, p. 388

1881 (?) Cordylocrinus ramulosus Wachsmuth & Springer. Rev. Palaeocr., pt. 2, pl. 61 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:235

1889 (?) Cordylocrinus ramulosus S. A. Miller. N. Amer. Geol. & Pal., p. 234

1897 (?) Cordylocrinus ramulosus Wachsmuth & Springer. N. Amer. Crin. Cam., 2:737 (authors' ed.); Mem. Mus. Comp. Zool., v. 21

1900 (?) Cordylocrinus ramulosus Schuchert. Bul. Geol. Soc. Amer., 11:279

Types not located. The original figures are repeated here, and the description is based upon the original description.

Dorsal cup small. Basals wider than long. Radials comparatively large, wider than long, very prominent below the facets, and contracted towards the upper lateral angles. Radial facets rather deeply curved; appear to occupy about one-third the width of the radial. Upper lateral faces of the right and left posterior radials form a deep notch for the reception of the first anal plate.

Tegmen. First few plates of the anal tube visible; the first pentagonal, followed by two or three quadrangular plates.

Arms. Two primibrachs, both fairly short. The first quadrangular; the second, the primaxil, pentangular, giving rise to two main arms which bifurcate again on the ninth brachial above the primaxil. Brachials in general quadrangular, except the axillaries; rounded on the back, wider than long; each bearing a pair of pinnules, one on each side. Pinnule ossicles longer than wide.

Column round, rather long, consisting near the body of very thin plates which become thicker at a greater distance. Cirri not observed.

Horizon and locality. From the shaly layers associated with the Coeymans limestone, Jerusalem hill and Litchfield, Herkimer county, N. Y.

Remarks. Hall figured a specimen (plate 36, figure 15) showing an irregularity in the bifurcation of the arms. There is apparently no reason why such an irregularity should not occur in the same species.

Genus MARSIPOCRINUS Bather 1889

(nom. nov. pro *Marsupiocrinus* Phillips 1839)

Marsipocrinus tentaculatus (Hall)

Plate 36, figure 18; text figure 50

1858 Platycrinus tentaculatus Hall. Pal. N. Y., 3:116, pl. 5, figs. 1–4

1868 Platycrinus tentaculatus Shumard. Trans. Acad. Sci. St Louis, 2:390

1881 Marsupiocrinus tentaculatus Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 65 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:239

1889 Marsupiocrinus tentaculatus S. A. Miller. N. Amer. Geol. & Pal., p. 260

1897 Marsupiocrinus tentaculatus Wachsmuth & Springer. N. Amer. Crin. Cam., 2:733, pl. 75, figs. 19 *a*, *b* (authors' ed.); Mem. Mus. Comp. Zool., v. 21

1899 Marsupiocrinus tentaculatus Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 2, p. 94

1900 Marsupiocrinus tentaculatus Schuchert. Bul. Geol. Soc. Amer., 11:279

Dorsal cup 11 mm broad by about 5 mm high. Basals fused, forming a pentagonal disk. Owing to the fractured condition of the base no sutures can be observed.

Radials hexagonal with slightly concave upper margins. An average radial is 5 mm broad by 2.8 mm high.

Primaxils trigonal, supporting 1 x 10 large axillary plates which in turn support two arms each.

These secundaxils either extend down to the radials or not — both conditions occurring in the same ray; pentagonal with their contiguous margins joining and their outer edges resting upon the interbrachial plates.

One large interbrachial; hexagonal, reaching to the top of the first arm plate and incorporating it with the calyx.

Tegmen. Structure unknown.

Arms flat-backed, with a length of not more than 18 mm. First four or five proximal brachials wedge-shaped and arranged in a single series; above, arms biserial. Pinnules slender and of medium length; composed of long ossicles, thickened at the two ends and slightly constricted in the middle. First pinnules found on the tertibrachs.

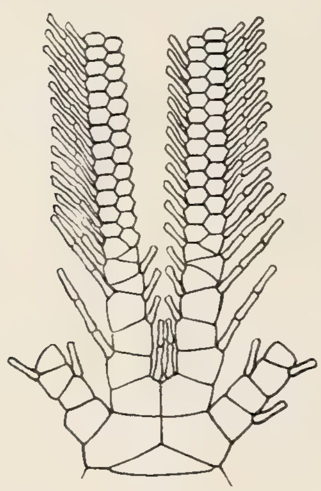

Figure 50 Marsipocrinus tentaculatus. Enlargement of arms and pinnules. (After Hall, 1859). See plate 36, figure 18.

Column, according to Hall, round (1858, p. 117), consisting of alternately thicker and thinner annulations in the small portion at that time attached to the specimen.

Ornamentation. Radials marked by coarse radiating ridges which pass to the adjoining radials, basals, and interbrachials.

Horizon and locality. From the calcareous layers of the shaly limestone of the Lower Helderberg group (New Scotland), Schoharie, N. Y.

Types. Holotype in the American Museum of Natural History, number 2303.

Remarks. The specimen figured apparently had a portion of its stem attached at one time, and was so figured by Hall. This fragment is now missing. Hall (1858, p. 117) notes the occurrence of another specimen apparently belonging to this species. It was enclosed in the solid stone and broken through the middle showing a long, slender anal tube.

M. tentaculatus differs from the other species of Marsipocrinus in the comparatively large size of the primaxils, the smaller size of the secundibrachs, and in the fact that these either do not meet the radials or else rest upon them by a small face.

Family HEXACRINIDAE W. & Sp.

Genus ARTHRACANTHA Williams 1883

Arthracantha eboracea (Hall) n. comb.

Plate 37, figures 1–4; text figure 51

1862 Platycrinus eboraceus Hall. 15th Ann. Rep't N. Y. State Cab. Nat. Hist., p. 119

1868 Platycrinus eboraceus Shumard. Trans. Acad. Sci. St Louis, 2:388

1872 Platycrinus eboraceus (in err.) Hall. N. Y. State Mus. Bul. 1, p. 1, figs. 16, 17. (Photographic plates distributed privately.)

1877 Platycrinus eboraceus S. A. Miller. Amer. Pal. Foss., p. 86

1878 Hexacrinus eboraceus Bigsby. Thesaurus Dev.-Carb., p. 18

1881 Platycrinus eboraceus Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 71 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:245

1889 Platycrinus eboraceus S. A. Miller. N. Amer. Geol. & Pal., p. 270

1897 Platycrinus eboraceus (discarded as unrecognizable, insufficient preservation) Wachsmuth & Springer. N. Amer. Crin. Cam., 2:650 (authors' ed.); Mem. Mus. Comp. Zool., v. 21

1903 Platycrinus eboraceus Clarke & Ruedemann. N. Y. State Mus. Bul. 65, pp. 76, 77

1904 Platycrinus eboraceus Clarke & Luther. N. Y. State Mus. Bul. 63, pp. 48, 55

Judging from Hall's original description, this species was founded chiefly on a set of basal plates. In the New York State Museum is the basal disk used by Hall in his description and bearing his manuscript label. It is in a rather poor state of preservation; the plates have in part been replaced by iron and show few characters of any particular value. Large pieces are gone and the edges have apparently been broken off since Hall's day. In the same collection there is also an isolated radial labeled by Hall. From other material examined it seems probable that this base and this radial are referable to the same species. These specimens therefore will be taken as the types of the species, setting aside the specimen figured by Hall in 1872 (plate 1, figures 16, 17) for reasons given hereafter. In addition to the type material isolated plates referable to this species have been found at various points in the Hamilton of western New York. Two dorsal cups in a fair state of preservation have also been obtained. One of these in the American Museum of Natural History is an internal cast which in addition to the dorsal cup shows portions of the tegmen; the other is a crushed but fairly good dorsal cup. These specimens permit the characters of the theca to be made out with a fair degree of accuracy. The stem and arms of the species are unknown. It is a large species, the base used by Hall in his original description indicating a size only comparable to that of Arthracantha splendens sp. nov. described in this work.

Dorsal cup subturbinate with gently curving sides; broader than high, one specimen giving a height of 19 mm and a breadth at the arm bases of 25 mm.

Basals fused to three elements, the sutures between which are plainly marked. Two of the plates practically equal in size; the third slightly smaller. Three basal elements no more closely united than are the other plates of the cup as is shown by plate 37, figure 3. In this specimen the smallest plate as the result of crushing and shearing has been separated from its companions and pushed a considerable distance down past them. The sutural margins of this plate and those with which it was in contact are clean and true showing that there had been little or no anchylosis. Cup formed by the basals has a height nearly one-half that of the dorsal cup. Basals smoothly rounded and arched somewhat along the median longitudinal axis. Immediately above the stem cicatrix plates slightly but sharply constricted. Stem cicatrix round and surrounded by a slightly raised rim.

Radials of nearly equal height and breadth, the type specimens giving the following measurements: height to facet 14.6 mm; height to upper surface 16.2 mm; breadth at top 15.8 mm; breadth at base 15.2 mm. Relative proportions of the radials vary in the same specimen; outline of the plate somewhat irregular and the faces not straight. Radial facet occupies about one-third of the upper face of a plate and lies to one side of the longitudinal median line of the radial. For the reception of the facet there is an excavation in the radial to a depth of 1.6 mm. This notch narrows from in the neighborhood of 5 mm in breadth at the top to 4 mm at the base. The articulating base proper is a practically flat platform standing out sharply from the radial and tilting slightly from the horizontal. This gives a slight outward inclination to the arms at their inception. The type of articulation together with the fact, as hereafter noted, that the proximal elements of the arms are incorporated to a certain extent in the theca make it evident that there could be but slight movement of the arms in the proximal portion. The point of greatest elevation on the radial is the middle of the facet rim. From this point the surface of the plate slopes more gently until it merges into the general marginal level. Upper faces of the plates only slightly notched interradially for the reception of the interradial tegminal plates; in some cases the notch is scarcely perceptible. On the inner surface of the theca, as may be observed in plate 37, figure 4, which shows a natural cast of the interior, interradial tegminal plates rest upon the radials in clearly marked notches.

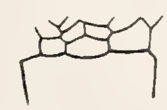

Figure 51 Arthracantha eboracea. A radius (left posterior) of the specimen shown on plate 37, figure 4. This shows the brachials, including the second secundibrach, uniting laterally with the plates of the tegmen.

Anal plate not clearly shown by any of the specimens. It appears to be of equal height with and somewhat narrower than the radials.

Tegmen appears to be low and arching; composed of rather small plates, so far as observed. In every interradius except the posterior, apparently, three tegminal plates rest upon the radials. The central plate rests in a slight interradial notch between each pair of radials. The plates adjoining the central plate unite laterally with the proximal brachials incorporating the latter into the tegmen. Plates of the posterior interradius can not clearly be made out but there seem to be more plates than in the other interradii.

Arms. The internal cast figured on plate 37, figure 4, gives us all the information we have regarding the arm structure of the species. From this specimen it appears that the primaxil immediately succeeded the radial without the intervention of a first primibrach. The presence of a primibrach in addition to the primaxil has been noted without an exception in all specimens of Arthracantha. It seems probable then that in Arthracantha eboracea the plate is present. The condition observed is no doubt due to the preservation of the specimen and may be explained in either of two ways. On the one hand, the first primibrach may be so reduced as only to appear externally, being overlapped by the primaxil on the inner side of the cup. What seems a more probable explanation is that the first primibrach, resting in the deeply incised radial facet, can not show in an internal mold. It is interesting to note that the brachials at least up to and including the second secundibrachs unite laterally with plates of the tegmen, thus becoming fixed. This feature is shown by plate 37, figure 4, and even better by a diagram of the left posterior radius, text figure 51.

Column not preserved, but judging by the cicatrix, it must have been comparatively large. Cicatrix in one specimen (plate 37, figure 3) measures 5 mm in diameter. In the type specimen it has a diameter of not less than 6.5 mm.

Ornamentation. The plates when the surface is well preserved have an irregular shagreen ornamentation. Irregularly dispersed over the surface are small rounded papillae which range upward in size to the pitted tubercles that bear the spines. The papillae apparently are incipient stages of the latter. The spine-bearing tubercles are crateriform, having a round shallow pit or socket in the summit for the reception of the spine. They have a somewhat irregular distribution on the surface of the radials and are more widely spaced than is usual in the genus. The arrangement of tubercles seems to vary within the species. They have not been observed on the basal plates and may be absent. In figure 2, plate 37, it will be noted that there is a rough alignment of tubercles into two rows. These start immediately beneath the radial facet and run toward the lower corners of the plate. Other spiniferous tubercles are indiscriminately scattered over the surface of the plate, becoming progressively less frequent toward the margins or newer portions of the plates. In the oldest portion of the plate, or immediately beneath the facet, the tubercles scarcely project above the surface, a result brought about by thickening of the plate through a superficial deposition of stereom. Some of the tubercles apparently have become nonfunctional, as the pits are partially filled and irregular in outline. It would appear in a few cases that the tubercles have become entirely buried and smoothed over. Whether spines were borne by the arms and tegmen can not be ascertained.

Horizon and locality. Hamilton (Moscow) shales. Type specimens from York, Livingston county; specimen belonging to the American Museum of Natural History (plate 37, figure 4) from Hamilton; locality of other figured specimen, Moscow, N. Y. Species reported by Clarke and Luther (1904, pp. 48, 55) from the upper Moscow shales and the Centerfield limestone (Ludlowville) near Canandaigua, New York. There is in the New York State Museum a very much crushed specimen, apparently belonging to this species, from the Moscow shale, Livonia salt shaft, 225–350 foot level.

Types, to which are attached Hall's manuscript labels, in the New York State Museum, numbers $\frac{4460}{1}$ and $\frac{4460}{2}$. Specimen figured on plate 37, figure 4, in the American Museum of Natural History, number $\frac{5022}{2}$. Fourth specimen figured (plate 37, figure 3) in the New York State Museum.

Remarks. This species was first described by Hall in 1862 (p. 119); no figure was given. Subsequently in 1872 in the so-called Bulletin 1 of the New York State Museum of Natural History, Hall figured the dorsal cup of a crinoid under the name Platycrinus eboraceus. This specimen evidently was not the one originally described by Hall, as it in no wise fits the description. Upon examination the figured specimen has been found to possess the dorsal cup of the Platycrinidae and does not even fall in the same family as the original types of Arthracantha eboracea. For a more detailed account of the figured specimen see description of Cyttarocrinus (?) jewetti sp. nov.

Bigsby (1878, p. 18) lists eboracea as Hexacrinus, evidently going on the assumption that all Devonian forms of this type are referable to Hexacrinus, inasmuch as he likewise refers Platycrinus eriensis Hall to the same genus. Wachsmuth and Springer list eboracea in their *Revision* (1881, p. 245, pt. 2, p. 71) as a valid species, but later in their more extensive work (1897, p. 650) they reject it as being insufficiently described.

The species may be distinguished from the other known Hamilton species by its large size and general form. The relative paucity of the spine-bearing tubercles and their size, which is above the average, are useful characters aiding in its recognition. Another feature which may be used in the case of isolated radials is their almost equilateral and rectangular outline. As noted under the description of Arthracantha punctobrachiata (Hall) Williams, it seems probable that these two species are distinct. The other Hamilton species Arthracantha carpenteri (Hinde) (1885, p. 157) is, I think, a valid species, more closely approaching the present one perhaps than it does Arthracantha punctobrachiata (Hall) Williams, to which it has been referred as a synonym by Wachsmuth and Springer, Whiteaves, and others. In A. carpenteri, as in the present species, the radials are practically equilateral. The species averages considerably smaller in size and there is a marked difference in the size and distribution of spine-bearing tubercles. In carpenteri these tubercles are irregularly but universally distributed over the surface of the radials. The surface of the plates between the tubercles is practically smooth, being marked only by the finest of the granules. The tubercles themselves are relatively much smaller in size. In this regard and in their spacing A. carpenteri more nearly approaches punctobrachiata, from which it differs in other characters, however.

Arthracantha punctobrachiata (Hall)

Plate 37, figure 5

1872 Platycrinus ? punctobrachiatus Hall. N. Y. State Mus. Bul. 1, pl. 1, fig. 15. (Photographic plates distributed privately.)

1883 Arthroacantha punctobrachiata Williams. Proc. Amer. Philos. Soc., 21:83

1885 Arthroacantha punctobrachiata Wachsmuth & Springer. Rev. Palaeocr., pt. 3, p. 119 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 37:341

1889 Arthracantha punctobrachiata S. A. Miller. N. Amer. Geol. & Pal., p. 225

The only specimen known of this species is the holotype figured by Hall in Bulletin 1 of the New York State Museum. It is in a poor state of preservation, enough characters being shown however to afford a reasonably accurate conception of the species. The specimen consists of a badly crushed dorsal cup and portions of the arms. The plates of the dorsal cup which are remarkably thin have in large part become detached from the shale and lost. It is evident that the species is quite distinct from Arthracantha carpenteri (Hinde), from the Hamilton of Ontario, which has been cited as a synonym, and because of its better state of preservation has been figured as A. punctobrachiata. The species is a small one, the crown measuring not more than 40 mm over all.

Dorsal cup. It is impossible accurately to judge the former shape of the dorsal cup. It seems probable however that it was more broadly turbinate than either A. eboracea or A. carpenteri. The dorsal cup had a height not in excess of 14 mm. The breadth can not be estimated with any degree of certainty. Basals form a low cup, apparently of proportionally much less height than in A. eboracea.

Radials spade-shaped with the greatest breadth slightly in excess of the greatest height. The following measurements are taken from an impression left on the shale by the right posterior radial, representing therefore the inside dimensions of the plate. Greatest breadth lies slightly below the level of the radial facet. Measurements are: greatest height

9 mm; height to facet 8 mm; greatest breadth 9.5 mm; breadth at base 4.5 mm. As in A. eboracea the radial facet stands out strongly, the plate sloping away steeply to the sides and more gradually to the base. Radials rather strongly notched interradially for the reception of the interradial tegminal plates.

Anal plate appears to be somewhat narrower than the radials; apparently succeeded by a number of small plates, but as the plates themselves are not preserved it is a matter of very great difficulty to distinguish the sutures.

Tegmen not known aside from the marginal interradial plates. These apparently have the same arrangement as in the case of A. eboracea and A. carpenteri. In each interradius except the posterior there is a median interradial tegminal plate with a smaller plate on each side. This plate abuts against the proximal brachials, incorporating them into the theca. Tegminal plates of the posterior interradius, as noted above, apparently numerous, but in this specimen they can not be distinguished clearly.

Arms relatively short and fairly stout, branching at least twice in a regular dichotomy. First primibrach rises well above the top of the radial and is somewhat shorter then the primaxil. Both primibrachs incorporated into the theca by lateral union with tegminal plates. Arms rounded on the back and loosely biserial, the ossicles being comparatively wide and tending toward a wedge-shape. Pinnules not observed.

Column. No part preserved. Owing to the poor preservation of the cup, stem cicatrix can not be seen.

Ornamentation. Surface of the radials covered with small papillae. Spine-bearing tubercles scattered rather evenly over the surface with the exception of a small area in the lower median portion of the plate. Tubercles small, and fairly uniform in size, the largest ones lying nearest the radial facet. A fragment of one basal shows tubercles, but how abundant they are can not be ascertained in the poor state of preservation of the specimen. Pitted tubercles which evidently bore spines range along the arms. One such tubercle is borne by each arm ossicle, and is found at the point where the rounded back gives way to the vertical side of the arm. This gives two lateral rows of spines along each arm. Tubercles extend as far distad as the arms are preserved.

Horizon and locality. All that is known of the type is that it comes from the Hamilton of western New York. Collected by Colonel E. Jewett.

Types. Holotype and only known specimen of the species, formerly in the Jewett collection, now in the Museum of Cornell University, number 2214.

Remarks. A. punctobrachiata is clearly distinct from either A. eboracea or A. carpenteri, the other known Hamilton species. A. punctobrachiata seems to have had a relatively broader cup than A. eboracea, and judging from the known material is a much smaller form. The more uniform size and distribution of the spine-bearing tubercles is a character of some importance in distinguishing the species. Of greater value is the shape of the radials. In A. punctobrachiata these are spade-shaped as opposed to the practically rectangular outline shown by the radials of A. eboracea. The plates of A. punctobrachiata are very thin while those of A. eboracea are unusually heavy for the genus. As the arms are not preserved in the case of A. eboracea it is not possible to make comparisons of these characters that might prove of considerable value. The arms of A. punctobrachiata and A. carpenteri differ to a marked degree. In A. punctobrachiata the arms are comparatively shorter and heavier, and bifurcate less frequently. The dorsal surfaces of the arms of A. punctobrachiata, as noted above, are rounded and bear lateral rows of tubercles which were probably spiniferous. In the case of A. carpenteri the dorsal surfaces of the arms are flattened and no spine-bearing tubercles are present. Again, the arm ossicles in the two species differ widely. In A. carpenteri they are compactly biserial, as against the looser, more wedgelike form shown by A. punctobrachiata.

Arthracantha carpenteri (Hinde)

Plate 60, figures 1–3; text figure 52

1885 Hystricrinus carpenteri Hinde. Ann. Mag. Nat. Hist., 15: 162, pl. 6

1885 Arthroacantha carpenteri ? (Probably syn. of A. puncto-brachiata.) Wachsmuth & Springer. Rev. Palaeocr., pt. 3, p. 119 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 37, 341

1889 Arthroacantha punctobrachiata Whiteaves. Contr. Can. Pal., v. 1, pt. 2, no. 2, p. 96, pl. 13, figs. 1, *1a*

1889. Arthracantha carpenteri (Probably syn. of A. puncto-brachiata.) S. A. Miller. N. Amer. Geol. & Pal., p. 225

1897 Arthracantha punctobrachiata Wachsmuth & Springer. N. Amer. Crin. Cam., 2:750, pl. 76, figs. *2a*, *2b* (authors' ed.); Mem. Mus. Comp. Zool., v. 21

1903 Arthroacantha punctobrachiata Shimer & Grabau. Bul. Geol. Soc. Amer., 13:184

1904 Arthracantha punctobrachiata Wood. Smith. Misc. Coll., 47:81, pl. 16, fig. 4

1910 Arthracantha punctobrachiata Grabau & Shimer. N. Amer. Index Foss., 2:520, fig. 1844

Arthracantha carpenteri (Hinde) from the Hamilton of Ontario, Canada, is, I believe, a valid species. It has been cited as a synonym of and, because of its better state of preservation, has been figured as A. punctobrachiata. The Canadian species is here figured and described for comparison with the New York form. It is on the whole a larger and stronger species, composed of heavier plates.

Dorsal cup subturbinate with gently curving sides, more rapidly spreading at the basals, slightly incurving at the distal margins of the radials; broader than high, a fairly well-preserved specimen having a height of 15.3 mm and a breadth at the radials of 21.2 mm. Other specimens give heights of 17 mm and 17.2 mm respectively, but they are crushed so that no accurate measurements of the breadth can be obtained.

Basals large and of almost uniform size; sutures between the three elements of the basal cup clearly marked. Cup formed by the basals broadly conical and low, about one-third the height of the dorsal cup. In two specimens typical basals give the following measurements: height 9 mm, greatest breadth 17 mm; height 7 mm, greatest breadth 14.5 mm.

Radials vary in shape and proportions in the same specimen. Right and left posterior radials smaller than the others and markedly narrower at the proximal face than at the distal, giving a spade-shaped appearance; the other plates rectangular, nearly as high as wide. Even here there is a slight variation. The anterior radial is usually narrower at the base than the right and left anterolateral radials, and therefore slightly less rectangular. In one specimen in which all the radials are well shown the following measurements were taken:

	Anterior	*Left antero-lateral*	*Right antero-lateral*
Greatest height	13 mm	13 mm	13 mm
Height to facet	11 mm	11 mm	11 mm
Greatest breadth	12.8 mm	12.8 mm	12.7 mm
Breadth at base	9.9 mm	12.3 mm	8.5 mm (?)

The radial facet stands out strongly. The plate slopes steeply away from it on each side and more gradually to the base. Radials notched interradially for the reception of the interradial tegminal plates.

Anal plate narrower than the radials, broader at the upper face than at the lower.

Tegmen. In each interradius, except the posterior, three tegminal plates rest upon the radials; central one the largest, the two lateral ones curving out to meet the primibrachs and first one or two secundibrachs on each side. First three plates followed by numerous rows of small interambulacral plates. Anal plate usually followed by five or six plates; one specimen studied has at least seven, and probably eight, plates in this row. There are no specimens at hand showing the tegmen, but it is figured and described as hemispherical, flattened in the central part and with an excentric anus placed within a small protuberance.

Arms. I have refigured here the specimen figured and described by Miss Wood (1904, p. 81, pl. 16, fig. 4) in which the arms are beautifully preserved. Two primibrachs; the first extending well above the top of the radial; primaxil broader and higher than the first primibrach. Both primibrachs and the lowest secundibrachs incorporated into the calyx by lateral union with the tegminal plates. The arms show three bifurcations above the primaxil in the length preserved (about 45 mm), and it is quite possible that at least a fourth bifurcation was present as the arms must have been several millimeters longer. Arms compactly biserial above the third or fourth secundibrach and flattened on the dorsal surface, giving a rectangular appearance particularly in the upper portions. Along the angle thus formed on each side of the dorsal surface each ossicle, especially above the secundaxil, bears on the dorsal surface a very small subspinous tubercle pointing distally and slightly outward (see text figure 52). Tubercles only seen well with a lens. Under the lens, because of the compactly biserial nature of the arms, the two parallel rows of tubercles give a serrated aspect to the dorsal surface of the arms. On the axillaries tubercles larger and stronger. Pinnules rather long and delicate.

Figure 52 Arthracantha carpenteri. Enlargement (x 13) of the upper portion of an arm of the specimen shown on plate 60, figure 1, showing the two dorsal rows of tubercles.

Column round and composed in the proximal portion of thin columnals with sharp edges.

Ornamentation. Pitted, spine-bearing tubercles small and irregularly but universally distributed over the surface of the radials and basals; more abundant on the radials. Tubercles on the radials appear to be most numerous just below the radial facet. Surface of the plates between the tubercles practically smooth, being marked only by the finest granules. There are one or two to several tubercles on the primibrachs and a few also occur on the lowest secundibrachs. Spine-bearing tubercles also found on the plates of the tegmen; according to Hinde, most numerous on the plates of the central portion. Spines elongate and cylindrical, not well preserved in any of the specimens at hand. According to Hinde they vary from 1.5 mm to 4 mm in length. Those on the basals and radials fairly uniform in size and averaging 2.5 mm in length; those on the plates of the tegmen only 1.5 mm in length, but nearly as thick as those of the cup.

Horizon and locality. From the Hamilton beds, Ontario, Canada. Specimens found at Arcona, Bartlett's Mill, Bosanquet and Thedford.

Types. The originally described material was in the collection of Doctor Hinde. Hypotypes and other unfigured specimens in the Museum of the Canadian Survey, in the United States National Museum and in the collection of Doctor Springer. Also two specimens in the Redpath Museum, Montreal, one of which is figured here.

Remarks. This species was described by Hinde in 1885 as distinct from the A. punctobrachiata of Hall and Williams. It was cited by Wachsmuth and Springer in 1885 as probably a synonym of A. punctobrachiata and in 1897 as a synonym; and has been so regarded since then. As stated above, the Canadian form is always figured for the species because of its better preservation. It is however a distinct species. A. carpenteri is a larger, stronger form than A. punctobrachiata. It is more nearly like A. eboracea in possessing practically rectangular radials; but the species averages considerably smaller in size and in the character and distribution of the tubercles more nearly approaches A. punctobrachiata. The arms of A. carpenteri are markedly different from those of A. punctobrachiata, as discussed in the description of that species under *Remarks*. There should be no difficulty in distinguishing these two species.

In two of the specimens figured here a Platyceras is shown attached to the tegmen. The parasitic attachment of a gastropod appears to be very frequent in this species.

Figure 1, plate 60, has been reproduced from the original drawing by Miss Wood.

Arthracantha ithacensis Williams

Plate 37, figures 6–8

1883 Arthroacantha ithacensis Williams. Proc. Amer. Philos. Soc., 21:85, with a plate

1884 Arthroacantha ithacensis Williams. Bul. U. S. Geol. Surv., 3:19

1885 Arthracantha (?) ithacensis Wachsmuth & Springer. Rev. Palaeocr., pt. 3, p. 119 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 37:341

1885 Hystricrinus ithacensis Hinde. Ann. & Mag. Nat. Hist., 15:158

1889 Arthracantha ithacensis S. A. Miller. N. Amer. Geol. & Pal., p. 225

1896 Arthracantha ithacensis Kindle. Bul. Amer. Pal., v. 2, no. 6, p. 33

1897 Arthracantha ithacensis Wachsmuth & Springer. N. Amer. Crin. Cam., 2:749, pl. 76, figs. 1*a*, *b*, *c* (authors' ed.); Mem. Mus. Com. Zool., v. 21

The description of this, the type species of the genus, is based upon gutta-percha squeezes of the type material used by Williams. The cast of the main type specimen shows the dorsal cup, the proximal plates of the tegmen, a portion of the arms, a small fragment of stem, and several spines. A second cast shows a badly crushed tegmen with some of the spines attached. Another specimen consisting of the basal plates alone was referred to this species and figured by Wachsmuth and Springer. There is some doubt whether this specimen is really referable to A. ithacensis. The casts fail to show many characters that might be made out if the original molds were carefully examined. The cup of the most important specimen is somewhat crushed. The distortion however is not of sufficient magnitude appreciably to affect the general shape of the cup. A. ithacensis is the smallest known species of the genus if we consider the type specimen as a mature individual and eliminate from consideration the isolated base referred to the species by Wachsmuth and Springer. In the case of the type specimen the estimated height of the crown is 45 mm and probably does not exceed that amount.

Dorsal cup subconical with curving sides; height about 8 mm and breadth about 13 mm. Basals fused to three elements, the sutures between which are clearly marked. Cup formed by the basals conical with a height of approximately one-third that of the dorsal cup. Basals somewhat constricted immediately above the stem cicatrix; the latter sharply defined and with a diameter of 2 mm.

Radials spade-shaped, appreciably narrower at the base than the top. Radial facet narrow compared with the Chemung species of the genus, having a width only slightly in excess of one-third that of the upper face of the radial. The most elevated point in the radial lies at the radial facet; from the middle point of the facet the plate slopes off abruptly to the sides and more gradually to the base, giving an elevated triangular area in the central portion of the plate with the apex at the radial facet. This area is not sharply delimited but with its smooth contours merges gradually into the marginal level of the plate.

Posterior interradius not shown.

Tegmen. Interradial plates of the tegmen lying immediately in contact with the radials were seen in two interradii. As here shown the median plate which in some species occupies the entire interradius is flanked laterally by a pair of plates of equal magnitude. These in turn abut laterally against the proximal brachials thus serving to incorporate them in the theca. This is the only portion of the tegmen shown by this specimen. Another cast shows the structure of the tegmen very poorly (plate 37, figure 7). Plates of the tegmen small. Ambulacrals clearly distinguished, showing as two rows of alternating plates of approximately equal size. Ventral tube similar to that of A. depressa.

Arms. Two primibrachs, twice as wide as long. First primibrach quadrangular; primaxil pentagonal, sharply angular above and with concave upper faces. Arms free beyond the first secundibrachs.

The arms of this species are poorly shown by the material at hand. In the best preserved specimen which shows only fragments of the arms, it is estimated that they had a length not greatly in excess of 35 mm. Arms slender, apparently bifurcating at least three times after the main division; loosely biserial somewhat after the manner of A. punctobrachiata. Like that species as well, each ossicle has a spine-bearing tubercle. Backs of the arms rounded. Pinnules slender and comparatively short.

Column preserved to a length of about 4 mm from the theca; composed of short ossicles which may be divided into nodes and internodes. Between each pair of nodes are three columnals the central one of which, like the nodes, is marked by a narrow raised keel.

Ornamentation. Surface of theca, and arms at least in the proximal portion, covered by small papillae or granules. Spine-bearing tubercles on basals, radials, brachials, and tegminal plates. The radial bears in the neighborhood of 20 tubercles. On the arms each brachial above the main bifurcation bears a tubercle. How far distad this character extends it is impossible to state owing to the poor preservation of the arms. On the tegmen the spines are numerous, and seem to be scattered rather generally over the surface. One spine borne by each plate. Spines themselves long and slender, the length being well shown in several cases. Spines borne by the plates of the dorsal cup attain a length of at least 6 mm. On the tegmen measurements of 13 mm were made.

Horizon and locality. Portage (Ithaca) beds, Ithaca, N. Y. A specimen that may belong to this species has also been collected in the lower Chemung beds, near Wallace, Steuben county.

Types in the museum of Cornell University. Gutta-percha casts studied and used in the preparation of the illustrations in the collection of Doctor Springer.

Remarks. Wachsmuth and Springer (1897, plate 76, figure 1*b*) figure a set of basal plates which they refer to A. ithacensis. The same specimen is figured here on plate 37, figure 8. Although the size of the tubercles and their dispersal over the surface suggests A. ithacensis, the size of the base together with its low broadly expanding form causes one to hesitate in definitely assigning it to this species.

An external mold and internal cast of the basal plates of a single specimen were collected by D. Dana Luther in the lower Chemung beds, near Wallace, Steuben county. They are not in very good condition, but there is little doubt that they belong to this species.

Arthracantha depressa W. & Sp.

Plate 37, figures 9–11

1897 Arthracantha depressa Wachsmuth & Springer. N. Amer. Crin. Cam., 2:751, pl. 76, figs. 3*a*, *b* (authors' ed.); Mem. Mus. Comp. Zool., v. 21

1902 Arthracantha depressa Luther. N. Y. State Mus. Bul. 52, p. 624

1904 Hystricrinus depressus Clarke & Luther. N. Y. State Mus. Bul. 63, p. 65

Gutta-percha squeezes of the type specimen of this species constitute the only material upon which the present description is based. One of these squeezes shows the dorsal cup and the base of the arms, while the other is a most excellent cast of the tegmen. Apparently both pertain to the same specimen. The theca, unfortunately, is much compressed on its long axis causing a crumpling and telescoping of the radials and a general distortion of the basal cup. This makes it impossible not only to obtain accurate measurements of the constituent plates but accurately to judge the relative proportions of the dorsal cup. Nevertheless the species seems to be a well-defined one and from the characters shown there should be little difficulty in recognizing it. From its general appearance one might infer that the type specimen represents an old individual as evidenced by what seems to be a superficial deposit of secondary stereom on the plates and by the general aspect of the spine-bearing tubercles.

Dorsal cup. Quite apart from the vertical crushing to which the dorsal cup has been subjected it appears that the cup is normally low and broad, this character being especially striking if one eliminates from consideration the proximal brachials which are incorporated into the theca by laterally apposed interradial tegminal plates.

Basals fused to three elements, the sutures between which are scarcely visible. This condition is unusual in the genus. The obscurity of the sutures may be due either to the preservation of the specimen or, what seems more probable, to a secondary deposit of stereom. The latter is indicated by the fact that the basal disk is marked by parallel series of lines which run parallel to the lower faces of the six plates constituting the second range. As a result the basal disk is marked by a set of hexagons nested one within the other. This peculiar marking seems to be due to a thickening of the plates and is here considered a secondary character rather than a feature representing original growth lines. Cup formed by the basals broad and low with only slightly sloping sides. No evidence of a stem cicatrix. Inasmuch as within this genus the stem cicatrix is normally large and sharply defined, this fact is of considerable interest. It may possibly be that this specimen represents an individual which had lost its stem. Such cases are apparently not uncommon among crinoids, having been observed in A r a c h n o c r i n u s and other genera. If we assume the loss of the stem in this individual the thickening of the basal plates might well follow as a secondary character.

Radials, as noted above, have been crushed and telescoped. They seem normally to have been broader than high with approximately the same breadth at top and bottom. This latter fact taken in conjunction with the shape of the basal disk argues strongly for a shallow dorsal cup with nearly vertical sides. Radial facet broad, occupying nearly one-half the upper face of the radial. The radial facet furnishes the most elevated point on the plate as is usual in specimens of this genus. It slopes outward giving the arms at their inception a slight inclination away from the cup.

Posterior interradius not preserved.

Tegmen. The squeeze of the dorsal cup shows the interradial tegminal plates in two interradii. In each case a single plate occupies the entire interradius, laterally abutting against the proximal brachials of the adjacent rays and incorporating them into the theca. This incorporation involves the brachials up to and including the second secundibrach. The other cast shows the tegmen remarkably well as may be seen from figure 11, plate 37. Tegminal plates fairly heavy. Largest plate in the tegmen approximately at the center. This plate is surrounded by four prominent interradial plates, one for each interradius except the posterior. In the latter three somewhat smaller plates meet the central one. Ambulacrals large and irregularly disposed. The chief point of interest in the tegmen is the ventral tube, which is little more than a slight swelling in the posterior interradius. Looking directly at the posterior interradius it appears that there is a median vertical row of three plates made conspicuous by being spiniferous. Each of the first two plates of this series is flanked laterally by a pair of large plates. The third and last distinctive plate of the median row merges into the cluster of small plates that forms the summit of the anal protuberance.

Arms. Primibrachs low and broad, the facet, as noted above, occupying nearly one-half the upper face of the radial. With a maximum breadth of 6.5 mm the first primibrach has a height of about 2.1 mm. The primaxil measures 6.2 mm by 1.8 mm. The upper faces of the axillary diverge at such a great angle as to present an almost flat surface. Both first primibrach and primaxil traversed medially by a sharply marked rounded ridge which bifurcates on the primaxil, the forks continuing along the rounded backs of the arms. First two secundibrachs remarkably broad, partaking of the nature of the primibrachs rather than the succeeding secundibrachs. Both meet the large interradial tegminal plate on one side and the homologous brachials of the other half of the ray on the other side. Thus these brachials are strongly incorporated into the theca. Arms above the second secundibrachs comparatively slender and so far as observed uniserial. No pinnules observed.

Column. No evidence of a stem cicatrix.

Ornamentation. As elsewhere noted, basal disk of this specimen marked by a series of hexagons composed of lines of varying strength. Each radial likewise apparently marked by lines running parallel to the base of the plate. These however look more like crumplings of the plate due to vertical crushing than they do to surface ornamentation or secondary deposition of stereom.

The spine-bearing tubercles of this species, so far as seen, occur only on the radials and certain of the tegminal plates. On the radials the tubercles are irregularly scattered over the surface, there being few tubercles to a plate. The average number on a plate seems not to exceed six or eight. Tubercles unusually prominent and very large in proportion to the size of the crinoid. As noted elsewhere, the three plates forming the median line of the ventral tube are spiniferous. The central plate of the tegmen has a spine-bearing tubercle; ambulacrals irregularly spiniferous.

Horizon and locality. Lower Chemung beds (Prattsburg sandstone), Steuben county, N. Y.

Types. Holotype and plastotypes in the collection of Doctor Springer.

Arthracantha granosa sp. nov.

Plate 37, figures 12–15

This species is represented by a splendid internal cast of a somewhat crushed theca, a portion of the external mold of the dorsal cup of the same specimen, external molds of portions of the arms, and isolated plates both in the form of molds and the actual substance of the plate itself. The species evidently differs from any other described, so, in spite of the imperfection of the material, it has seemed best to describe it. With two exceptions, all the material came from one closely circumscribed outcrop and undoubtedly pertains to the one species.

Species a large one, probably only being surpassed in size by A. splendens among the species known. Theca here figured of about the size of A. eboracea, but isolated plates indicate that the form attains a considerably greater size.

Dorsal cup measures 16 mm in height to the radial facet and has a breadth of about 20 mm at the same level. The breadth is estimated from the crushed specimen and, as given, may be too great. Cup narrow at the base, above expanding in a smooth even curve to a level lying at about three-fourths the height of the radials. Above this level the cup constricts to the level of the arm facets. In this character it resembles A. splendens. The shoulder in A. granosa, however, is much less prominent.

Basals fused to three elements, the sutures between which are indicated by slightly depressed lines. Cup formed by the basals about one-half the height of the dorsal cup. Radials slightly wider at the top than the bottom. Their width at about one-half their height is slightly greater than at their upper margins. Arm facet occupies about one-half the upper margin of the radial; horseshoe-shaped and inclines outward.

Anal plate narrower than the radials and of about the same height.

Tegmen nearly flat. Interradial plates well shown in the internal cast. Laterally the first interradial abuts against the first primibrach and primaxil, reaching nearly to the top of the second. On each of its long concave sloping shoulders it bears a single plate which laterally abuts against the primaxil, and the first secundibrach, reaching about midway up the side of the latter. This lateral interradial supports a second, and this in turn a third. A fourth is probably present. These plates abut laterally against members of the radial series and serve to incorporate the latter at least to and including the second secundibrach. The median uppermost pair of faces of the primary interradial supports two plates. From each of these proceeds a lateral series that imbricates with the upper faces of the first lateral series described above. Above the plates just described, which have a more or less regular sequence, come the irregularly disposed plates that form the tegmen proper. Tegmen composed of numerous small plates; ambulacra covered by two rows of rather large alternating plates. In the posterior interradius the anal supports three large plates of which the median is the smallest. The lateral plates rest in part on the anal and in part on the adjacent radials. Laterally they abut against the primibrachs and on one side the plate seems to reach well up on the first secundibrach. The median plate supports three small plates, while the laterals are followed by plates of fairly large size which abut laterally against the secundibrachs. The higher ranges of plates can not be made out distinctly. Anal opening apparently lies at about the level of the second secundibrach.

Arms remarkably long. One set of arms, which judging by the size might well have belonged to the theca here figured, measure not less than 70 mm in length. Arms compactly biserial with rounding backs and sides; comparatively slender, bifurcating three or four times above the main bifurcation. In the specimen showing four divisions, the last bifurcation comes in the extreme distal portion of the arms. Pinnules long and slender. An interesting and unusual feature is shown in several specimens. That is, external molds of the ventral surface are preserved. The ambulacral furrow is covered by numerous small plates, irregular in size and arrangement and as a rule tumid. Laterally this covering extends up on the ventral surface of the pinnules.

Column. Only about 3 mm of the proximal portion preserved. Columnals, as here shown, low and annulate.

Ornamentation. All the plates of the dorsal cup rather thickly covered with large spiniferous tubercles, the number on the basals specially noteworthy. Several are clustered immediately about the column. One basal segment, of which but a portion is shown, has three tubercles within 3 mm of the stem cicatrix. Probably about twenty tubercles borne by each radial. Judging from the fragmentary molds of the tegmen it appears that a number of its plates are spiniferous. Spine-bearing tubercles occur on the arms as well, so far as observed restricted to the immediate neighborhood of the bifurcations. As a rule a tubercle is borne by the axillary alone, but other tubercles to the number of two or three are found on the proximal ossicles of the succeeding series. In one case a second tubercle was observed immediately below the bifurcation. Primaxil probably not spiniferous. It is impossible to determine whether the next following bifurcation develops this structure. Primibrachs and succeeding arm ossicles for an unknown distance covered with coarse granules which have a tendency to coalesce, especially on the primibrachs.

Horizon and locality. The specimens constituting the material upon which this description is based were collected by D. Dana Luther from the Portage (Grimes sandstone), Deyo basin, two miles south of Naples, N. Y. A specimen, doubtfully referred to this species, was found in the lower Chemung beds, Avoca, Steuben county; two others come from the lower Chemung, near Wallace, Steuben county, N. Y.

Types. Cotypes in the New York State Museum.

Remarks. This species probably resembles A. depressa more than any other described species. Even taking into consideration the vertically telescoped cup of the latter, A. granosa has a relatively higher and narrower cup. The primibrachs in A. granosa are fully twice the height of those in A. depressa and the arms are relatively stouter in their proximal portions. In A. depressa the first interradial tegminal plate abuts against the radial series reaching up to and serving to incorporate the second secundibrach. In A. granosa the same plate only reaches to near the top of the primaxil. In relative size of tubercles the species are very similar and dissociated plates of the two might be confused. The tubercles are more abundant in A. granosa. In A. depressa there are no granules on the primibrachs.

A. splendens differs from the present species in its lower primibrachs and its relatively smaller and more numerous tubercles. The primary interradial tegminal plates reach up on the secundibrachs, as in A. depressa. The large size of A. splendens, the high shoulder on the radials, and the shape of the radials themselves are all characters that might come with maturity, and so are not used for comparison.

A very much crushed and fragmentary specimen of Arthracantha in the collection of the New York State Museum comes from the Chemung, Avoca, Steuben county, N. Y. The general character of the cup is like that of granosa; and, if uncrushed, I think the shape of the cup would be the same. There are spines on the few tegminal plates that are visible, and the arms at the base are heavy and granulose. The specimen is doubtfully referred to granosa, and, though in such a poor state of preservation is figured here (plate 37, figure 15) for purposes of comparison and to show the size and number of the tubercles.

Two molds of bases, crushed and somewhat fragmentary, of an Arthracantha were collected by Luther in the lower Chemung beds, near Wallace, Steuben county, which seem closer to A. granosa than any other form. The tubercles are large, very numerous on one, fewer on the other. It is quite likely that they belong to this species and, if so, are the largest specimens found.

Arthracantha splendens sp. nov.

Plate 37, figure 16

This, by far the largest and most imposing known species of the genus, is represented by an external mold from the Chemung. One side of the dorsal cup and a portion of the arms are preserved, together with a trace of the proximal portion of the stem. Dorsal cup somewhat crushed but not enough appreciably to affect its general outlines. Crown, when complete, probably with a height of not less than 125 mm unless the arms were unusually short compared with their stoutness.

Dorsal cup subovoid in shape; height to the arm facets 35 mm, maximum breadth about the same. Greatest diameter of the cup slightly below the arm bases. Above this there is a sharp constriction of the cup, the diameter at the arm bases being but 28 mm.

Basals large forming a subconical cup that has a height slightly more than three-fifths the height of the dorsal cup.

Radials spade-shaped. In this species the usual conditions are reversed in that the widest portion of the radial is at the base. One of the radials measures 22 mm in breadth at the base and 15 mm at the top; height to the radial facet 19.3 mm. Facet horseshoe-shaped, lying almost horizontal; breadth 7.5 mm. The surface of the radial rises in an even curved slope from the base and sides, culminating in a point slightly below the radial facet. Above a horizontal line passing through this point the plate abruptly pitches inward giving a steep declivity. The shoulder formed is very prominent and a most striking character. This form of the radials results in a marked constriction of the theca as elsewhere noted.

Posterior interradius unknown.

Tegmen. All that can be seen of the tegmen are the proximal interradial plates. Entire interradius between the arm bases occupied by a single interradial tegminal plate. Laterally this abuts against the primibrachs of the adjacent ray. Above the level of the primaxil the plate narrows upward in a gentle curve to near the apex where the sides abruptly converge, the two faces thus formed supporting a pair of plates. Upper sloping faces of the interradials support a pair of tegminal plates as well. The latter abut against the secundibrachs of the adjacent rays incorporating them into the theca as the proximal brachials are incorporated by the large interradial itself. Supported by this lower lateral pair of plates is at least one more pair which serve to incorporate still higher ranges of brachials. A most unusual character of this species is the relatively small size of the tegmen. In the other species of the genus the dorsal cup expands to the arm bases, the greatest diameter of the theca occurring at this level. In splendens, however, there is an abrupt constriction of the dorsal cup immediately below the arm bases. As a result, while the maximum diameter of the dorsal cup is approximately 35 mm, its diameter at the arm bases is but 28 mm. Allowing for the thickness of the arms, which is very considerable, it may easily be seen that the diameter of the tegmen is comparatively small.

Arms, so far as they are preserved, very stout and tapering gradually distad. From this it appears that they were of considerable length. Primibrachs two; low and broad. The upper faces of the primaxil slope at an unusually low angle. Secundibrachs incorporated in the theca to the number of eight or more. The first four pairs of secundibrachs meet and imbricate on the inner side of the ray which, taken in connection with their incorporation into the theca by the interradial tegminal plates, must have resulted in great rigidity. It is difficult exactly to determine the nature of the higher brachials. Immediately above the primaxil they are remarkably broad and low with parallel faces. Higher up brachials apparently very loosely biserial, each ossicle crossing the median line of the arm and wedging in for some little distance on the other side. It is quite possible, of course, that in the more distal portions of the arms a closely biserial condition obtained.

Column. Not enough preserved to show any distinctive characters; apparently composed of low columnals similar in all respects to those shown by other species of the genus.

Ornamentation. Surface of the dorsal cup up to the "shoulders" of the radials coarsely granular. Above the shoulder and on the slope of the declivity radials covered by a coarse vermicular marking which extends up on the primary interradials and the proximal brachials. Spine-bearing tubercles occur plentifully on the basals and radials. Tubercles absolutely of rather large size, being of about equal dimensions with those borne by A. depressa. Relatively, however, they can not be called large. Upon the basals and the lower portions of the radials tubercles somewhat scattered and irregularly disposed. Tubercles progressivly become more numerous in the upper portion of the radial, reaching their maximum development along the "shoulder" of the plate where they are closely crowded and of much smaller size. Above this line there apparently are no spiniferous tubercles. There are in the neighborhood of from forty to fifty tubercles to a radial. The spines themselves unknown.

Horizon and locality. From the lower Chemung beds, about four miles north of Bath, N. Y.

Type. Holotype and only known specimen in the New York State Museum.

Remarks. The great size of A. splendens at once distinguishes it from all other known species of the genus. The constriction of the dorsal cup at the arm bases and the large number of spines borne on the dorsal cup form other characters that serve to distinguish it. Another character which, so far as known, is unique is the fact that the radials are so much broader at the base than at the top.

Order FLEXIBILIA Zittel

While the Monograph on the Devonian Crinoids was in preparation, Doctor Springer's Monograph on the Crinoidea Flexibilia went to press. The New York material has been studied and figured by Doctor Springer, so that practically all the field of the Flexibilia of New York, in manuscript, was covered by his work. Doctor Springer very kindly loaned me his descriptions and plates and I have here reproduced his descriptions and some of his original figures.

Suborder **SAGENOCRINOIDEA** Springer

Family ICHTHYOCRINIDAE Wachsmuth & Springer

Genus CLIDOCHIRUS Angelin 1878

Springer's description. Ichthyocrinidae with rays in contact except in lower part at the posterior side. Crown elongate, expanding above radials. Radianal in primitive position under right posterior radial, resting on basals and touching right anterior radial. Infrabasals variable; either large, exposed above the column, or small, entirely concealed. Basals large, exposed above the column. Anal *x* alone, or followed by others in single vertical series, arched over by brachials. Primibrachs two. Arms dichotomous, interlocking. Column large, with or without proximal enlargement. Otherwise similar to Ichthyocrinus.

Genotype. Clidochirus pyrum Angelin.

Distribution. Silurian to Devonian (Lower Carboniferous?); Sweden and the United States.

Clidochirus schucherti (Talbot)

Plate 38, figures 1, 2

1905 Ichthyocrinus schucherti Talbot. Amer. Jour. Sci., 2:30, pl. 3, fig. 1

1920 Clidochirus schucherti Springer. Crin. Flex., p. 299, pl. 37, figs. 12–13 *b*

Springer's description. A medium-sized species. Crown short, conical, with rather narrow base, expanding uniformly to about the middle tertibrachs, and becoming strongly contracted above that by the infolding of the arms. Spread of calyx from base to upper secundibrachs, about 1 to 3; height to width at that level, 1 to 1.5; side outline but slightly convex;

cross-section circular; base larger than proximal columnal. Surface smooth. Crown of maximum specimen, 27 mm high by 20 mm wide at upper secundibrachs; width of base at infrabasals, 6 mm.

Infrabasals small, not visible beyond the column. Basals large, showing a full pentagon in side view. Anal *x* large, perhaps followed by another. Radianal smaller than radials in other rays. Brachials four times wider than high, evenly curved, without surface angularity or imbrication; secundibrachs mostly four, abnormally eight; tertibrachs five to eight or more, with another bifurcation visible in some rays. Column of good size, proximal columnals not enlarged; alternating nodal joints becoming rounded a short distance below.

This species was founded upon a specimen from the New Scotland beds of the Helderbergian of New York, and described under Ichthyocrinus. Miss Talbot's description and diagram, while in other respects excellent, are not correct in representing four primary plates in each ray. The specimen is partly imbedded in the matrix, leaving only three rays exposed, and these injured by weathering, so that the plate can be well distinguished in only two of them. One has four, the other three. No other species or specimen of this family is known in which there are four primary plates (radial and three primibrachs) in all the rays, except in the Carboniferous. From these facts we must infer that the ray with the four plates is the right posterior with the radianal in primitive position, and that there are a radial and two primibrachs in each of the other four rays.

This is confirmed by the discovery of another specimen from the same horizon in New York in which the crown is free and the anal structures clearly shown, thus leaving no doubt as to its generic position under Clidochirus. The stem in the type specimen also is that of this genus, and not of Ichthyocrinus. This species added to the one from West Virginia, brings the range of the genus strongly into the Devonian.

Horizon and locality. From the New Scotland limestone at Clarksville and Schoharie, N. Y.

Type in the Yale University Museum, New Haven, Conn. The other specimen figured here is in the collection of Doctor Springer, now deposited in the United States National Museum.

Remarks. One of the figures of this species (figure 2) has been reproduced from the original drawing prepared by Doctor Springer.

Genus SYNAPTOCRINUS Springer 1920

Springer's description. Ichthyocrinidae with rays usually in contact all around. Crown elongate, expanding distally from radials up. Infrabasals entirely within the ring of basals. Posterior basal elongate, much larger than others. No radianal. Anals and interbrachials usually wanting. Primibrachs two. Arms dichotomous, interlocking or closely appressed. Column strong, enlarging proximally, covering a large part of the basals.

Genotype. Forbesiocrinus nuntius Hall.

Distribution. Devonian; United States.

Synaptocrinus nuntius (Hall)

Plate 38, figures 3–7

1862 Forbesiocrinus nuntius Hall. 15th Rep't N. Y. State Cab. Nat. Hist., p. 124

1865 Taxocrinus nuntius Meek & Worthen. Proc. Acad. Nat. Sci. Phila., 9:140

1868 Taxocrinus nuntius Shumard. Trans. Acad. Sci. St Louis, 2:398

1872 Forbesiocrinus nuntius Hall. N. Y. State Mus. Bul. 1, pl. 1, fig. 12. (Photographic plates distributed privately.)

1877 Taxocrinus nuntius S. A. Miller. Amer. Pal. Foss., p. 92

1879 Taxocrinus nuntius Wachsmuth & Springer. Rev. Palaeocr., pt. 1, p. 49 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 31:272

1889 Taxocrinus nuntius S. A. Miller. N. Amer. Geol. & Pal., p. 285

1899 Taxocrinus nuntius Grabau. Bul. Buff. Soc. Nat. Sci., nos. 2, 3, 4, p. 145, fig. 27

1900 Taxocrinus nuntius Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., 11:198

1920 Synaptocrinus nuntius Springer. Crin. Flex., p. 302, pl. 38, figs. 3–6

Springer's description. Type of the genus. Specimens usually small, but may attain large size. Crown elongate, widest about the third bifurcation, where height to width is 1 to 1.3; spread of calyx from perimeter of column facet to the primaxil, 1 to 2.5; cross section at that level stellate; side outline straight; base concave, the concavity filled by column and including the basals except for small points sometimes exposed. Rays strongly elevated and angular in the middle; primary plates and axillaries nodose; sutures sinuous. Surface strongly ornamented with small papillae, tending to coalesce into longitudinal wrinkles. A large crown is 20 mm high to about the fourth bifurcation, probably extending considerably higher; width, 24 mm; base outside of column, 7 mm.

Infrabasals small, filling about half the diameter of column facet. Basals small, visible only in small angles beyond the column, except the posterior basal, which is greatly elongated, extending to the full height of the radials, and terminating in an acute angle, leaving no surface for attachment of anal plates. Radials wider above than below, elevated into large, angular, median nodes resembling short spines projecting downward over the proximal columnals, with lateral margins flattened toward the sutures; similar nodes surmount the two primibrachs and all the axillaries beyond, the intervening brachials being elevated and sharply angular in the middle. All brachial plates are much wider than long, and have the lateral margins abruptly deflected from the median elevated part into low, winglike buttresses, which meet at the interradial sutures and interlock; just at the edge they often have a slight elevation or fold parallel to the median line, strongly resembling rows of interbrachial plates. Primibrachs increasing rapidly in width upward in line with margins of radials. Secundibrachs three; tertibrachs about four to six or seven, the longer intervals being in the outer rami, some branches bifurcating once more. Column large next to the calyx, where it fills the concave base; it diminishes gradually for about a dozen moderately thick, rounded and equal ossicles, with thin projecting rims; below that they become thicker and more rounded, with large ones at intervals of four or five.

The description of brachial structures is chiefly taken from the large specimen obtained at a different locality from the type (plate 38, figures 5, 6); the nodes are less accentuated in smaller specimens, but the angularities and general features of surface marking are the same. Out of four well-marked specimens, three are about equally small; but notwithstanding the great disparity in size of the large one, I am unable to see any specific difference between them. The sharply angular distal end of the posterior basal, constant in all the specimens, precludes any suggestion of anal structures. Since the foregoing description was prepared I have obtained from the type locality in Erie county another still larger specimen, measuring 45 mm high by 35 mm wide. It is so encrusted with pyrites that the detailed structures are obliterated, but the nodose axillaries are almost spiniferous.

Hall in describing the species notes its remarkable resemblance to "Forbesiocrinus" thiemei, now the type of Wachsmuthicrinus, as well as its difference from that species in arm structure. This resemblance is heightened by the nodose and spiniferous character of the axillaries so conspicuous in the specimens found since his time.

Horizon and locality. From the Hamilton beds. Type from Hamburg, Erie county; probably the Moscow shales. Specimens have been collected at Eighteen Mile creek, Erie county, and Bellona, Yates county, N. Y. Bellona specimen undoubtedly from the Moscow shales. Species also reported from the Ludlowville shales of Eighteen Mile creek (Grabau, 1899, p. 145).

Types. Hall's original is in the collection of the American Museum of Natural History, number $\frac{5033}{1}$. Other specimens are in Columbia University and in the collection of Doctor Springer.

Remarks. All the figures of this species have been reproduced from the original drawings prepared by Doctor Springer.

Suborder **TAXOCRINOIDEA** Springer

Family TAXOCRINIDAE Bather (em. Springer)

Genus EUTAXOCRINUS Springer 1906

Springer's description. Taxocrinidae with rays not abutting over interbrachials. Infrabasals low, taking little part in calyx wall. Posterior basal elongate. Radianal if present only in upper oblique position. Interbrachials few or none. Primibrachs two. Arms dichotomous, usually divergent. Column usually enlarging next to calyx. Otherwise as in Taxocrinus.

Genotype. Taxocrinus affinis Müller.

Distribution. Silurian to lower part of Lower Carboniferous; Continental Europe, the United States and Canada.

Eutaxocrinus ithacensis (Williams)

Plate 39, figures 1–4

1882 Taxocrinus ithacensis Williams. Proc. Acad. Nat. Sci. Phila., v. 34, pt. 1, p. 28, pl. 1, fig. 10

1884 Taxocrinus ithacensis Williams. Bul. U. S. Geol. Soc., no. 3, pp. 12, 24

1886 Taxocrinus ithacensis Wachsmuth & Springer. Rev. Palaeocr., pt. 3, p. 144 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 38:68

1889 Taxocrinus ithacensis S. A. Miller. N. Amer. Geol. & Pal., p. 285

1896 Taxocrinus ithacensis Kindle. Bul. Amer. Pal., v. 2, p. 33
1920 Eutaxocrinus ithacensis Springer. Crin. Flex., p. 367, pl. 50, figs. 1, 3

Springer's description. A small species. Crown elongate, turbinate, narrowly expanding to the tertibrachs, where height to width is 1.2 to 1. Calyx narrow, with small base; side outline straight, spreading to top of primaxil, 1 to 2.6; height to width, 1 to 1.2. Arms broadly rounded, tapering rapidly to small ends. Rays with smooth margins, increasing in width from radials up leaving only narrow, elongate spaces. No interbrachials. Surface smooth.

Infrabasals low, like a columnal. Basals small. Primibrachs increasing in width upward. Secundibrachs three or four, the latter number predominating; two more bifurcations beyond, after which the arms infold. Column large and long, enlarging at the calyx where it is flush with the basal ring, and also toward the root; proximal columnals very thin, strongly crenulated, narrowing for about 5 mm, beyond which alternate columnals increase in length somewhat irregularly, until toward the middle of the stem they become long and convex; this continues until the column ends in an encrusting root. Dimensions of type: height of crown, 19 mm; width, 10 mm; base, 3 mm; length of stem, 180 mm; diameter at calyx, 3.2 mm; at end of conical enlargement, 2 mm; near root, 3 mm.

Doctor Williams in describing this species figured sections of the stem, which is substantially complete, with its root attached to a Spirifer, as shown by my figure 1 on plate L (plate 39, figure 1), a few columnals only being missing at the fracture. The original figure is misleading and quite fails to show the slender turbinate outline of the crown and narrow interbrachial spaces; compared with my figure, which is made with photographic accuracy direct from the type, it would scarcely be supposed to have been from the same specimen. The secundibrachs are inconstant, varying from three to four, sometimes five. The anal side is not shown.

This species comes from the Ithaca formation. It bears considerable resemblance to Taxocrinus communis, from the base of the Carboniferous, from which it might not be easily distinguished but for the number of primibrachs. This and the next species occur rather plentifully in the shales about Cayuga lake, chiefly in the form of natural molds; but the type specimen is well preserved in its rotund condition. Apparently the attachment of the stem to other objects is a frequent condition, as Williams says it was found in several cases.

Horizon and locality. From the Portage (Ithaca), Sherburne sandstone, Reticularia laevis beds, at Ithaca, N. Y., and from the Ithaca beds in the ravine east of South Otselic about 200 feet above the bottom section. Specimens referred to this species come from the Ithaca beds at Montour Falls.

Types in the Cornell University Museum. Plastotypes are in the collection of Doctor Springer.

Remarks. Two of the figures here used are reproduced from the originals prepared by Doctor Springer. One (plate 39, figure 1) is Williams' principal type. Another specimen, a young form referred to this species, is also figured here (figure 3). This specimen shows a very prominent, large, rounded columnal immediately below the most proximal thin columnals. Springer, in a letter to me, stated that this was not uncommon among young forms of this and other species, and that he did not attach importance to it.

I have referred to this species two specimens from the Ithaca beds, Montour Falls, one of which is too crushed for use. The other is figured here (figure 4); it shows the posterior side of the calyx. The left posterior ray shows two bifurcations above the primaxil. The first bifurcation is on the third secundibrach, the second on the sixth tertibrach. Both the inner and outer branches of the first bifurcation show the second bifurcation on the fifth tertibrach. This variation in the higher brachials, I think, may well be expected within the species. The habit of this specimen is somewhat more spreading than in the type, but I think this, in large part, is due to the manner of preservation.

Eutaxocrinus alpha (Williams)

Plate 39, figures 5–13

1882 Taxocrinus ithacensis *var.* alpha Williams. Proc. Acad. Nat. Sci. Phila. v. 34, pt. 1, p. 29

1920 Eutaxocrinus alpha Springer. Crin. Flex., p. 368, pl. 50, figs. 2, 4, 5

Springer's description. When describing the preceding species Doctor Williams gave the varietal name alpha to a small form occurring at the same localities, but from a higher horizon. He published no figures, but later furnished me casts from the original natural molds of the specimens which he regarded as types; these are shown by my figures 2 and 4 on plate L (*see* plate 39, figures 5, 6), to which I added figure 5 (*see* plate 39, figure 7) of a specimen with a long stem having prominent elongate columnals. After the plate was printed I came into possession of a number of similar specimens of this variety having more or less of the stem preserved, all exhibiting a striking uniformity in the small size and in the stem characters. The crown is usually less than 5 mm in height, with the arms limited to two visible bifurcations; and the stem is proportionally very long — in one case 15 cm without reaching the extremity. There are a few thin ossicles conically enlarging next to the calyx, followed by alternating ossicles with the larger ones convex; in the median part the columnals increase in size, becoming rather uniformly elongate, barrel-shaped or doubly-conical; beyond this the stem diminishes gradually to a slender thread, and the columnals become cylindrical and proportionally very much elongated. These are all thoroughly juvenile characters; but in view of the difference in horizon, and greater regularity in the size and proportions of the stem ossicles in a good series of specimens, it is advisable to recognize this form as a full species, of which figure 5 (*see* figure 7) represents the typical form, rather than figures 2 and 4.

Horizon and locality. From the lower Chemung beds at Ithaca, N. Y., in layers about 300 feet above those with E. ithacensis; and from the lower Chemung beds (Hydnoceras colony) at Avoca, Steuben county, N. Y.

Types in the Cornell University Museum. Squeezes of the types and other specimens are in the collection of Doctor Springer and the New York State Museum.

Remarks. The figures shown here on plate 39, figures 5–7, are reproduced from the originals prepared by Doctor Springer.

There are in the New York State Museum a series of young specimens referred to this species, from the lower Chemung beds of Avoca, Steuben county. Some of them are illustrated, enlarged, on plate 39, figures 8–13. Two of the specimens (figures 10 and 11) show a subradial plate which is not shown in any of the other specimens, not even in the one in which we have the mold of both sides. This plate was at first thought to be part of the basal, and was interpreted to be an extra high basal such as is seen in some of the larval forms of Antedon; but plasticine squeezes brought out the suture lines, which closer study showed were also visible on the mold. This extra plate bulges out beyond the radials and the basal cup. These very young forms recall the hypothetical ancestral form of the Flexibilia (Springer 1906, p. 493, pl. 5, fig. 9).

Eutaxocrinus curtus (Williams)

Plate 39, figures 14–17

1882 Taxocrinus curtus Williams. Proc. Acad. Nat. Sci. Phila., v. 34, pt. 1, p. 30

1884 Taxocrinus curtus Williams. Bul. U. S. Geol. Soc., no. 3, pp. 12, 24

1886 Taxocrinus curtus Wachsmuth & Springer. Rev. Palaeocr., pt. 3, p. 144 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 38:68

1889 Taxocrinus curtus S. E. Miller. N. Amer. Geol. & Pal., p. 285

1896 Taxocrinus curtus Kindle. Bul. Amer. Pal., 2:34

1920 Eutaxocrinus curtus Springer. Crin. Flex., p. 369, pl. 50, figs. 6–9

Springer's description. A small species. Crown short, stout, more or less rotund, widest about the upper secundibrachs; height to width about 1 to 1. Dimensions of mature specimen, 16 mm high by 15 mm wide; base, 4.5 mm. Calyx low, broadly expanding with side outline convex; height to width 1 to 2; base broad; spread of calyx from base to primaxil, 1 to 2.2. Infrabasals hidden by column. Basals very small. Rays wide and heavy, and strongly increasing in width from radials to axillary secundibrachs, above which the divisions become very small, in young specimens looking like mere threads. No interbrachials, and spaces very narrow and elongate. Secundibrachs three or four, irregularly. Column large, enlarging at the calyx with thin columnals which alternate with longer and more convex ones farther down; mode of termination unknown.

This species is found associated with E. ithacensis, from which it is well distinguished by its broad and short crown and more blunt habit generally. Williams' description was made from a young specimen, on which he noted as a character that the stem does not enlarge next to the calyx. This is not the case in the adult, like the fine specimen from the New York State Museum shown by figure 8 of plate L (*see* plate 39, figure 16); and there is a notable difference among specimens in this respect due to age. The appearance of branching roots in figure 6 (*see* plate 39, figure 14) is misleading, caused by incidental depressions in the somewhat injured natural mold from which the impression was taken; the specimens are mostly in that condition.

Horizon and locality. Upper Devonian, Chemung group; Ithaca and Avoca, N. Y. Williams gives the horizon as Portage. There is reason to believe that the type specimen, which he did not figure but of which he sent me an impression from the original natural mold, identified as the type, was associated with variety alpha rather than with ithacensis, and therefore belongs to the Chemung. The originals of figures 8 and 9 (figures 16 and 17) are from the Chemung beds at Avoca, Steuben county, in which E. alpha also occurs; the two species being thus associated at this locality probably occur in the same formation at the type locality also. The horizon of figure 7 (figure 15) is doubtful, and I regard figures 6, 8 and 9 (figures 14, 16, 17) as controlling for the characters of the species.

Types. Museum Cornell University, Ithaca.

Remarks. Two of the figures used here (figures 14 and 15) are reproduced from the originals prepared by Doctor Springer.

The specimens of this species coming from Avoca were collected in the *Hydnoceras* colony at Cotton hill.

(?) **Eutaxocrinus pulcher** Springer

Plate 38, figures 8–10

1920 (?) Eutaxocrinus pulcher Springer. Crin. Flex., p. 369, pl. 75, fig. 10

Springer's description. A medium-sized species, of delicate and graceful habitus. Crown elongate, very narrow, spreading but little from the base where it is flush with the top columnal. An average uncompressed specimen has the crown 40 mm high; 10 mm wide; base, 6 mm; calyx at top of axillary primibrach about as high as wide. Interbrachials wanting, or irregular; when present they are usually hidden by close apposition of the arms; and anal interradius extremely narrow, with posterior basal but slightly differentiated; anal tube not observed, but must have been very small. Arms tapering gradually to the fourth bifurcation, with relatively long brachials, and upper division series long and slender. Sutures strongly arcuate throughout. Column large, with wide proximal enlargement. Surface smooth.

Infrabasals low, not higher than a thin columnal. Basals short. Radials and primibrachs large and of nearly equal size. Secundibrachs four, about half as wide as preceding plates; higher brachials diminishing by about one-half at each bifurcation, but the long branches themselves taper but little.

This species is of remarkably graceful contour, with flowing lines and gentle curves. It is not as well illustrated as is desirable, because overlooked until all the plates for the T a x o c r i n i d a e were printed. The specimen figured on plate 75 (*see* plate 38, figure 8) is much flattened, and does not show the almost cylindrical form of the uncompressed crown. The anal interradius can scarcely be distinguished from the others, and upon the evidence of the specimens in the New York State Museum originally studied it was thought to be undifferentiated. Material subsequently collected by me at the type locality furnished some additional information, from which it appears that the posterior basal is somewhat larger than the others, but of similar shape; and that the anal and other interbrachial areas may be occupied by plates or perisome irregular in shape, size and position, so far as can be seen from the exterior — largely due to the close compression of the rays, whereby the interradial structures are pushed to the inside and only incidentally exposed. There may be a small tube, invisible in the fossils as found, and the lowest plate of such a tube would be entirely separated from the posterior basal, but supported on the shoulders of the radials — the basal not being suturally connected with the plates succeeding it. The specimens upon which we have to depend occur in a micaceous sandstone, mostly in the form of natural molds; in the few which have the skeleton preserved the preservation is unfavorable for definition of the sutures and finer structures. With the information now available the reference to the present genus must be made with doubt. Additional figures which I had prepared will be published in the forthcoming work on the New York Devonian crinoids now in course of preparation by the New York State Museum.

Horizon and locality. From the lower Chemung beds, Belmont, N. Y. A poor mold of what appears to be the same species was collected by Mr Charles Butts in the Chemung beds at Alfred, N. Y.

Types in the New York State Museum. Other specimens in the New York State Museum and in the collection of Doctor Springer.

Remarks. I have refigured here the type specimen figured by Doctor Springer. Two other specimens in the New York State Museum are here figured. The original drawings were prepared, but not used, by Doctor Springer; and through his kindness I have had them for reproduction here (plate 38, figures 9, 10).

(?) **Eutaxocrinus amplus** Springer

Plate 38, figure 11

1920 (?) Eutaxocrinus amplus Springer. Crin. Flex., p. 370, pl. 50, fig. 10

Springer's description. An extraordinarily large species. Crown elongate and robust; the type and only specimen is 70 mm high by 30 mm wide; base, 10 mm; height to width of calyx at primaxil, 1 to 1.3; spread from base, 1 to 2. Side outline convex. Arms very strong throughout, not diminishing rapidly upward; sutures broadly arcuate. Interbrachials present. Anal structures unknown. Surface smooth.

Infrabasals very low, not distinguishable from a columnal. Basals small, in form of low pentagons. Radials and primibrachs three times as large as the basals, not materially widening upward, twice as wide as high, and of nearly equal size. Secundibrachs four; these and higher brachials in each division of about the same size, wider than high, and each about two-thirds as wide as those of the preceding division. Branching above the secundibrachs somewhat irregular, with five to ten plates in outer ramus of tertibrachs and four to seven in the inner, and longer intervals above; one ray probably injured and recuperated. Arms extending beyond fourth bifurcation, and infolding at about that level. Interbrachials few, narrow and elongate, in two or three ranges; a small intersecundibrach present. Column large, tapering rapidly from the calyx at first and then gradually until becoming cylindrical, with slightly alternating columnals of even diameter.

This species is proposed upon a single specimen from the New York Chemung, being an impression from a natural mold in the collection of the late Professor James Hall now in the University of Chicago. In its peculiarly large and robust habit it is unlike any other of this genus, and looks more like a specimen of Onychocrinus ramulosus. This resemblance is heightened by the presence of two or three irregular ramule-like arm-branches, but in general structure the arms are in nowise like those of that genus. Lack of knowledge of the anal structures makes the generic position of the species uncertain.

Horizon and locality. From the upper Chemung beds, Binghamton, New York.

Type. Plastotype and only known specimen in Chicago University, Walker Museum.

Remarks. The figure of the species used here was reproduced from the original drawing prepared by Doctor Springer.

Eutaxocrinus dumosus sp. nov.

Plate 38, figure 12

Eutaxocrinus dumosus is of medium size with turbinate body and comparatively short arms. The crown when complete would have measured at least 30 mm. Cup low, of the same width as the column in the proximal portion (5.5 mm); gradually increasing in width upward, having a width at the radials of 7 mm.

Dorsal cup. Infrabasals can scarcely be distinguished from the thin columnals. They form a very thin ring at the top of the column. Basals of comparatively large size; an average one has a height of 1.7 mm and a breadth of 3.1 mm. Radials somewhat over twice as wide as high, an average one having a width of 3.3 mm and a height of 1.5 mm. Practically no variation in width in the radial series. Upper margins of the radials slightly arcuate.

Tegmen not preserved.

Arms. Two primibrachs, both considerably wider than high, with slightly arcuate upper margins. The first quadrangular, an average one having a width of 4 mm and a height of 1.6 mm; primaxils pentagonal giving rise to 2 x 5 arms. An average one has a width of 4 mm and a greatest height of 2.1 mm.

Arms bifurcate on the fifth or sixth brachial above the primaxil; and again on the fifth brachial above this, but only on the inner branch of each half ray. Secundibrachs about one-half the width of the primibrachs, the series decreasing gradually in size upwards and flaring out again on the secundaxil. Tips of arms not shown, but arms apparently not much longer; no indication that a third bifurcation might be expected. Upper margins of brachials slightly arcuate.

Column. About 46 mm preserved. Gradually decreases in width, having a diameter at the place of attachment to the calyx of 5.5 mm, in the most distal part preserved of 3.2 mm. For a distance of 22 mm column made up of very thin columnals of about the same thickness. From this point on there is a variation in size, thin columnals alternating with thick ones, or it may be that two or three thin ones occur between the thicker ones. All columnals have crenulate margins.

Horizon and locality. From the Ithaca beds, De Ruyter, N. Y. A younger specimen from the west side of Cayuga lake, near Ithaca, perhaps belongs to this species. It is in a poorly preserved condition and not much can be made out of it.

Types originally in the collection of D. S. Chatfield. Gutta-percha squeezes in the New York State Museum and in the collection of Doctor Springer.

Remarks. The species to which E. dumosus bears the closest resemblance is E. ithacensis (Williams). The calyx in the latter is more spreading than in the former. In dumosus there are five or six secundibrachs, whereas ithacensis has four (rarely five). The thin columnals in dumosus cover twice the distance that they do in ithacensis, and the margins of the articulating faces of all the columnals are crenulate.

Genus TAXOCRINUS Phillips 1843

Springer's description. Taxocrinidae with rays not abutting over interbrachial areas. Infrabasals low, forming but a small part of the calyx wall; sometimes entirely concealed by the column. Posterior basal elongate. Radianal only in upper oblique position. Interbrachials variable, usually present in lower part of area; frequently numerous, with distal margin crescentic, rising toward the rays; sometimes wanting. Primibrachs three. Arms dichotomous, divergent. Column usually enlarging proximally. Tegmen composed of pliant skin with calcareous spicules imbedded, traversed by calcified ambulacra passing between parted orals to an open mouth. Anal opening excentric, at the end of a tube formed by extension of the ventral perisome and supported at the posterior side by a vertical series of anal plates.

Genotype. Cyathocrinus ? macrodactylus Phillips.

Distribution. Middle Devonian to close of Lower Carboniferous; Great Britain, Belgium, and the United States.

Remarks. There is only one representative of this genus in the New York Devonian, Taxocrinus lobatus (Hall). Hall (1864, p. 55;

1875, p. 169) referred to Taxocrinus communis a specimen from the Chemung at Forestville, Chautauqua county, N. Y. There was only a single specimen and one side of this was buried in the rock. This specimen is not in the New York State Museum and has not been located. No evidence has been found of the occurrence of this species in the Chemung of New York. It is described by Doctor Springer in his recent Monograph as one of the earliest Carboniferous occurrences of the genus from the lowest part of the Waverly Group, Richfield, Ohio. Hall (1875, pl. 12, figs. 3, 4, 5) figured three specimens under this species, only one of which (figure 3) belongs there. The others (figures 4, 5) belong under Forbesiocrinus (Springer 1920, plate 52, figures 1–4).

Taxocrinus lobatus (Hall)

Plate 39, figures 18–20

1862 Forbesiocrinus lobatus Hall. 15th Rep't N. Y. State Cab. Nat. Hist., p. 124

1868 Forbesiocrinus lobatus Shumard. Trans. Acad. Sci. St Louis, 2:371

1872 Forbesiocrinus lobatus Hall. N. Y. State Mus. Bul. 1, pl. 1, fig. 11. (Photographic plates distributed privately.)

1877 Forbesiocrinus lobatus S. A. Miller. Amer. Pal. Foss., p. 79

1879 Taxocrinus lobatus Wachsmuth & Springer. Rev. Palaeocr., pt. 1, p. 49 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 31:272

1889 Taxocrinus lobatus S. A. Miller. N. Amer. Geol. & Pal., p. 286

1900 Taxocrinus lobatus Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 3, p. 198

1901 Taxocrinus lobatus (in err.) Shimer & Grabau. Bul. Geol. Soc. Amer., 13:185

1904 Forbesiocrinus lobatus Clarke & Luther. N. Y. State Mus. Bul. 63:55

1904 Taxocrinus lobatus Wood. Smith. Misc. Coll., v. 47, no. 1471, p. 81

1920 Taxocrinus lobatus Springer. Crin. Flex., p. 386, pl. 52, figs. 9–11

Not Taxocrinus lobatus *var.* Whiteaves. Contr. Can. Pal., v. 1, pt. 2, 1889, p. 94, pl. 12, fig. 1

Springer's description. A medium-sized species. Crown elongate, turbinate below; height to width at second axillaries, 1.9 to 1. Calyx narrowly spreading, 1 to 3, with nearly straight sides; height to width at primaxil, 1 to 1.4. Arms large and deeply rounded, strongly divergent, tapering very gradually, the first division series being almost as large as the primibrachs; infolding about the fourth bifurcation, but much longer and bifurcating further beyond; sutures strongly arcuate, and a strong node on each axillary. Interbrachial spaces wide, chiefly filled with strong perisome. Anal tube large and prominent. Surface smooth. Crown of mature specimen, 41 mm high; 22 mm wide; base, 6 mm.

Infrabasals low but showing well above the column. Basals fairly large, with acute angles. Posterior basal extremely large and broad with very wide concave socket, supporting a large anal tube with lower plates large, as wide as high, becoming shorter above, and bordered on both sides with wide areas of very strong perisome. Radials and primibrachs of similar form and size, almost as long as wide. Primibrachs three, exceptionally two; secundibrachs four, sometimes five, nearly as wide as the primibrachs. Tertibrachs 6 on inner and about 8 in outer division. Interbrachials 1 to 3, and small intertertibrachs sometimes present, followed by extensive perisome. Column unknown.

The brachials throughout in this species are much longer than is usual for the genus, and the development of anal structures and perisome much more profuse than in any other Devonian species, recalling those of the later Subcarboniferous. In arm structure it superficially resembles T. kelloggi, but it has a much narrower and more conical calyx, and is very different in other details. The type specimen is in poor condition, and does not show the structures plainly; it seems, however, to have but two primibrachs in part of the rays, whereas the other two extremely well-marked specimens have three consistently throughout. One of these (figure 10; our figure 19) shows all the characters of the species most beautifully; and the other (figure 11), though not so perfect, fully confirms it. The latter has a Gasteropod commensally attached over the anus.

Horizon and locality. From the Hamilton (Moscow shale) beds, at Bristol, Ontario county, and at Canandaigua lake, N. Y.

Types. Hall's original (figure 18), in the American Museum of Natural History, number $\frac{5034}{1}$. Other specimens in the New York State Museum and in the collection of Doctor Springer.

Remarks. For figure 19, plate 39, the original drawing prepared by Doctor Springer was used. Type specimen, as figured here (plate 39, figure 18), shows 8 mm of column; composed of thin columnals which gradually become longer. Column in the most proximal part with a diameter of 3.6 mm; but it narrows rapidly, and at a distance of 6 mm has a diameter of 2.3 mm. Hall (1862, p. 124; 1872, pl. 1, fig. 11) figured and described this specimen with the column attached. When I received the specimen the column was separated from the crown; I have figured it attached as in the original figure.

There are in the New York State Museum parts of three columns which unquestionably belong to this species. In one case (plate 39, figure 20) the column is preserved for a length of 17 cm and beyond this the impression of the column is preserved for 2.5 cm. This column is attached to a crushed calyx, so that its character is beautifully shown from the most proximal part. Round; for a distance of about 8 mm composed of thin columnals of the same size. At the base of the calyx width 5.4 mm; at a distance of 8 mm diameter 3.5 mm; and practically this same diameter maintained for the remainder of the column, so far as preserved. In the more proximal portion there is an alternation in the size of the columnals; usually every eighth columnal enlarged and projecting beyond the others forming a nodal columnal. In the more distal portion of the stem columnals practically of the same size; even the nodals disappear or become much less prominent.

Springer has noted in his description the presence of a gastropod commensally attached over the anus in one of his specimens. This apparently is not an uncommon occurrence in this species, for among the few specimens which represent it in the New York State Museum two show this commensal relation, one a young specimen and the other an adult.

Order INADUNATA Wachsmuth & Springer

Suborder **LARVIFORMIA** Wachsmuth & Springer

Family PISOCRINIDAE Angelin

Genus HYPSOCRINUS Springer & Slocom 1906

Hypsocrinus fieldi Springer & Slocom

Plate 40, figures 1–5

1906 Hypsocrinus fieldi Springer & Slocom. Field Mus. Pub., no. 114, Geol. ser., v. 2, no. 9, p. 296, pl. 81, figs. 1–6

This New York species was recently described by Springer and Slocom. No representative in the New York State Museum; holotype and only known species in the Field Columbian Museum, Chicago, Ill.

Original description. Calyx elongate, cylindrical, slightly expanding to the arm bases. Base truncate; basal facet broad, slightly concave, entirely filled by the column; axial canal stellate or pentagonal, interradial in position. Basals very elongate, forming two-fifths to half the height of the cup. Radials, three large and two small, all arm-bearing; the two smaller ones short, wider than high, separated from the basals by three much more elongate inferradials, one of which is directly beneath the right posterior radial, and represents the radianal; the other two are for the most part directly under the right anterior radial, whose lower margin meets them by an obtuse angle, but in part obliquely under the left lower corner of the anterior radial, meeting it by a curved suture; the other three radials are large and elongate plates. Arm facets very shallow, curved, not entirely filling the distal face of the radials, but leaving short, sloping shoulders between, which are rounded off exteriorly, but probably formed a support for oral plates in the tegmen. Arms simple, uniserial, tapering rapidly, and doubtless very short. No trace of a dorsal canal in radials or brachials. Anal structures and tegmen unknown. Surface smooth; calyx plates slightly rounded, and sutures distinct. Stem unknown; but it was large at the proximal end, as the radiate markings of its articulation are visible to the edge of the basal facet.

Horizon and locality. Devonian; Hamilton group (Moscow shale). Found near East Bethany, New York.

The specific name is in honor of Marshall Field, the founder of the Field Columbian Museum, where the type specimen is deposited.

Remarks. Springer and Slocom state that they have omitted from their description some details apparent enough in the figures, which might be abnormal or due to individual variation, such as the lateral bulging, because there was only one specimen at hand. Since asymmetry is frequently characteristic of this group, they think it quite probable that other specimens will show the same character.

Construction of the tegmen unknown. Springer and Slocom state: "The tegmen is clearly not an elevated pyramid like that of Haplocrinus, but, beyond this, no opinion can be ventured with our present knowledge" (p. 271).

Pisocrinus and Haplocrinus are the two genera most nearly related to Hypsocrinus structurally.

Family ANAMESOCRINIDAE nov.

Family created to contain the new genus Anamesocrinus. Forms small, monocyclic, with five basals, regular in form and size. Three of the radials, the right anterior, left anterior and right posterior compound. Each radial supports several arms. The two posterior radials support on their shoulders the first plate of what appears to be an armlike anal tube.

This new family differs from the Pisocrinidae in having three radials bisected and in the numerous arms. Among the Heterocrinidae, it resembles the Ordovician genus Ectenocrinus in the character of the dorsal cup. The numerous arms to each radial recall the Catillocrinidae.

Genus ANAMESOCRINUS nov.

[Ety. ἀνάμεσος, *intermediate;* κρινον, *lily*]

Genus represented in the New York State Museum by ten specimens, all of the same species. Description, however, based upon the three figured here (plate 40, figures 6–9) since they best show the details. Genus seems to be of intermediate character. Dorsal cup like that of the Ordovician genus Ectenocrinus; arms resembling those of the lower Carboniferous genus Catillocrinus.

Since only the one species is known the specific description serves for both genus and species.

Genotype. Anamesocrinus lutheri sp. nov.

Distribution. Upper Devonian (Portage and lower Chemung) of New York.

Anamesocrinus lutheri sp. nov.

Plate 40, figures 6–9; text figure 53

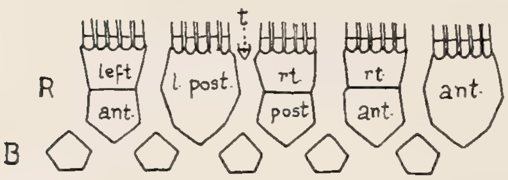

Figure 53 Analysis of calyx of Anamesocrinus lutheri, the genotype; *t*, the first plate of the anal tube (?).

A very beautiful little crinoid. Because of its small cup and the long, slender, unbranching arms, it bears a decided resemblance to a tassel. It is so delicate that some of the Portage material (Laona sandstone) only shows faint impressions of the arms and poor, crushed preservation of the calyces. In other material from the Lower Chemung beds (plate 40, figures 8, 9) only the molds remain and the drawings have been made and the specimens studied from the gutta-percha squeezes. On a small piece of shale from the Lower Chemung, Fillmore, N. Y., two specimens are well preserved, one showing the crown and the other the crown and the column. These have constituted the best material for the description of the species.

As noted above, species small; crown in the different specimens showing a length of 12 mm, 15 mm, 10.5 mm, 14.5 mm, etc. The measurements given in the description will be taken from the specimens figured on plate 40, figures 6–8.

Dorsal cup conical, having a width at the base in one specimen of 1 mm and at the arms of about 2.5 mm. Another specimen shows the same width at the base and a width at the arms of 2.8 mm.

Basals five, pentagonal, average ones having a height of 1 mm and a breadth of 1.5 mm, and a height and breadth of 1.5 mm.

Of the five radials three are compound, more or less equally bisected transversely — the left anterolateral, right posterior, right anterolateral. A typical radial gives a height and width of about 1.7 mm. Compound radials slightly narrower than the others. Upper edges of the radials bear small sockets for the reception of the arms.

Only two specimens show the posterior side of the calyx. In one, the right posterior and right anterolateral compound radials are shown; posterior interradius not visible. The other specimen apparently showed the posterior interradius. This specimen was figured under Doctor Kirk's supervision (plate 40, figure 7), and afterwards a wax impression was taken which removed the crown and the upper part of the column from the shale to the wax permanently, thus exposing the anterior side of the crown (plate 40, figure 6). The specimen is so delicate that it is utterly impossible to attempt to remove the specimen for study of the posterior side. All the figures made under Doctor Kirk's supervision have been very carefully and accurately drawn, so his figure (plate 40, figure 7) is used here for description. A small plate similar to the anal plate of Ectenocrinus (Bather, 1900, p. 146) rests upon the shoulders of the left posterior radial and the right posterior super-radial. This plate is very suggestive of an anal or first tube plate. The fact that the figure shows an arm resting upon it need not be given great weight for the specimen is in a crushed condition and several arms have been pushed out of place.

Tegmen not exposed in any of the specimens.

Arms simple, very slender, about four or five times as long as the calyx, and, with the exception of the first brachial of each arm, made up of few, long brachials, measuring 2.2 mm, 3 mm, etc., the proximal ones being the longest. First brachial of each arm very short (about .3 mm); not much longer than wide. There is some difficulty in ascertaining the number of arms to a ray because they are missing or pushed out of position in those specimens where an entire radius is visible. From a study of the different specimens, five seems to be the correct number to a ray in the larger forms, thus giving a total of twenty-five arms. One specimen, a smaller form figured on plate 40, figures 6, 7, seems to have fewer arms (two or three) borne by the compound radials.

Column round; expanded at the point of attachment to the calyx, having a diameter in an average specimen of about 1 mm. It gradually narrows for a distance of about 1.8 mm until the diameter is about .4 mm. Proximal enlarged portion made up of very thin columnals, but they grow gradually longer in the more distal portions of the stem, having three or more times the length of the proximal columnals.

Horizon and locality. Five specimens from the Portage (Laona sandstone) beds, Laona, Chautauqua county, in the bed of Canadaway creek. Also from the lower Chemung beds: two specimens (plate 40, figures 8, 9) found along the road from Watkins to Elmira; two specimens, one of which is figured on plate 40, figures 6, 7, from Fillmore, east side of the Genesee river, Scott's ravine; and one poorly preserved specimen apparently belonging to this species from East Koy creek, Cooley's farm near East Pike, Genesee county, N. Y.

Types. Cotypes in the collection of the New York State Museum.

Remarks. As noted above, Anamesocrinus lutheri shows characters similar both to the Ordovician Ectenocrinus and the Lower Carboniferous Catillocrinus.

The species has been named in honor of D. Dana Luther by whom the majority of the specimens were collected.

Family HAPLOCRINIDAE Roemer

Genus HAPLOCRINUS Steiniger 1837

Haplocrinus clio Hall

Plate 40, figures 10–14

1862 Haplocrinus clio Hall. 15th Ann. Rep't N. Y. State Cab. Nat. Hist., p. 143, pl. 1, figs. 5–9

1868 Haplocrinus clio Shumard. Trans. Acad. Sci. St Louis 2, p. 376

1877 Haplocrinus clio S. A. Miller. Amer. Pal. Foss., p. 81

1878 Haplocrinus clio Bigsby. Thesaurus Dev.-Carb., p. 17

1886 Haplocrinus clio Wachsmuth & Springer. Rev. Palaeocr., pt. 3, p. 162 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 38:86

1889 Haplocrinus clio S. A. Miller. N. Amer. Geol. & Pal., p. 252

1900 Haplocrinus clio Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 3, p. 198

1910 Haplocrinus clio Grabau & Shimer. N. Amer. Index Foss., 2:500

Dorsal cup very small, subangularly turbinate below the arm openings, pentagonal when viewed from above, and with projecting arm bases.

Basals five, very small and pentagonal.

Radial plates large. Three of them, the right and left anterolateral and the right posterior, compound, consisting of two plates each; two of them, the anterior and left posterior, very large, simple, and heptagonal. In the series of two, first plate small; quadrangular in two rays and pentagonal in the third, the right anterolateral; all much wider than high. Second plate large, intermediate in size between the first small plates and the large radials; two of them pentagonal and one hexagonal, the right posterior. All of the five large radials strongly protrude at the upper margin for the articulation of the arms, and show a large arm opening with a central septum passing into the interior of the body. Upper margin of the radials thickened, the upper edges rounding over into the summit.

Tegmen composed of five triangular plates, the orals. Sutures of adjacent orals in line with the median line of the radials, and the broad base of each rests upon the two adjacent radials. Orals have grooved sutures which are shallow near the base of the orals and broaden out above so that they truncate the top of the oral pyramid. When viewed from above these sutures form a five-pointed, stellate depression. Lower lateral angles of the orals truncated to form the upper border of the arm openings.

Arms apparently composed of long, slender brachials, deeply grooved on the ventral side, corresponding to the size of the arm opening. First brachial articulated by a mitred end to the sloping facet of the radial plate.

Column missing. From the cicatrix seen to be large, round and deeply impressed.

Ornamentation. Surface of all the plates marked by fine, wrinkled radiating striae.

Horizon and locality. From the Marcellus shale beds (Cherry Valley limestone), near Manlius, Onondaga county, New York.

Types. Cotypes in the American Museum of Natural History, number $\frac{4371}{1}$.

Family SYMBATHOCRINIDAE Wachsmuth & Springer

Genus SYMBATHOCRINUS Phillips 1836

Symbathocrinus subtrigonalis sp. nov.[1]

Plate 40, figures 16, 17

Species considerably larger than the other species figured here (plate 40, figures 15, 18). Dorsal cup turbinate with a height of approximately 4.5 mm and a breadth of 8.9 mm.

Dorsal cup. Basal ring broken away in the only specimen of the species; basals apparently were quite small.

Radials pentagonal, narrow at the base and gradually widening upward. Anterior radial gives the following measurements: height, 4.5 mm; width at top, 4.3 mm; width at base, 2.5 mm. Arm facets straight, occupying the entire width of the radials.

Two posterior radials notched for the reception of the anal *x* which has a length of 4.5 mm and a greatest width (near the base) of 2 mm. Second plate of anal tube visible; above this tube concealed by the arms.

Arms composed of long, quadrangular brachials, the most proximal ones averaging about 2 mm in length. Backs of the brachials wedge-shaped; angle not sharp and becomes quite rounded proceeding distad. Lateral apposed faces sharply squared off.

Column missing, but apparently was round.

Ornamentation. Plates of the cup and brachials faintly granulose.

Horizon and locality. From the lower Moscow limestone, Hamilton group, at Cashong creek, near Bellona, N. Y.

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[1] While this paper was in press, there appeared a paper by Springer "On the Fossil Crinoid Family Catillocrinidae" in which this new species is described and figured as S. hamiltonensis (Smith. Misc. Coll., 1923, v. 76, no. 3, p. 29).

Types. Holotype in the collection of Doctor Springer, now deposited in the United States National Museum, Washington.

Remarks. Comparison of this species with Symbathocrinus sulcatus will be found under the description of that species. S. subtrigonalis is quite distinct from S. matutinus of the Hamilton of Iowa in its much greater size, shape of the cup and the radials and in the character of the arms.

Species named from the character of the arms.

Symbathocrinus sulcatus sp. nov.

Plate 40, figure 15

Theca rather below the average size, measuring 4.3 mm in breadth by 2 mm in height. Dorsal cup narrower and more turbinate than in most of the Carbonic forms.

Dorsal cup. Basals fused to three, extending well beyond the stem.

Radials pentagonal, narrow at the base, and widening gradually upward. Articular extensions of the radials or " muscle-plates " large, and forming a moderately elevated pyramid, which is capped by the orals. Anterior radial gives the following measurements: length, 2 mm; width at top, 2.7 mm; width at base, 1.2 mm. Arm facets straight, occupying the entire width of the radials.

Arms composed of long quadrangular brachials, averaging about 1.5 mm in length in the proximal 15 mm of the arm. Backs of brachials wedge-shaped, while the lateral apposed faces are sharply squared off. Total length of arms probably about 25 mm. Arms as preserved in this specimen measure 22 mm.

Ventral margins of brachials distinctly notched for the reception of the covering plates, of which there are four or five on each side of an ossicle.

Column round and of medium size; composed of alternating wide and narrow columnals, except in the proximal portion, where the first five columnals are of the same width.

Ornamentation. The most distinctive feature of the ornamentation of this species is the deeply grooved or depressed character of the radials along their common sutures, which suggested the name sulcatus. Besides this, plates of dorsal cup and arm ossicles finely papillose.

Horizon and locality. Onondaga limestone. Only specimen known from Limerock, near Le Roy, Genesee county, N. Y.

Types. Holotype in the collection of the New York State Museum.

Remarks. Inasmuch as the small, unfused basal is exposed in this specimen, it is evident that the posterior interradius is buried in the exceedingly hard matrix, precluding any possibility of uncovering it.

There seems to be no doubt, however, that the form should be referred to Symbathocrinus rather than to Stylocrinus, to which, chiefly by virtue of its geological position, it might be expected to belong. The nature of the articular extension of the radials — a feature used by Wachsmuth and Springer in the separation of the two genera (Revision of the Palaeocrinoidea, pt. 3, p. 171) — is essentially that characteristic of Symbathocrinus.

Symbathocrinus sulcatus differs from S. matutinus (plate 40, figure 18), from the Hamilton of Iowa in a number of respects. S. matutinus has a more prominent and projecting basal ring; cup lower in proportion to the width; arms much longer and proportionally more slender. Nodal columnals more prominent and more rounded, giving the column a beadlike appearance.

The new species of Symbathocrinus from the Hamilton of New York, subtrigonalis (plate 40, figures 16, 17), is a much larger form with heavier cup plates. Dorsal cup twice the size of that of sulcatus; radials not so flaring and do not show the pronounced depressions in the region of the sutures. Median dorsal ridge on the brachials less angular in the most proximal part of the arms and becomes more rounded distad.

Genus STYLOCRINUS Sandberger 1850

Stylocrinus (?) **canandaigua** sp. nov.

Plate 40, figure 19

Species represented by a single dorsal cup from the Hamilton beds of the Canandaigua lake region, N. Y. Though so little of the specimen is shown, the species is here described and figured because the genus has hitherto been noted only from the European Devonian (Springer, 1913, p. 209; Bather, 1900, p. 152).

Dorsal cup small and bowl-shaped, having a height of 6 mm, a width at the bottom of 3 mm and at the top of approximately 7 mm. Basals three, of unequal size; height approximately 1 mm. Radials quadrangular or pentagonal, depending upon their relation to the basals. One of them has a height of 5 mm, a width at the base of 2.3 mm and at the top of 3.8 mm. Radial facets appear to be directed downward and inward.

Column. Cicatrix with subpentagonal outline due to the radial ridges.

Ornamentation. A low ridge extends up to the center of each radial and is more faintly shown on the basal cup. Ridge becomes lower just above the middle of the radial plate, almost giving the appearance of being broken; and from this point it spreads out toward the upper corners leaving on each side a slight but noticeable depression.

Horizon and locality. From the Hamilton (Moscow) shales, west shore of Canandaigua lake, N. Y.

Types. Holotype and only known specimen in the collection of the New York State Museum.

Remarks. At first glance this specimen might be taken for a Symbathocrinus, a genus which has been described from the American Devonian; but the radial facets characteristic of Symbathocrinus and the additional facet on one of the radials for the support of the anal tube are not present. So far as can be ascertained the specimen is referable to Stylocrinus.

Species named for the locality in which it was found.

Suborder **FISTULATA** Wachsmuth & Springer

Family HETEROCRINIDAE Zittel

Genus BRACHIOCRINUS Hall 1859

Brachiocrinus nodosarius Hall

Plate 41, figures 1–4

1859 Brachiocrinus nodosarius Hall. Pal. N. Y. 3:118, pl. 5, figs. 5–7, pl. 6, figs. 1–3

1868 Brachiocrinus nodosarius Shumard. Trans. Acad. Sci. St Louis, 2:356

1877 Brachiocrinus nodosarius S. A. Miller. Amer. Pal. Foss., p. 72

1881 Brachiocrinus nodosarius Wachsmuth & Springer. Rev. Palaeocr., pt. 2, p. 229 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 33:413.

1889 Brachiocrinus nodosarius S. A. Miller. N. Amer. Geol. & Pal., p. 229

1895 Herpetocrinus nodosarius Bather. Amer. Geol., 16:213–217

1899 Brachiocrinus nodosarius Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 2, p. 88.

1900 Herpetocrinus nodosarius Schuchert. Bul. Geol. Soc. Amer., 11:279.

1903 Brachiocrinus nodosarius Clarke & Ruedemann. N. Y. State Mus. Bul. 65, p. 65

1905 Brachiocrinus (Herpetocrinus ?) nodosarius Talbot. Amer. Jour. Sci., 20:32; pl. 4, figs. 7, 8

1911 Brachiocrinus nodosarius Kirk. Proc. U. S. Nat. Mus., v. 41, no. 1846, p. 48

Talbot's description. In Hall's description, these fragments of crinoids are considered as arms or parts of arms; and this opinion was held by Wachsmuth and Springer in 1881. In 1895, Bather brought arguments to prove that they belong to columns, not arms (page 213), 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 (1900, p. 146).

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 (1895, pp. 215, 216).

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 bulblike 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 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 many individuals 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. From the New Scotland limestone, east of Clarksville; Helderberg mountains, Schoharie, N. Y. Also found in the Coeymans at Schoharie.

Types. Cotypes in the American Museum of Natural History, numbers $\frac{2296}{1}$, $\frac{2296}{2}$, and in the New York State Museum, numbers $\frac{4080}{1}$, $\frac{4080}{2}$.

Remarks. The specimens in the New York State Museum show very distinctly the character of the cirri and the column with its bulblike distal extremity. In one specimen (plate 41, figure 3) below this small knoblike or bulblike process the column is present, composed of a few short, narrow columnals and tapering almost to a point.

Since Talbot's description was published, Kirk (1911, p. 48) in his paper on "The Structure and Relationships of Certain Eleutherozoic Pelmatozoa" has discussed Herpetocrinus and Brachiocrinus. He states: "Brachiocrinus is structurally similar to Herpetocrinus in that the column bears two rows of cirri. These are much heavier than in the case of Herpetocrinus and are composed of beadlike ossicles. The column is round, and it does not seem wholly certain that any but the distal portion bears lateral appendages. In one or two instances the portion of the column preserved appears involute. This coiling suggests, however, that the *distal* portion of the column forms the center of the coil, and not the proximal end, with the attached crown. If such be the case, we must consider Brachiocrinus as having the distal portion of the column flexible, more or less prehensile, and occasionally involute. For a short distance up the column is a double row of cirri, by means of which objects could be grasped. So considered Brachiocrinus is not closely comparable to Herpetocrinus, as has hitherto been thought."

Springer (1913, p. 212) lists Brachiocrinus as doubtfully synonymous with Herpetocrinus.

Genus DELTACRINUS Ulrich 1886

Deltacrinus clarus (Hall)

Plate 41, figure 5; text figure 54

1862 Cheirocrinus clarus Hall. 15th Ann. Rep't N. Y. State Cab. Nat. Hist., p. 116, pl. 1, fig. 17

1868 Cheirocrinus (Calceocrinus ?) clarus Shumard. Trans. Acad. Sci. St Louis, 2:358

1877 Calceocrinus clarus S. A. Miller. Amer. Pal. Foss., p. 72

1878 Cheirocrinus clarus Bigsby. Thesaurus Dev.-Carb., p. 16

1886 Calceocrinus clarus Wachsmuth & Springer. Rev. Palaeocr., pt. 3, p. 281 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 38:205

1886 Deltacrinus clarus Ulrich. 14th Rep't Geol. Surv. Minn., p. 109

1889 Deltacrinus clarus S. A. Miller. N. Amer. Geol. & Pal., p. 238

1893 Calceocrinus clarus Bather. Crin. Gotland, pt. 1, p. 66

1900 Calceocrinus clarus Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 3, p. 196

1904 Calceocrinus clarus Clarke & Luther. N. Y. State Mus. Bul. 63, p. 55

1913 Deltacrinus clarus Springer. Zittel Eastman's Textbook Pal., p. 214

Species of medium size. Cup a little flattened on the dorsal side; slight constriction just above the middle, above this it expands. The specimen gives the following measurements: width at base, 6.5 mm; width at median constriction, 6.2 mm; width at arm bases, 7.5 mm. Character of the posterior side of the cup shown here by a diagram (figure 54).

Dorsal cup. Basals fused to three forming a fairly large, subtriangular, convex disk. "Anterior" basal, the triangular plate which hinges on the left anterior inferradial and represents the fused left posterior and left anterior basals, well shown. This plate does not enter into the stem articulation. Rest of the basal disk formed by the posterior and right anterior basals (right posterior basal atrophies) largely concealed by the stem because of the way in which the specimen lies in the rock. The character and relations of these basals may be seen in the accompanying figure. As shown there, the posterior and right anterior basals are bounded for some distance by the large radials.

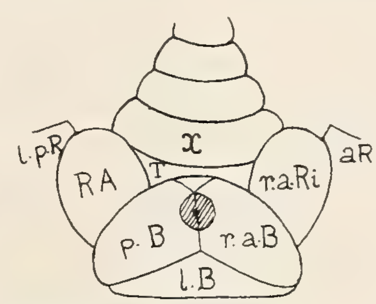


Figure 54 Diagram of posterior side of Deltacrinus. (After Bather, 1893). *l. B*, the "anterior basal" formed by the fusion of the left posterior and left anterior basals; *r. a. B*, right anterior basal; *p. B*, posterior basal; *a. R*, anterior radial; *l. p. R*, left posterior radial; *T*, T-piece formed by the fusion of the right posterior and right anterior superradials; *r. a. Ri*, right anterior inferradial; *RA*, radianal, the right posterior inferradial; *x*, first plate of the anal tube.

Two simple radials, the anterior and left posterior, well shown; large, roughly five-sided and somewhat thickened at the junction of the arm plates. Anterior radial has a length of 8.6 mm and a width of approximately 7 mm. Left anterior inferradial short and triangular; 5.5 mm wide, 2 mm high; its base a little concave in the center and straight on each side. Left anterior superradial short, pentagonal, supporting a single simple arm; width 4.6 mm, height 2 mm. The radials of the posterior side are shown in the accompanying diagram. Fused right posterior and right anterior superradials form a low wide plate, the T-plate which is separated from the large simple radials by the right anterior inferradial and the radianal (right posterior inferradial).

Tegmen. Anal tube not visible in the specimen. It is supported by the T-piece and the two inferradials to the right, but does not touch the two large, simple radials.

Arms borne by the anterior radial, left anterior superradial and left posterior radial. Arm borne by the left posterior radial nearly concealed. Left anterior superradial bears a single, simple arm made up of rounded or subcylindrical brachials about once and a half wider than high. Second arm plate above the anterior radial axillary, giving rise on the inner or abanal side to a single arm; on the outer or adanal side the immediately succeeding plate again bifurcates giving rise to two arms. This gives to this ray three arms which bifurcate several times; all composed of long, cylindrical brachials.

Column short and flexuous. Columnals shorter in the proximal part of the stem.

Ornamentation. Surface finely papillose.

Horizon and locality. From the Hamilton (Moscow shales) beds, Canandaigua lake, N. Y.

Types. Holotype in the collection of the American Museum of Natural History, number $\frac{4473}{1}$.

Remarks. The specimen figured, Hall's type, shows the column attached by a spreading root to the column of another crinoid. Hall (1862, p. 117) pointed out that this attachment must have taken place while the other crinoid was living, or otherwise the pendent arms of the Deltacrinus would have reached quite or almost to the muddy sediment on the bottom.

In a recent paper (1918, pp. 86–88), Jaekel describes the group to which Deltacrinus and Halysiocrinus belong as reef-dwellers with recumbent stem and obliquely erected head. They are specialized forms which have developed their peculiar characters because of their mode of life. The crown which has developed bilateral symmetry can be bent over toward the stem. In this " shut up " position the broad, undivided arm (borne by the left anterior superradial) lies above the other arms and serves as a protection to the crown, particularly against tidal currents.

Jaekel's explanation of the habit of these forms is, I think, more natural. Certainly the animal with crown erect is in a better position, as pointed out by Jaekel, for the food to be carried to the mouth along the ambulacral furrows than if the arms were pendent. According to Jaekel's views the specimens of this group, as figured on plate 41, are in an incorrect position.

Genus HALYSIOCRINUS Ulrich 1886 (em. Bather 1893)

Halysiocrinus secundus (Hall) n. comb.

Plate 41, figures 6–9; text figures 55–57

1872 Calceocrinus (Cheirocrinus) secundus Hall. N. Y. State Mus. Bul. 1, pl. 1, figs. 13, 14. (Photographic plates distributed privately.)

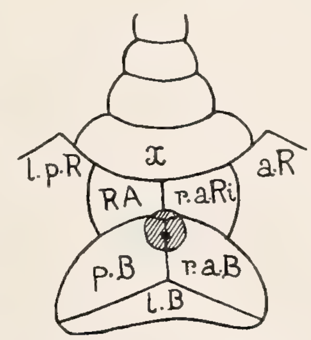


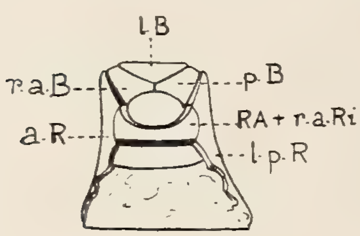
Figure 55 Diagram of the posterior side of Halysiocrinus. (After Bather, 1893). *l. B*, the "anterior basal" formed by the fusion of the left posterior and left anterior basals; *r. a. B*, right anterior basal; *p. B*, posterior basal; *a. R*, anterior radial; *l. p. R*, left posterior radial; *r. a. Ri*, right anterior inferradial; *RA*, radianal, the right posterior inferradial; *x*, first plate of the anal tube.

Dorsal cup. A comparatively small, slender species. Dorsal cup, seen from the left anterior radius, narrow at the base; becomes somewhat constricted medially, and widens out again rather abruptly at the arm bases. One specimen gives the following measurements: width at base, 5.4 mm; width at median constriction, 5 mm; width at arm bases, 6.3 mm.

Basals fused to three, forming a fairly large, subtriangular, convex plate, which measures 4.6 mm along its articulating edge. Left posterior and left anterior basals fused, forming what is styled an anterior basal. Anterior basal triangular; its length, measured along the hinge line, 3.5 mm. It will thus be seen that 1.1 mm of the length of the hinge line is made up by the posterior and right anterior basals. Stem attached along the suture line of the right anterior and posterior basals, and about .5 mm from the point of union of the three basal plates.

Large radials, the anterior and left posterior, with a maximum length of 6.5 mm. Their common suture is 2.9 mm in length. Left anterior inferradial subtriangular in shape and quite small; width 2.3 mm along the hinge area, height 1.2 mm. Left anterior superradial has a width of 3.6 mm and a height of 1.9 mm. Radial suture straight and occupies the entire width of the superradial.

Radianal and right anterior inferradial fused, forming a plate 4.5 mm in width, which rests in shallow excavations in the anterior and left posterior radials. Proximally upon it rests the posterior and right anterior basals, while distally it connects with the broad anal *x*.



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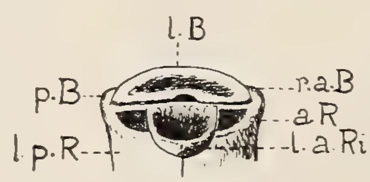

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Figure 56 Halysiocrinus secundus. Enlargement (x 4) showing basals and stem attachment. (See plate 41, figures 6, 7). For labelling, see figure 55.

Figure 57 Halysiocrinus secundus. Hinge area (x 3). (See plate 41, figures 8, 9). *l. a. Ri*, left anterior inferradial; other labelling as in figures 54, 55.

Hinge area well exposed in the larger specimen, and on plate 41, figure 9, will be found a semi-diagrammatic figure (x 3) of this structure. From this figure and figure 8 on the same plate, as well as text figures 56, 57, it will be seen that the following plates take part in forming the hinge line: left posterior basal and left anterior basal (fused), posterior basal, right anterior basal, anterior inferradial, left posterior radial, and anterior radial. Hinge line straight, except that in the middle there is a crescentic notch in that portion of the hinge formed by the basals. This is shown in figure 9, plate 41, where the opening appears somewhat to one side of the middle, owing to a slight disarrangement of the plates. Opening doubtless functioned as a passage for the nutrition and enervation of the muscles and ligaments of the hinge area.

Portion of the hinge area formed by the left posterior and anterior radials and the left anterior inferradial subtriangular, more or less completely divided into three pits. Central pit of the same width as the left anterior inferradial; separated from the lateral pits by two rounded ridges, perpendicular to the hinge line. These ridges seem to be processes of the left anterior inferradial, and to mark the sutures of this plate with the anterior and left posterior radials in the hinge area. Thus the small triangular, lateral pits lie in these two radials. Central horseshoe-shaped pit with several irregular ridges running perpendicular to the hinge line; about ten in number and probably constituted points of attachment for the muscles that controlled the elevation of the crown. On the other side of the hinge, these muscles were probably attached along the long, narrow, somewhat crescentic groove that traverses the basals.

What the mechanism of the depression of the crown was, is somewhat uncertain. Undoubtedly the major portion of the work was done by gravity. It is probable, however, that in addition, there were bundles of elastic tissue that functioned somewhat in the same manner as the elastic tissue in the arms of recent crinoids. If this be the case, the two small triangular, lateral pits might well serve for the reception of elastic ligament.

Foregoing description and measurements made from the specimen figured on plate 41, figure 8. Structure of arms, anal tube and stem taken mainly from the somewhat smaller specimen figured on the same plate, figure 6.

Tegmen. Anal *x* a large, broad plate, supporting a single series of large quadrangular plates which constitute the dorsal portion of the ventral tube. In the smaller specimen six of these plates preserved, giving a tube about 11 mm in length, exclusive of the anal *x*. It is probable that when complete this tube did not have more than two additional plates. Ventral surface of tube covered by a large number of thin plates, the general appearance of which suggests that they were not closely united laterally but were set in a flexible integument. As preserved, the plates overlap one another, and the exposed edges present an uneven, ragged outline. This unevenness does not seem to be due to the weathering, or fracture. It seems possible, therefore, that the ventral side of the tube was more or less flexible, and capable of distention to some degree.

Arms. Brachials of left anterior ray form a stout, nonbifurcating arm. In the smaller specimen, seven brachials preserved, forming an arm 18 mm in length. In the lateral arms, second brachial axillary. In the inner or abanal half of the arm, third succeeding plate axillary, after which no further division apparently takes place; in the outer or adanal division of the arm, second plate following the primaxil axillary. Outer or adanal half of the resultant bifurcation not preserved; inner half bifurcates again, apparently for the last time, on the fourth succeeding brachial. Arms of the larger specimen not less than 25 mm long.

Horizon and locality. Only two specimens known from the Onondaga limestone, near Lima, N. Y.

Types. Cotypes in the Jewett collection, Cornell University Museum, number 7327.

Column composed of round, thick ossicles; in the proximal portion measures 1.7 mm in diameter.

Remarks. This species was figured by Hall in 1872 in the so-called New York State Museum Bulletin 1, plate 1, figures 13 and 14 (photographic plates issued privately), as Calceocrinus (Cheirocrinus) secundus. The species does not belong in this genus, as brought out by the description and figures, but in the genus Halysiocrinus. The fused left posterior and left anterior basals do not enter into the stem articulation, the T-piece is obsolete, the radianal (right posterior inferradial) and right anterior inferradial are fused into one plate and support the anal *x* which also abuts by its lower corners on the two large simple radials.

See *Remarks* under Deltacrinus clarus.

Family CYATHOCRINIDAE Roemer (em. W. & Sp.)

Subfamily **CARABOCRININAE** Springer

Genus LASIOCRINUS Kirk 1914

Lasiocrinus scoparius (Hall)

Plate 42, figures 4–10; plate 43, figures 1–7

1859 Homocrinus scoparius Hall. Pal. N. Y., 3:102, pl. 1, figs. 1–9

1868 Homocrinus scoparius Shumard. Trans. Acad. Sci. St Louis, 2:378

1877 Homocrinus scoparius S. A. Miller. Amer. Pal. Foss., p. 82
1879 Homocrinus scoparius Wachsmuth & Springer. Rev. Palaeocr., pt. 1, p. 79 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 31:302
1889 Homocrinus scoparius S. A. Miller. N. Amer. Geol. & Pal., p. 255
1893 Homocrinus scoparius Bather. Crin. Gotland, pt. 1, p. 105
1897 Homocrinus scoparius Wachsmuth & Springer. N. Amer. Crin. Cam., 1:45 (authors' ed.); Mem. Mus. Comp. Zool., v. 20
1899 Homocrinus scoparius Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 2, p. 92
1900 Homocrinus scoparius Schuchert. Bul. Geol. Soc. Amer., 11:279
1905 Homocrinus scoparius Talbot. Amer. Jour. Sci., 20:20, pl. 3, fig. 3
1911 Homocrinus scoparius Kirk. Proc. U. S. Nat. Mus., v. 41, no. 1846, p. 58
1914 Lasiocrinus scoparius Kirk. Proc. U. S. Nat. Mus., v. 46, no. 2038, pp. 474–482, pl. 42, figs. 10, 11, 12

Kirk (1914, pp. 481, 482) created a new genus for this species and, at that time, referred only one other species to it, Homocrinus tenuis Bather from the Silurian of Gotland. Bather's species is shown here (plate 43, figure 8), so that the Devonian representative of the genus may be compared with the Silurian.

Dorsal cup elongate conical, subpentagonal above, with a broad base from which the sides slope gradually up to the top of the radials; as broad or broader at the top of the radials than it is high.

Infrabasals five, equal, slightly longer than wide, pentagonal. Narrower at the base and the lower lateral faces the longer, bringing the greatest width at the top.

Basals longer than wide, hexagonal with the exception of two, the posterior and right posterolateral which come in contact with the anal plates and are heptagonal. They are larger than the other basals and of about equal height and width.

Radials relatively small, as wide or wider than high, pentagonal, except the right posterior which comes in contact with the anal and the right tube plates and is irregularly hexagonal. Radial facet occupies practically the entire width of the upper face.

Radianal quadrangular, small. Rests below upon the left shoulder of the right posterolateral basal and the right shoulder of the posterior basal; above is bordered by the anal *x* and the right posterior radial. Anal *x* of about the size of the adjoining radials and in line with them. Bordered on each side by the right and left posterior radials, rests below upon the truncated posterior basal and the radianal, and supports above two plates of the anal tube.

Tegmen. Anal tube long, more than half, sometimes three-fourths as long as the arms. Near the base composed of larger plates, and above of a number of parallel, vertical rows of small hexagonal plates. Plates at the summit spiniferous, some of them bearing quite strong spines. Talbot (1905, p. 20) only recognizes five spines belonging to five large plates at the upper end of the sac. Some of the specimens figured here (plate 42, figure 4; plate 43, figure 2) certainly show the spiniferous summit as described by Hall, though some of the spines appear to be stronger than the others.

Arms long. Apparently great variability in the number of primibrachs to the ray, even in the same individual; lowest number three, highest six; four or five seems to be the usual number. Primibrachs short and quadrangular; primaxil pentagonal. First bifurcations on the primaxils equal; above this arms divide seven or eight times by bilateral heterotomy at regular intervals. Bifurcations closer together in the more proximal portion of the arms.

Arms of earlier species apparently isotomous, as shown in Lasiocrinus tenuis (plate 43, figure 8).

Column long, slender, consisting of irregularly alternating larger and smaller columnals. Most proximal columnals shorter. Column rounded below, becoming obtusely pentagonal and enlarged above. Thicker joints nodose; canal small and round. One of the specimens figured here shows delicate cirri on the distal portion of the column; not found above the middle of the stem. Talbot (1905, plate 3, figure 3) figures the distal end of a column, with cirri, showing a coil or loop. This is characteristic wherever the distal end of the column is present.

Horizon and locality. Common in the thinly laminated or shaly layers in the Coeymans limestone at Schoharie, Jerusalem hill and Wheelock's hill, Litchfield and North Litchfield, N. Y. Hall reports the species from the Manlius (Tentaculite limestone) at the Helderberg and Schoharie. Talbot (1905, p. 20) states that no such specimens have come under her observation, but we have two specimens in the New York State Museum so labelled.

Types. Cotypes in the American Museum of Natural History, number $\frac{2294}{1}$.

Lasiocrinus (?) **schohariensis** sp. nov.

Plate 43, figure 9

Species described from a gutta-percha squeeze taken from a mold of the specimen. This is the only specimen in our possession, and only the anterior side of the calyx is shown.

Dorsal cup with a height of 6 mm and a width of 5 mm; expanding regularly from the base to the top of the radials, resembling an inverted cone. Width at the base 2.1 mm, at top of radials 5.2 mm.

Infrabasals pentagonal, slightly wider at the top than at the bottom. Only infrabasal shown in its entirety has a height of 2.3 mm and a width of 2 mm.

Basals hexagonal, very little larger than the infrabasals. Only two visible; one has a height of 2.8 mm and a breadth of 1.9 mm; the other slightly broader.

Radials roughly pentagonal, shorter than the basals, with an average height and width of about 2 mm. Radial facet occupies very nearly the entire width of the radial. Anal plates not exposed.

Tegmen not known.

Arms. Five or six primibrachs, all a little broader than high; first four or five quadrangular, the fifth or sixth, pentangular, axillary, giving rise to two equal branches. Only a few brachials shown above this point, so nothing further can be stated as to the later bifurcations of the arms.

Column round, composed of columnals of alternating thicknesses. At varying intervals there are conspicuously large, projecting columnals, nodals, with rounded edges. Stem, from the base of the cup, gradually enlarges in diameter for a distance of about 30 mm; then it gradually tapers until at a distance of 87 mm from the cup, diameter less than half the diameter at the base of the cup.

Horizon and locality. From the Schoharie grit, Pine hill, near Highland Hills, N. Y.

Types. Holotype in the collection of the New York State Museum.

Remarks. An exact generic determination of this species can not be made without the anal area which is not visible, but the species is referred with a query to Lasiocrinus. The column of this species is very characteristic.

Genus ITEACRINUS nov.

[Ety. ἰτέα, *willow;* κρινον, *lily*]

The genus Iteacrinus is based upon two species. Calyx broad and low, broader than high. Arms heterotomous: ten main rami bearing long, slender, nonbranching ramules at regular intervals alternately on each side (bilateral heterotomy). Rami diverge; not in contact above the primaxil. Anal area only shown in one species. Here, radianal relatively large; anal *x* rises above the level of the radials. Anal tube slender and made up of delicate plates; length unknown. Column pentangular. Genus differs from Vasocrinus in the more delicate form, shape of the calyx, and in the long, slender, unbranched ramules. Anal *x* rises above the line of the radials and the radianal is relatively large in Iteacrinus, whereas in Vasocrinus it is small. Anal tube in Iteacrinus more slender and composed of delicate plates. Iteacrinus quite distinct from the other genera.

Name Iteacrinus given to this genus because of the resemblance of the slender rami with their long, slender ramules to willow branches. It is here placed in the family Cyathocrinidae. In the two species representing the genus the radial facet is wider and less curved than is usual in the family, but other genera in the same family, such as Lasiocrinus, show the same characteristic.

Genotype. Iteacrinus flagellum sp. nov.

Distribution. Upper Devonian (lower Chemung) of New York.

Iteacrinus flagellum sp. nov.

Plate 42, figure 2

The specimen representing this species is preserved as a mold in the Chemung sandstone. A gutta-percha squeeze has been made and the description is based upon this. Specimen shown from the posterior side. Crown fairly well preserved and about 30 mm of the stem. Crown, with the arms extended, had a length of about 65 mm.

Dorsal cup wider than high, giving the measurements: height 4.2 mm, width 5.9 mm. Infrabasals pentagonal, small, with a height of 1 mm or less. Basals longer than wide, hexagonal, with the exception of the posterior and right posterolateral which come in contact with the anal plates and are heptagonal. Posterior basal is the only one fully shown; height 2.3 mm, breadth 2.1 mm.

Radials heptagonal, except the right posterior which is hexagonal, being truncated to rest upon the right posterolateral basal. Radials slightly broader than high, an average one having a width of 2.2 mm and a height of 1.8 mm. Radial facet slightly curved; does not occupy the entire width of the radial, though there is not a great deal of difference in their respective widths.

Anal *x* hexagonal, very little smaller than the left posterior radial. Radial a little smaller and pentangular. Upon the upper face of the radianal rests the right tube plate. Anal *x* bears upon its three upper faces the left, middle and right tube plates. These first tube plates hexagonal and almost as large as the anal *x*.

Tegmen. Ventral tube not complete, so nothing can be said as to its length and the character of its distal extremity; slender and appears to taper little in the portion preserved. Width at the base 3.2 mm. First few plates of the ventral tube large; plates higher up small, hexagonal and arranged in vertical rows. Two rows of plates with a definite furrow between them extend along the median dorsal line of the tube. On their outer borders they are provided with delicate folds and furrows, three or four to a plate, which connect with similar folds and furrows from the adjoining vertical rows of plates. Each vertical row of plates marked with a faint ridge. Areas of folds and furrows at the outer edge of the rows of plates appear to be depressed. There seems to be a strengthening of the tube at the sides and in the median dorsal line.

Arms ten, long and slender, having a length, when extended, of at least 60 mm. Three primibrachs; the first two of about equal length, the third, the primaxil, usually longer and wider at the top. Above the primaxil, arms divide by bilateral heterotomy on every third brachial, giving rise to two conspicuously unequal branches, the smaller one-half, or less, the thickness of the main branch. This gives a main arm with long, slender armlets or ramules at regular intervals. All brachials quadrangular; those of the armlets comparatively longer.

Column preserved to a distance of 30 mm, but so weathered that the stem characters are visible only in the first 8 mm. Stem here made up of alternating thin and thick columnals. Average thin columnals measure about .2 mm in length; alternating columnals have an average length of .7 mm.

Ornamentation. Basals, radials, anal *x*, radianal and first tube plate possess radiating folds or ridges which cross the suture lines and are rather pronounced at the margins of the plates, but do not extend far toward the centers of the plates. Between the ridges, at the angles where three plates come together, are rather deep depressions or pits, and there is a pronounced depression or furrow between adjoining basals. The low ridges extending up the vertical rows of tube plates and the fine ridges and furrows along the outer edges of these plates also constitute part of the ornamentation. Entire ornamentation of this species not conspicuous.

Horizon and locality. From the lower Chemung beds, Cotton hill, one mile north of Avoca, Steuben county, N. Y.

Types. Holotype in the collection of the New York State Museum.

Remarks. The structure of the stem and the manner of branching of the arms is quite characteristic. Named flagellum because of the whiplike appearance of the slender arms with the long, slender armlets.

Iteacrinus robustus sp. nov.

Plate 42, figure 3

This species is also represented by the mold of a single specimen which shows what appears to be the anterior side. Very similar to Iteacrinus flagellum, but differs from it in enough points to give it specific value.

A larger, stronger-appearing form, and the ridges and depressions of the dorsal cup are more pronounced. Anal side unknown. A small portion of the anal tube visible; so far as can be ascertained, similar to that of I. flagellum. Three primibrachs appear to be the usual number, though one ray (the right anterolateral ?) shows four. The anterior (?) ray in one branch shows a bifurcation on the fourth brachial above the primaxil which gives rise to two equal branches. With this variation, the branching is of the same type as in I. flagellum, except that the armlets are given off usually from every fourth instead of every third brachial.

Horizon and locality. From the lower Chemung beds, Cotton hill, one mile north of Avoca, Steuben county, N. Y.

Types. Holotype in the New York State Museum.

Genus CRADEOCRINUS nov.

[Ety. κράδη, *twig;* κρινον, *lily*]

The two species belonging to this genus are slender and of small to medium size. Calyx slender and elongate. Arms heterotomous: ten main rami bearing very slender, nonbranching ramules at regular intervals alternately on each side (bilateral heterotomy). Rami diverge but little and in one species are almost in contact for some distance above the primaxil. Very little of the anal area preserved in either species. Radianal pentagonal, of medium size compared to the other plates. From the position of the radianal it seems likely that the anal *x* is not in line with the radials, but this can not be ascertained definitely from the material at hand. First tube plates in one species large and hexagonal. Their arrangement suggests an anal tube composed of similar plates; but none of the upper portion of the anal tube is preserved. Column subpentangular to rounded.

The two species placed in this genus have been so grouped provisionally, while some details are lacking, because a general similarity of characters seems to warrant it. One species is represented by a single specimen which shows only a very little of the anal tube; and no specimen of the other species shows more than the radianal. Cradeocrinus is here referred to the family Cyathocrinidae. Radial facets wider and less curved than is usual in this family, but other genera of the family, such as Lasiocrinus, show this same characteristic. Genus quite distinct from the other genera of the family. There is a similarity to the Lower Carboniferous genus Goniacrinus, but the radianal is large and the anal region quite distinct. In Goniacrinus anal *x* is like one of the radials, in line with the radials and followed by a prominent series of plates which pass into the anal tube.

Genotype. Cradeocrinus elongatus sp. nov.

Distribution. Upper Devonian (Portage and lower Chemung) of New York.

Cradeocrinus elongatus sp. nov.

Plate 41, figures 11–13

Specimens of this species occur in the form of molds in the Chemung sandstone. Description based upon gutta-percha squeezes taken from the molds.

Dorsal cup long and slender. In one specimen height of 4 mm, width at the top of the radials 3 mm; in another specimen, height and width about 4 mm.

Infrabasals small, pentagonal, slightly broader at the top than at the bottom. An average one has a height and greatest width of about .6 mm.

Basals the largest plates of the cup; hexagonal and elongate, slightly wider at the top than at the bottom. An average basal has a height of 2.5 mm, a width at the base of .6 mm and at the top of 1 mm.

Radials comparatively small, pentagonal, an average radial having a height and width of about 1.1 mm. Radial facet only slightly curved and about three-fourths the width of the radial.

Anal plates are not exposed. One specimen shows part of the radianal which apparently is pentagonal.

Tegmen not exposed.

Arms. Three primibrachs, all longer than wide. One specimen in the right anterolateral ray shows four. First two (or three) quadrangular, primaxil pentagonal and broadens out at the top. Above the primaxil the arms bifurcate by bilateral heterotomy, giving a slender armlet at the fourth brachial above the primaxil and usually at every third brachial above this point. All brachials quadrangular. In a typical specimen the arms have a length of 42 mm. They are only slightly divergent, being almost in contact for some distance above the primaxil.

Column subpentangular in the proximal part, becoming fairly rounded in the more distal portion. Columnals with rounded edges. While all are thin, columnals of two thicknesses are shown alternately arranged.

Ornamentation. The species can hardly be said to be ornamented. There are conspicuous depressions or furrows between the basals, between radials and basals and between the radials. One radial shows incipient ridges along its edges.

Horizon and locality. From the lower Chemung beds, Cotton hill, one mile north of Avoca, Steuben county, N. Y.

Types. Cotypes in the collection of the New York State Museum.

Cradeocrinus pergracilis sp. nov.

Plate 42, figure 1

A very graceful little species, represented by a single mold in fine sandstone, from which a gutta-percha squeeze has been made. Drawing (plate 42, figure 1) and the description based upon this squeeze. Crown measures about 16 mm; about 27 mm of column preserved.

Dorsal cup obconic, having a height of 2.3 mm, a width at the base of .9 mm and a width at the top of the radials of 2.3 mm (the same as the height).

Infrabasals pentagonal, comparatively long, the lateral faces being the longest, and slightly wider at the top. Average infrabasal (right posterior) has a height of .8 mm and a width at the top of .7 mm.

Only the posterior and right posterolateral basals visible; heptagonal, the posterior supporting the anal *x* and radianal, and the right posterolateral having an additional face for the support of the radianal. Other basals probably hexagonal, as usual. Right posterolateral basal gives the measurements: height, 1+ mm; width, 1 mm.

Radials pentagonal, slightly smaller than the basals, the posterior radials being smaller than the others. Right anterolateral radial has a height and a breadth of about .8 mm. Radial facet practically straight and occupying almost the entire width of the radial.

Radianal small, pentagonal. Anal *x* larger than the radianal, but small, resting upon the truncated upper face of the posterior basal.

Tegmen. Only a few of the proximal plates of the anal tube shown; of about the size of the radianal, and apparently hexagonal.

Arms. Three primibrachs, noticeably longer than wide, the first one the longest. The third, the primaxil, broadens out just below the point of bifurcation and gives rise to two equal branches. Arms divide by bilateral heterotomy at least three times above the primaxil, first on every fourth, then apparently on every third brachial, giving rise in each case to conspicuously unequal branches. Brachials quadrangular, longer than wide, and joining by straight sutures. Arms but little divergent.

Column. About 27 mm preserved; round and made up of alternating thin and thick columnals with slightly rounded edges. No indication of cirri in the portion of the stem preserved.

Horizon and locality. From the Portage (Ithaca) beds, in the ravine east of South Otselic, from the base of the exposed section.

Types. Holotype in the collection of the New York State Museum.

Remarks. This species may readily be distinguished from elongatus, the other species of the genus, by the difference in size, the relatively shorter dorsal cup and basals, and the slender, rounded stem with its alternating thin and thick columnals.

Subfamily **GASTEROCOMINAE** Springer

Genus SCHULTZICRINUS Springer 1911

Schultzicrinus typus Springer

Plate 44, figures 1–7

1872 Cyathocrinus (?) sp. undet. Hall. N. Y. State Mus. Bul. 1, pl. 1, fig. 6. (Photographic plates distributed privately.)

1911 Schultzicrinus typus Springer. Mem. Mus. Comp. Zool., v. 25, no. 3, pp. 132, 133, pl. 3, figs. 1–6

Original description. Calyx rather small, depressed hemispheric, wider than high; widest at upper angle of basals, contracting above that. Base truncate; infrabasal disk large and distinct; axial canal usually quadripartite, with large central opening and four small ones surrounding it. Anus rather large, encroaching on posterior basal; posterior radials meeting above it without intervening plate, so far as known. Radial facets shallow, filling almost the entire distal face of the plate, and directed obliquely upward. Arms long and heavy, broadly rounded or almost flat, closely abutting; brachials broad and long, except the first, which is usually very short; ventral furrow broad and shallow, with large covering plates, about five pairs to a plate of average size. Surface smooth. Column large, with very conspicuous nodals about twice the diameter of the internodals, and three or four times as long; there is considerable variation in the length of these plates, as well as in the number in the internodes.

Types. Cotypes in the collection of Doctor Springer, now deposited in the United States National Museum at Washington.

Horizon and locality. From the Onondaga limestone. Types from the vicinity of Le Roy, Genesee county; other localities Lima, Livingston county; Limerock and vicinity, Genesee county, N. Y.

Remarks. This genus and species was founded by Springer (1911, p. 132) upon a series of excellent specimens. Some of his figures are reproduced here (plate 44, figures 2–6).

To this species is referred a specimen (plate 44, figure 7) in the collection of Cornell University, figured by Hall in his so-called Bulletin 1 as Cyathocrinus ? sp. undetermined. This specimen is from the Onondaga of Lima, N. Y., and is in a badly crushed condition.

There are in the New York State Museum several specimens of this species most of them in a very fragmentary condition. Three specimens and many fragments occur on the slab with two of the types of Arachnocrinus bulbosus (plate 45, figure 1) but they are too much weathered to figure. A very beautifully preserved specimen from Limerock, Livingston county, is figured here (plate 44, figure 1). It shows the calyx, arms, and about 12.5 cm of stem.

Schultzicrinus (?) **elongatus** Springer

Plate 44, figures 8–10

1911 Schultzicrinus (?) elongatus Springer. Mem. Mus. Comp. Zool., v. 25, no. 3, p. 133, pl. 3, figs. 7*a*, *b*, *c*, *d*

Species described by Springer from one specimen. No specimen of this species in the collection of the New York State Museum. Springer's description and figures are given here.

Original description. I have figured under this name a specimen found associated with the foregoing, knowing that it may not belong to this genus. I wanted to give it a name for reference, in hope that future discoveries may throw more light upon it. It has similar broad, upright, closely abutting arms, but they become narrow, deep, and rounded distally. Differing from the type species, and all others of this group, the arms distally become strongly ornamented with fine, sharp pustules. The cup is of a very different style from that of the others, spreading upward instead of contracting. Unfortunately we have but the one specimen, and a fragment of cup that may be the same; and with so much lacking in this its real generic characters remain obscure. I doubt if it has the anal opening through the cup. It will be observed that the specimen has a tripartite axial canal in the column; and as this had not been observed in any of the other American forms of this group, except Miss Wood's "Tripleurocrinus," I first thought they might go together; but the type is so different that this seems impossible, and, as already shown, too much importance must not be given to the form of the canal.

Horizon and locality. From the Onondaga limestone, Le Roy, N. Y.

Types. Holotype in the collection of Doctor Springer, now deposited in the United States National Museum.

Genus ARACHNOCRINUS Meek & Worthen 1866

Arachnocrinus bulbosus (Hall)

Plate 45; plate 46, figure 1

1862 Cyathocrinus bulbosus Hall. 15th Ann. Rep't N. Y. State Cab. Nat. Hist., p. 123, pl. 1, figs. 19–22

1866 Arachnocrinus bulbosus Meek & Worthen. Geol. Surv. Ill., 2:177

1868 Cyathocrinus bulbosus Shumard. Trans. Acad. Sci. St Louis, 2:362

1877 Cyathocrinus bulbosus S. A. Miller. Amer. Pal. Foss., p. 74

1878 Cyathocrinus bulbosus Bigsby. Thesaurus Dev.-Carb., p. 16

1879 Arachnocrinus bulbosus Wachsmuth & Springer. Rev. Palaeocr., pt. 1, p. 93 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 31:316

1889 Arachnocrinus bulbosus S. A. Miller. N. Amer. Geol. & Pal., p. 224

1900 Arachnocrinus bulbosus Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 3, p. 196

1903 Arachnocrinus bulbosus Clarke & Ruedemann. N. Y. State Mus. Bul. 65, p. 64

1904 Cyathocrinus bulbosus Clarke & Luther. N. Y. State Mus. Bul. 63, p. 43

1911 Arachnocrinus bulbosus Springer. Mem. Mus. Comp. Zool., v. 25, no. 3, pp. 128, 129, pl. 2, figs. 3–12

Arachnocrinus bulbosus (Hall) has been recently described by Springer (1911, pp. 128, 129) with a number of very good specimens at hand. His description will be used here instead of the original description by Hall.

Springer's description. Type of the genus. A rather small species, with small, globose calyx and ponderous arms; distinguished at once by the great size of its axillary brachials, which are several times as large as the others, extending throughout the rays, giving them a very unusual appearance; average ordinary brachials measure 1 mm high by 3 mm wide, while the axillaries next to them are 3 mm by 4.5 mm. Articulating facet on radials facing obliquely outward. Arms long, cylindrical, with frequent bifurcations, and very little taper to the fourth bifurcation, the farthest preserved. Primibrachs very irregular in number, from 3 to 12; shown by five specimens as follows:

l. ant.	l. post.	r. post.	r. ant.	ant.
—	9	7+	6	—
—	3	3	3	—
5	7+	5	10	12
8	3	4	—	—
—	15	5	3	12+

The anterior ray probably bifurcates higher than the others, as a rule. Dorsal canal extending throughout the arms. Ventral furrow broad, roofed by two interlocking rows of covering plates, about three pairs to the ordinary brachial and nine or ten pairs to an axillary (*see* plate 45, figures 3, 4). Infrabasal disk small, with obtusely quandrangular column facet, central axial canal, and usually four smaller ones surrounding it. Anus relatively small, and so far as observed not followed by any plate between the radials; figure 6*a* looks as if there might have been one, but this is not certain, as the plates are displaced. Column with highly projecting nodals and long internodes. Surface smooth.

Horizon and locality. From the Onondaga limestone near Le Roy, Genesee county, N. Y., associated with Myrtillocrinus and Schultzicrinus. One specimen in the New York State Museum from the Onondaga limestone of Ontario, Canada; other specimens from Limerock and Stafford, Genesee county, and from Livingston county.

Types in the American Museum of Natural History, number

$\frac{2977}{1}$, in the University of Chicago Museum, number 13134, and in the New York State Museum, number $\frac{4040}{1}$, the last two being here figured. Other specimens figured are in the New York State Museum and in the collection of Doctor Springer.

Remarks. An anal plate appears to be present in one of the specimens figured here (plate 45, figures 6, 7). In another specimen (plate 45, figure 11) portions of only two arms are shown and these show no bifurcations though nine and fifteen brachials are shown. This is similar to the irregularity in bifurcation of rays shown in one of Springer's specimens (1911, plate 2, figure 10).

The nodals of the column are ornamented with sharp nodes or spines. This is shown on plate 45, in figures 12, 13. I have figured here a much weathered specimen with about 55 mm of column preserved. The nodal columnals are rather quadrangular due to the presence of four short, but rather strong, spines which correspond in position to the four axial canals (figure 13). Sometimes there are smaller tubercles between the stronger ones.

Arachnocrinus extensus W. & Sp.

Plate 46, figure 6; plate 47, figures 1, 2

1879 Arachnocrinus extensus Wachsmuth & Springer. Rev. Palaeocr., pt. 1, p. 93 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 31:316

1889 Arachnocrinus extensus S. A. Miller. N. Amer. Geol. & Pal., p. 224

1911 Arachnocrinus extensus Springer. Mem. Mus. Comp. Zool., v. 25, no. 3, pp. 129, 130, pl. 1, figs. 1, 2, 3, 4; pl. 2, figs. 1, 2.

Springer's description. A large species, perfectly distinguished from A. bulbosus by the absence of any special enlargement of the axillary brachials; all brachials are very short and wide in the lower part of the ray, about 1.5 to 5, deeply rounded, but their surface not convex, the axillaries only larger by the slope necessary to start the divisions. Arms thick, round, long, branching three to five times. The rays divide usually on about the third primibrach (occasionally one or two less or more), except the anterior, which uniformly divides much higher up, having 9+, 13, 15, 15, and 19 primibrachs respectively in five specimens; the halves then bifurcate repeatedly at intervals of from five to twenty brachials on a fairly regular plan, with minor variations; the outer branches in each dichotom continue in a definite direction, while the others branch from them towards the inner side to the number of four or five bifurcations, the inner ones mostly branch once or twice, so far as preserved, and probably more. This gives from twenty to twenty-five ultimate divisions to the ray, or 100 to 125 in all, with the arms still strong and but little tapering. It is probable that five bifurcations was the usual limit, as I have a specimen, not figured, with one ray five inches long extending far beyond the fifth and no sign of further branching. There is far more regularity in the arm distribution than in the type species. Radial facets large, occupying the greater part of the distal face of the plates. The calyx plates are rather thin, and are broken and displaced in all the specimens, so their exact form and position cannot be stated, and in all the base is injured beyond recognition. Loose columnals are found, however, in the same beds, showing that the axial canal is quadripartite. Anus small, with no plate between the radials above it.

Horizon and locality. From the Upper Helderberg (Onondaga), Falls of the Ohio, Louisville, Ky., and the equivalent rocks near Le Roy, Genesee county, N. Y. In the New York State Museum are specimens, apparently referable to this species from the Onondaga, Limerock, Genesee county and Schoharie county.

Types in the collection of Doctor Springer, now deposited in the United States National Museum.

Remarks. Springer figures under this species two New York specimens from the vicinity of Le Roy, Livingston county, one of which (1911, plate 2, figure 2) I believe to be A. ignotus. I have figured here a specimen from Limerock, Genesee county, which is apparently referable to this species. Another specimen from Schoharie county is a fragment of a much larger form, but in too poor a condition to figure. A portion of an arm (plate 47, figure 2), from Le Roy is provisionally placed here. It is part of a very large specimen, and shows the absence of an enlarged axillary and the long, thick, rounded character of the arm of A. extensus. The brachials in this portion of arm seem slightly longer and rounder than in the typical specimens.

Arachnocrinus ignotus Stauffer

Plate 46, figures 2–5

1918 Arachnocrinus ignotus Stauffer. Jour. Geol., 25:555, pl. 1, fig. 1

Original description. This is a medium to small-sized species of Arachnocrinus. The calyx is too poorly preserved for description, or is too deeply imbeddded in the matrix to be seen, but doubtless it is small.

Arms more or less uniform in size, uniserial, long and showing frequent bifurcations. These bifurcations are not uniformly spaced on the different arms, and one arm does not branch within the limits of the preserved specimen. It probably bifurcates farther out from the calyx. The cross-section of the arms is circular and the shape of the arm plates resembles a truncated cone with the base upward. It is not quite clear whether the number of arms is five or six because the branching in one or two cases begins so near the calyx. Dorsal canal extending throughout the arms.

Horizon and locality. From the Onondaga limestone, Le Roy and Stafford, N. Y., and in Ontario, north shore of Lake Erie, three and one-half miles east of Port Dover.

Types. Holotype collected in Ontario by Dr C. R. Stauffer.

Remarks. This species is represented in the New York State Museum by several specimens which were already described and figured in manuscript previous to the appearance of Doctor Stauffer's description. Our material is in a better state of preservation than the type material, and from a study of this additions may be made to the original description.

In three of the specimens illustrated the dorsal cup is broken, but the fourth specimen shows the cup entire. Small, the arms being very long in proportion to the size of the cup.

Branching of arms similar to that of A. extensus. As noted in the original description, bifurcations in the different arms not uniformly spaced. First bifurcation may be near the calyx or several brachials away, and is followed by several bifurcations. In no case has an arm without bifurcations been observed; in one of the specimens one ray shows five bifurcations. Axillaries, as in A. extensus, not enlarged. Upper or distal margin of each brachial thickened, giving the appearance of a ring around the brachial at the upper edge. Thickened area prolonged into more or less prominent short nodes or spines, one on each side, which gives a spiny or thorny appearance to the arms. In some specimens a very small spine has been observed at the margin of the brachial in the median dorsal line; but in no specimen has this been found to be constant throughout. This, however, may be accounted for by the character of the preservation; in more weathered specimens spinose character of the arms accentuated. A low broad carina is seen extending up the dorsal side of the more distal parts of the arms in some cases. This characteristic is shown in the figure of the holotype, but no mention of it is made in the description.

Springer has figured (1911, plate 2, figure 2) a specimen of Arachnocrinus under the species extensus which I believe may belong to this species. Especially in the distal portions of the arms this specimen shows a tendency to thickening of the brachials at the upper margin with slight lateral extensions. Another specimen, in the New York State Museum, shows the thickening of the brachials, but the nodes are only slightly developed. This amount of variation might well be expected within the limits of the species.

Genus MYRTILLOCRINUS Sandberger 1855

Myrtillocrinus americanus Hall

Plate 44, figures 11–13

1862 Myrtillocrinus ? americanus Hall. 15th Ann. Rep't N. Y. State Cab. Nat. Hist., p. 142, pl. 1, figs. 2–4

1868 Myrtillocrinus americanus Shumard. Trans. Acad. Sci. St Louis. 2:381

1877 Myrtillocrinus americanus S. A. Miller. Amer. Pal. Foss., p. 84

1878 Myrtillocrinus americanus Bigsby. Thesaurus Dev.-Carb., p. 18

1886 Myrtillocrinus americanus Wachsmuth & Springer. Rev. Palaeocr., pt. 3, p. 186 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 38:110

1889 Myrtillocrinus americanus S. A. Miller. N. Amer. Geol. & Pal., p. 262

1897 Myrtillocrinus americanus Wachsmuth & Springer. N. Amer. Crin. Cam., 1:89, pl. 3, fig. 13 (authors' ed.); Mem. Mus. Comp. Zool., v. 20

1900 Myrtillocrinus ? americanus Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 3, p. 198

1904 Myrtillocrinus americanus Clarke & Luther. N. Y. State Mus. Bul. 63, p. 43

1911 Myrtillocrinus americanus Springer. Mem. Mus. Comp. Zool., v. 25, no. 3, p. 125, pl. 3, figs. 8 *a*, *b*, 9

Dorsal cup small, broadly ovoid, widest at the upper end.

Infrabasal disk pentagonal and apparently undivided. It forms a low ring around the top of the column.

Basals large, hexagonal, slightly wider than high, widening upwards. Appear pentagonal because the lower margins are so nearly in a line.

Radials large, hexagonal, higher than wide, with the lateral margins subparallel. Radial facet large, occupying the greater portion of the plate and raised above the margins of the plate. Subelliptical in shape, with the longer axis vertical, and has a small central foramen, the opening for the dorsal canal. Upper margin excavated by the passage leading from the food groove of the arms into the body cavity.

Tegmen. Five large orals, somewhat unequal, constituting almost the entire tegmen; elevated into strong nodes covered with unequal pustules. A few of the ambulacrals in the small interoral grooves are preserved. Anal opening not known; not through the dorsal cup, probably small and obliterated in fossilization.

Arms not known, but judging from the facet they must have been round and heavy.

Column proportionally large and round, composed of rounded columnals of about the same length, except in the most proximal portion where they are shorter. Axial canal has four peripheral canals.

Horizon and locality. From the Onondaga limestone, near Caledonia, Livingston county, and Le Roy, Genesee county, N. Y.

Types. Holotype in the American Museum of Natural History, number $\frac{2976}{1}$.

Remarks. Springer (1911, p. 126) refers Miss Wood's Tripleurocrinus levis (plate 44, figure 14), with a query to the genus Myrtillocrinus and further states that he sees nothing in the specimen figured to distinguish it from Myrtillocrinus americanus. If that be the case this specimen furnishes the arm characters hitherto unknown for the species. The arms are heavy, apparently simple, and composed of brachials somewhat shorter than wide.

Myrtillocrinus (?) **levis** (Wood)

Plate 44, figures 14, 15

1904 Tripleurocrinus levis Wood. Smith. Misc. Coll., v. 47, no. 1471, p. 57, pl. 16, figs. 2, 2 *a*

1911 Myrtillocrinus levis (syn. ? of M. americanus) Springer. Mem. Mus. Comp. Zool., v. 25, no. 3, p. 126, pl. 3, figs. 10 *a*, *b*

Original description. Body small, sides diverging at an angle of about 45 degrees. Surface smooth. Infrabasals not observed, but their presence may be inferred from the truncated lower edge of the basals. Basals pentagonal. Only two of these plates are preserved on the single specimen found. Radials one-third larger than the basals, four-sided below, the upper portion of the plate curving inward and backward on either side to form a deep food groove. The structure of the anal area can not be determined. Arm facets occupying two-thirds the width of the radials, and directed obliquely upward. Width of the arm plates about twice their thickness.

Plates of the column vary in size, every second or third plate being larger. The central canal is triangular in section, with three small circular canals opposite its sides and connected with it by short transverse canals.

Horizon and locality. From the Onondaga limestone, Le Roy, N. Y.

Types. Holotype in the United States National Museum, number 35,146.

Remarks. The genus Tripleurocrinus Wood will not stand, according to Springer (1911, p. 126), because the genus is based upon the fact that the axial canal in the stem has three peripheral canals instead of four as in the type Myrtillocrinus americanus. This is not a dependable character since there is wide variation in the form of the axial canal, not only within the same genus, but also within the same species, among crinoids belonging to this horizon of the Devonian, having an unusual type of axial canal. Springer further states: "I see nothing in this specimen which I have figured....................to distinguish it from Myrtillocrinus americanus of which, however, it furnishes the arm characters hitherto unknown." He figures the specimen as Myrtillocrinus ? levis (Wood).

Genus MICTOCRINUS nov.

[Ety. μικτός, *mixed;* κρινον, *lily*]

There has recently been added to the New York State Museum a single specimen of a form belonging to this group. Arms suggestive of Arachnocrinus, having more of the character of the arms of A. extensus, though branching less frequently. Cup large, probably in shape and character near Myrtillocrinus or Gasterocoma. The crushed condition of the cup obscures the form; probably ovoid, broader at the top, possibly slightly flaring, though I think this is due to its crushed condition.

Tegmen not known. Posterior basal appears to be truncated and followed above the truncation by a small oblong plate, interpreted to be the anal plate. Above this plate character of calyx not distinguishable. Three infrabasals. Column must have been round and of unusually large diameter; axial canal with four peripheral canals.

I have hesitated to make a new genus for such an imperfect specimen but it seemed wiser and less confusing than to force it into a genus with which all its characters obviously do not agree.

Genotype. Mictocrinus robustus sp. nov.

Distribution. Middle Devonian (Onondaga) of New York.

Mictocrinus robustus sp. nov.

Plate 60, figures, 4, 5; text figure 58

The species is represented by a single specimen, and that not complete; but it is quite distinctive.

Dorsal cup in a crushed condition; probably ovoid in shape, broader at the top. Slight tendency to flaring near the top most likely due to the crushed condition. Cup large, but accurate measurements can not be taken because of the state of preservation. Height to the radial facet 10 mm, and as the facet is horseshoe-shaped the total height would be about 3 mm more.

Infrabasal ring comparatively large, having a height where best preserved of 2 mm. Three infrabasals, two large and one small. Only two suture lines identified with certainty, but the small plate appears to be the anterior one.

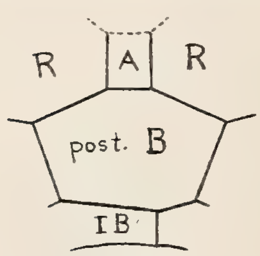

Figure 58 Mictocrinus robustus. Diagram (x 2) showing the posterior basal and the first anal plate resting upon it. The shape of the anal plate is better shown here than on figure 5, plate 60. *A*, anal plate; *post. B*, posterior basal; *R*, radial; *IB*, infrabasal.

Basals large, with a width at the bottom about equal to the height but broadening out near the top. Right posterolateral plate has a height of 6.2 mm and a maximum width of 7.2 mm. Posterior basal considerably larger than the others and slightly truncated at the apex for the reception of the anal plate; height 6.2 mm, maximum width 9.1 mm.

It is difficult to get accurate measurements of the radials. Height to the radial facet in the right posterior radial 3.5 mm; width at this point approximately 9 mm. Radial facet deep and horseshoe-shaped; radial probably had a total height of about 7 mm.

Anal plate small, resting upon the truncated posterior basal and separating the two posterior radials; width 2.7 mm, height 3.1 mm. The structure above this first plate can not be determined.

Tegmen not known.

Arms heavy, rounded; composed of brachials which are broader than long in the proximal portions and more nearly of equal breadth and length in the distal parts. Brachials thickened somewhat along the distal margin where they tend to project slightly. Dorsal canal shown in an isolated brachial. Three bifurcations a considerable distance apart are shown on one arm. Arm not fully preserved, but it is unlikely that a higher bifurcation occurs. Though there are fewer bifurcations the arms in genera. show a strong resemblance to those of Arachnocrinus extensusl

Column not preserved; but judging by the infrabasal disk it must have been round and unusually large. Axial canal with four peripheral canals.

Ornamentation. Surface of dorsal cup and arms covered with numerous, very characteristic, rounded pustules; more numerous on the plates of the dorsal cup than on the arms.

Horizon and locality. From the Onondaga limestone at Clarence, near Buffalo, N. Y.

Type. Genoholotype in the collection of the New York State Museum.

Family BOTRYOCRINIDAE Bather

Genus BOTRYOCRINUS Angelin 1878 (em. Bather 1891)

Botryocrinus nycteus (Hall) n. comb.

Plate 47, figures 3–6

1862 Poteriocrinus nycteus Hall. 15th Ann. Rep't N. Y. State Cab. Nat. Hist., p. 120

1868 Poteriocrinus nycteus Shumard. Trans. Acad. Sci. St Louis, 2:392

1872 Poteriocrinus nycteus Hall. N. Y. State Mus. Bul. 1, pl. 1, figs. 3, 4. (Photographic plates distributed privately.)

1877 Poteriocrinus nycteus S. A. Miller. Amer. Pal. Foss., p. 88

1878 Poteriocrinus nyctaeus Bigsby. Thesaurus Dev.-Carb., p. 20

1889 Poteriocrinus nycteus S. A. Miller. N. Amer. Geol. & Pal., p. 275

1903 Poteriocrinus nycteus Clarke & Ruedemann. N. Y. State Mus. Bul. 65, p. 78

1904 Poteriocrinus nycteus Clarke & Luther. N. Y. State Mus. Bul. 63, p. 52

The description of this species is based upon Hall's type and a larger specimen which shows about 16 cm of column and in which the dorsal cup is better preserved.

Dorsal cup turbinate, with the height and greatest width nearly equal. Infrabasals pentagonal, a little longer than wide; wider at the top than at the bottom, with the lower lateral faces the longer. Basals of about the same height and width, or slightly higher than wide. Two, the posterior and right posterolateral heptagonal, because they border the anal plates; the others hexagonal.

Radials in general slightly wider than long, heptagonal, the upper margin prominent and thickened in the region of the radial facet which occupies a little over a third of the width of the radial. Radianal small, oblique and quadrangular. Anal *x* a little smaller than the radials and in line with them. It rests upon the truncated posterior basal and is bordered on the left by the left posterior radial, on the right by the right posterior radial and the radianal. In the type two tube plates distinguished resting upon the anal *x* and a small one upon the left flank of the right posterior radial; other plates can not be made out. The larger specimen shows three plates resting upon the anal *x*.

Tegmen. Ventral sac better shown in the type; large, slightly curved at the tip, more than three times the height of the dorsal cup. Composed of vertical rows of hexagonal plates, the lower ones resting upon the anal *x* being the largest. The ventral sac in the larger specimen does not appear to be as long; but it is poorly preserved, and the full length may not be well determined.

Arms. Three primibrachs, all longer than wide; first two quadrangular, the third pentagonal, axillary. This gives to each ray two main arms bearing armlets which in some places appear to be on every second brachial, alternately on each side. Brachials above the primaxils quadrangular and generally slightly longer than wide; all seem to be slightly constricted at the middle. Armlets slender, composed of long, narrow brachials. Arms poorly preserved in both specimens.

Column round. Upper part composed of columnals of unequal length in a somewhat regularly alternating order. In the more distal part columnals are longer, and all of nearly the same size. Margins of columnals finely crenulate, this character being visible only in a few places in the type.

Ornamentation. Radials and anal *x* marked at the margin by incipient radiating ridges, slightly stronger on the anal *x*. Radiating, subangular ridges present on the plates of the ventral sac. Plates of the cup and arms striato-granulose, the striae being arranged in a radiating direction. The larger specimen does not show the ornamentation. The striato-granulose character of the plates has been almost entirely destroyed in the cleaning of the specimen.

Horizon and locality. From the Hamilton (Moscow) shales, Ontario county, N. Y. Holotype collected at Vincent; the larger specimen from Cashong creek, near Bellona, N. Y.

Types. Holotype in the collection of the New York State Museum.

Remarks. The species was described by Hall as a Poteriocrinus. The quadrangular radianal, the anal *x* in line with the radials and supporting several tube plates, together with the other characteristics, makes it evident that this species does not belong in the genus Poteriocrinus.

Botryocrinus crassus (Whiteaves)

Plate 47, figures 7, 8

1887 Homocrinus crassus Whiteaves. Contr. Can. Pal., v. 1, pt. 2 (advance sheets), p. 95; 1889, pl. 12, fig. 2

1889 Homocrinus crassus S. A. Miller. N. Amer. Geol. & Pal., p. 255

1893 Botryocrinus crassus (doubtful whether species will stand) Bather. Crin. Gotland, pt. 1, p. 103

1898 Botryocrinus crassus Whiteaves. Contr. Can. Pal., v. 1, pt. 5, p. 375

1901 Botryocrinus crassus Shimer & Grabau. Bul. Geol. Soc. Amer., 13:185

1906 Botryocrinus crassus Bather. Ottawa Naturalist, v. 20, no. 5, p. 101

This species of Botryocrinus from the Hamilton of Ontario has been added here for comparison with the New York forms. The species of Botryocrinus in Europe[1] and America have been described by Bather (1906), and his redescription of Whiteaves' holotype (following the order of the original description) is given here.

Bather's description. Dorsal cup somewhat bell-shaped, rather broad and sharply inflated near the base, and very slightly constricted just about the middle of the basals. Height of dorsal cup, from the lower margin of the infrabasals to the top of the radial facet, 14 mm, to the bottom of facet, 12.75 mm; maximum width of cup, 13.4 mm; width at base, 4.5 mm. Infrabasals pentagonal, about one-half the size of the basals, and wider than high. Basals moderately large, about equal in size to the anterior radials; higher than wide; the three anterior ones hexagonal, the two posterior ones heptagonal and truncated above. Radianal plate equal in size to the infrabasals, rhomboid (see measurements below) and resting between the two posterior basals, the right posterior radial, and the superior anal plate *x*. Radials pentagonal, outer surface nearly flat below, slightly raised in the middle, and above this truncated abruptly and obliquely by the facet for the arms, angle of facet with general side of cup being 135 degrees. The facet is shallowly excavated with contour almost circular, but broader than high, width 4 mm; height 3.1 mm; axial canal small, ovate, marginal, its acutely pointed apex opening directly into the ventral groove, which forms an obtusely angular notch in the centre of the upper margin of the plate. Right and left posterior radials a little smaller than the rest. Superior anal plate *x* pentagonal, equal in size to the right posterior radial and facetted above for the reception of plates of the anal tube (*vide infra*). Cup-plates thick; all rounded towards the sutures, especially in the upper part of the cup; outer surface apparently smooth, but where the test is well preserved, as on the posterior basal and anterior radial, are slight traces of shagreen ornament.

Measurements in millimetres:

	Height	*Width below*	*Width above*	*Length of suture between plates*
Infrabasals	4.	2.5	5.	3.
Left anterior basal	8.	5.4	7.	4.5
Anterior radial	6.5	7.	6.4	4.
to bottom of facet	4.	...	....	...
Right posterior radial	5.	5.4	4.75	4.
to bottom of facet	2.75	...	....	...
Anal *x*	4.8	4.7	3.75	left side 4.; rt. side 2.6

[1] Recently (Haarmann 1920) six species (five new) have been added from the Rhenish Devonian.

Each of the sutures bounding the radianal is 3 mm long, and the plate in each direction is 3.6 mm.

Relation of the species. The radials slope outwards towards the facet, in the way characteristic of Botryocrinus. The axial canal is quite distinct from the ventral groove, though not actually separated therefrom by stereom. The sides of the ventral groove slope inwards at a wide angle, and at the same time separate from one another, so that the communication between ventral groove and axial canal becomes wider. Right posterior radial has portions of three or four rather solid covering plates. The chief point of difference between Homocrinus and Botryocrinus, so far as the dorsal cup is concerned, lies in the number of plates supported by the anal plate *x*. These plates are not preserved, but one can see the facets for them on the upper surface of the plate *x*. There is one small deeply grooved facet in the middle, and another rather smaller immediately to the right of this. The right and left slopes of anal *x* have larger curved facets, of which that on the left still bears a fragment of the succeeding tube-plate. Two small similar facets are clear on the adjacent slope of the left posterior radial and one at all events is to be made out on the right posterior radial. These facets are surrounded by a slightly elevated rim, so that their size and position are well defined. The arrangement of the tube-plates of the proximal row must therefore have been very like that of Botryocrinus ramosissimus, as figured in "Crinoidea of Gotland" I, plate 5, figure 164.

Among all specimens of Botryocrinus hitherto examined, this is the only one in which the greatest width of the cup is less than the height. This fact and the bell-shape of the cup certainly warrant the retention of the species.

Horizon and locality. From the Hamilton beds, near Thedford, Ontario.

Types. Holotype is in the Museum of the Geological Survey of Canada.

Botryocrinus americanus Rowley

Plate 47, figures 9, 10

1904 Botryocrinus americanus Rowley (in Greene). Contr. Ind. Pal., pt. 18, p. 184, pl. 54, figs. 12, 13, 14

1906 Botryocrinus americanus Bather. Ottawa Naturalist, v. 20, no. 5, pp. 93–104

There are so few American Devonian species of Botryocrinus that, in addition to Botryocrinus crassus (Whiteaves), Botryocrinus americanus Rowley from the Hamilton of Indiana is also included here for comparison with the New York forms. I have been unable to obtain the original, and have therefore used Rowley's figures as well as his description

Original description. The infrabasals are five in number, rather large, quadrangular, convex and spread out horizontally to more than half the width of the calyx. There is a shallow excavation for the reception of the column. The columnal canal is pentagonal.

The basals are five in number, width and length equal, sharply convex or wartlike, the two posterior being seven-sided, the remaining three, six-sided. The wartlike nodes on these plates are not central but near the bottom of the plate giving the calyx, in a basal view, a pentagonal outline. The anterior and the adjoining lateral radial are pentagonal, wider than long and with scars for arm attachment more than half their width. These three plates are more protuberant near the middle of the scar. The two posterior radials are five-sided but somewhat smaller in size. Lying between the two posterior basals but not reaching the infrabasals, is a quadrangular interradial plate, a little larger than an infrabasal, hardly convex. Above and to the left of this plate is another and larger interradial, five-sided and with its top suture on a line with the top of the radials. This plate rests between a basal, the first interradial, and two radials. Plates all rather thick. Shallow pits mark the junction of sutures. Ventral parts and arms unknown. This fossil agrees with the Silurian genus Botryocrinus in the number and arrangement of its plates, but, despite the presence of two interradials, the body is quite symmetrical in shape. Botryocrinus has previously been found in the Silurian of Europe.

Horizon and locality. From the Hamilton beds, near Charlestown, Indiana.

Type. Holotype in the G. K. Greene collection, now in the American Museum of Natural History.

Remarks. Bather discusses this species of Rowley's in his paper on the species of Botryocrinus in Europe and America. He states (1906, pp. 103, 104):

Professor Rowley's clear description unfortunately omits a few details that would have helped to complete the present diagnosis. The figure suggests that the arm facet occupies the whole upper surface of the radial, but it is merely described as more than half the width. It might be possible to distinguish facets for tube-plates on the summit of *x*, though the phrase "its top suture on a line with the top of the radials" suggests that it only supported one plate. Though very different in shape from all other dorsal cups of Botryocrinus, there seems no reason to doubt Prof. Rowley's description of his species. After all, the characters are only an intensification of those noted in Botryocrinus crassus from the same formation.

Botryocrinus concinnus sp. nov.

Plate 47, figures 11, 12

There is only one specimen of this beautiful species at hand; but it has been splendidly preserved and so well worked out from the shale that both the anterior and posterior sides of the calyx are shown. The specimen measures about 33 mm to the ends of the arms in the one ray where they are exposed practically to the tips.

Dorsal cup shaped almost like an inverted thimble. It flares most rapidly up to the basals and from there upward the increase is very gradual.

Infrabasals five, pentagonal, an average one having a breadth of 2.6 mm and a height slightly over 1 mm.

Basals the largest plates in the cup, one of them measuring 3 mm in breadth and 4 mm in height; hexagonal except the posterior one which is heptagonal because it is in contact with the anal and radianal.

Radials pentagonal with curving facets for the reception of the first primibrachs. These facets do not occupy the entire upper surface of the radials. An average radial measures about 2.1 mm in height and about 3.1 mm in breadth.

In the posterior region the quadrangular radianal characteristic of Botryocrinus very distinctly shown, though small. Length and width about 1.5 mm. Anal plate large, having a breadth and height approximately 2.3 mm; rather squarish in appearance; in line with the radials and does not extend above them. It borders a radial on each side and the posterior basal and the radianal below. Above two tube plates rest upon the anal. Very little of the anal tube can be made out from the posterior side.

Tegmen. A few of the proximal plates of the ventral sac are shown, and part of the distal portion from about the middle of the arms to the tips is visible from the anterior side. Proximal plates rest in parallel rows upon the anal plate. In upper portion of ventral sac plates ornamented with radiating ridges which are strengthened into small nodes where several ridges come together. Plates here can not be made out, but the general aspect suggests that they are arranged in parallel rows. Ventral sac extends to the tips of the arms in the specimen, but whether it originally extended farther can not be ascertained.

Arms. Two primibrachs in the anterior and right and left posterior rays, the second axillary. In the right and left anterolateral rays, three primibrachs, the third axillary. Ten arms altogether. In the rays with two primibrachs, the first is small, about twice as wide as high, and the primaxil also is smaller than in the other rays. In the anterior and right and left posterior rays, the arms bifurcate on the third brachial above the primibrachs. Anterior ray the only one in which the arms are shown to their extremities. In this ray the arms, above the primibrachs, branch five times by slightly unequal bifurcations. Right anterolateral ray only shows one bifurcation above the primibrachs, the bifurcation occurring on the fourth brachial above the primaxil. Brachials, especially in the upper portion of the arms, somewhat longer than wide, and except at the axillaries, join by straight faces.

Column wanting. A broken portion of the proximal columnal shows that the column was round and stout for the size of the calyx, measuring about 2.6 mm in diameter.

Horizon and locality. From the Hamilton beds (Skaneateles shale), east side of Owasco lake, Cayuga county, N. Y.

Types. Holotype in the collection of the New York State Museum.

Remarks. This species is very similar to Botryocrinus crassus (Whiteaves), but there seem to be sufficient differences to make it a separate species. Only the calyx of B. crassus has been found so nothing is known of the arms. B. crassus is larger than B.

concinnus and has a concave and shallow constriction just below the middle. The radial facets are narrower and more curving in B. crassus, and the radials in the region of the facets are thickened and project rather prominently.

Botryocrinus obconicus sp. nov.

Plate 47, figure 13

Species represented by a single specimen showing the dorsal cup and 33 mm of stem. Dorsal cup very characteristic, however, and would readily distinguish obconicus from the other species of Botryocrinus.

Dorsal cup elongated, with gradually sloping sides, suggesting an inverted cone. Infrabasals pentagonal and elongated, having a height of 2.3 mm, a width at the base of 1.2 mm and at the top of 1.8 mm. Basals likewise elongated, hexagonal, except the posterior one which is in contact with the anal and radianal. An average one gives the following measurements: breadth 2 mm, height 3.2 mm.

Radials pentagonal, not quite as elongated as the infrabasals and basals, having a height and breadth of approximately 2.3 mm. Facet for the reception of the first primibrach very slightly curved and occupies about two-thirds of the upper face of the radial.

Characteristic quadrangular radianal well shown. Anal plate appears to be heptagonal, in a line with the radials and not extending above them; bordered on each side by a radial, and below it rests upon the posterior basal and the radianal. Above it appears to have been bordered by three plates of the anal sac, but only the middle one is now present.

Tegmen missing.

Arms missing. Portions of the first primibrachs preserved, and these are bent inward as seen in figure 13, plate 47.

Column. About 33 mm preserved. Round, with a diameter of 2 mm, and made up of columnals which grow slightly thicker in the more distal portion of the column.

Horizon and locality. From the Hamilton (Moscow shale) beds on the west shore of Canandaigua lake, probably in the vicinity of Menteth's point.

Types. Holotype in the collection of the New York State Museum.

Botryocrinus sentosus sp. nov.

Plate 41, figure 10

The single specimen upon which this species is based occurs on the same slab with one specimen of Decadocrinus multinodosus sp. nov. and two specimens of Logocrinus geniculatus sp. nov. It is a beautiful species of Botryocrinus, the crown measuring at least 65 mm in length.

Dorsal cup rather spreading and low; height 8 mm, width at the top of the radials approximately 19 mm. Infrabasals small, pentangular; average height 2 mm, width 3.2 mm. Three of the basals hexagonal, the other two heptagonal because they come in contact with anal plates. Average basal has a height of 4 mm and a width of 6 mm.

Radials heptagonal, an average one having a height of 4.3 mm and a width of 7 mm. Posterior radial smaller than the others. Radial facet slightly curved, occupying a little over two-thirds of the upper face of the radial.

Anal *x* of about the size of the radials and in line with them. Radianal rather large, quadrangular, resting between the posterior and right posterior basals and bordered above by the anal *x* and the right posterior radial.

Tegmen not exposed.

Arms. Two primibrachs; the first quadrangular, the second pentangular, axillary. First primibrach and primaxil of the right posterior radius shorter and slightly broader than those of the other radii. An average first primibrach has a height of 2.5 mm and a breadth of 4.5 mm; an average primaxil has the same width, and is only slightly longer.

Arms bifurcate on the fifth brachial above the primaxil and seem to bifurcate regularly on every third brachial above this. At least ten bifurcations above the primaxil. Sometimes the two members of a bifurcation fairly equal; usually a noticeable difference, the smaller branches occurring alternately on each side (bilateral heterotomy). This gives the effect of a central, stout branch or arm giving off smaller, but very stout, bifurcating branches regularly, on alternate sides to the tips. Bifurcations of the branches occur usually on every third brachial and, as on the main branch, have unequal members.

Column pentalobate and made up of nodes and internodes. Nodal columnals thicker and extend out beyond the other columnals. Internodes made up of columnals of alternating sizes. Except in the most proximal internode, the internodes average about seven or eight columnals. All columnals thickened at the five angles thus emphasizing the pentalobate character of the stem. Axial canal large and circular.

Ornamentation. Species very characteristically ornamented. Plates of the dorsal cup have strong radiating folds which cross the suture lines. Ornamentation of the arms very striking. Every axillary brachial above the primaxil, whether in the main arm or the branches, bears a conspicuous spine just below the point of bifurcation. In most cases the spines are broken so that they resemble nodes; but in the distal portion of the arms a few are preserved, and one of these has a length of 2.8 mm. Spines in the more proximal parts of the arms must have been much stronger.

Horizon and locality. From the Hamilton (Moscow) shales, Cashong creek, Yates county, N. Y.

Types. Holotype in the collection of the New York State Museum.

Remarks. Botryocrinus sentosus has been placed provisionally under this genus. While this monograph was waiting publication, a paper by Erich Haarmann appeared (1920) describing six (five new) species of Botryocrinus from the Rhenish Devonian. Among them is B. irregularis which somewhat resembles B. sentosus in general habit, but the two species are quite distinct. B. irregularis has three or four primibrachs, and likewise differs in the absence of spines on the arms and the character of their bifurcations.

The name sentosus was given because of the thorny appearance given to the species by the numerous spines on the arms.

HALLOCRINUS gen. nov.

Genus formed to receive Hall's "Cyathocrinus" ornatissimus.

Dorsal cup broadly subturbinate. Infrabasals low, but form a conspicuous part of the dorsal cup. Radial facet occupies a variable amount of the upper face of the radial, but as a rule extends almost completely across it. Posterior interradius has a large radianal and anal in the cup, followed by three tube plates. Ventral sac of large size; composed of numerous vertical rows of thin plicated plates. Arms broad and stout at the base, the second primibrach and at times the primaxil reaching down on one side or the other and resting on the radial. Arms peculiar and of considerable interest. After the main fork, rami give off long pinnuliferous branches at regular intervals to the inner side of the ray. This is a striking character and one which apparently led Jaekel to place the species in his genus Cosmocrinus. Column pentagonal in the proximal portion, becoming round distad. Columnals in the more distal portion of the stem long, cylindrical and highly ornamented.

Named in honor of James Hall.

Genotype. "Cyathocrinus" ornatissimus.

Distribution. Upper Devonian (Portage) of New York.

Hallocrinus ornatissimus (Hall) n. comb.

Plate 49, figures 4, 5; plates 50, 51

1843 Cyathocrinus ornatissimus (incl. M. portlandicus) Hall. Geol. Rep't 4th Dist. N. Y., p. 247, fig. 108

1877 Cyathocrinus ornatissimus S. A. Miller. Amer. Pal. Foss., p. 75

1878 Cyathocrinus ornatissimus Bigsby. Thesaurus Dev.-Carb., p. 17

1889 Cyathocrinus ornatissimus S. A. Miller. N. Amer. Geol. & Pal., p. 236

1900 Cyathocrinus ornatissimus Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 3, p. 196

1903 Scytalocrinus ornatissimus (in err.) Clarke. N. Y. State Mus. Mem. 6, p. 348, pl. *F*

1905 Cosmocrinus ornatissimus Whitfield. Bul. Amer. Mus. Nat. Hist., 21:20, pl. 2, fig. 2, pl. 3, fig. 2

1913 Cosmocrinus ornatissimus Springer. Zittel-Eastman Textbook Pal., p. 221

The description of the species is based on a number of specimens in the American Museum of Natural History. These specimens are all from the original locality in the town of Portland, New York, and constitute the material used by Hall in his original description.[1] They are in all cases somewhat distorted by pressure making it difficult accurately to judge the relative proportions of the dorsal cup. The original figured type of Hall is on a waterworn fragment of limestone which doubtless was found on the beach of Lake Erie. The specimen itself is rather badly weathered. Some of the other specimens, unfortunately, have been treated with acid which to a great extent has ruined the surface sculpture. The cup of one specimen (plate 51) is given a deceptive appearance. The acid has attacked the plates unevenly, working most strongly along the sutures and particularly at the angles of the plates. This results in depressed areas at these points giving the plates a relief at variance with that shown by the other specimens examined. The available specimens vary in size from one having an arm length of approximately 16 mm to one in which the arms attain a length of not less than 100 mm.

Dorsal cup subturbinate though in different specimens the cups are given shapes varying from narrowly turbinate to broadly basin-shaped depending upon the degree and character of distortion. Plates of the dorsal cup wider than high tending to give a somewhat low, broadly expanding cup. This character is more marked in adult specimens than

[1] A specimen from the same locality has recently (1921) been acquired by the New York State Museum from Williams College through the kindness of Doctor Cleland. It also was part of the material used by Hall in his original description.

in the young forms. It is difficult to give measurements of the plates of an individual as none is in favorable condition to show all the plates in a good state of preservation. The original Hall type here figured (plate 50, figure 1) has been chosen to give the majority of measurements. Dorsal cup of the type specimen has a height to the radial facet of 11 mm and a diameter at the base of the arms of about 20 mm. Another specimen which is somewhat unsatisfactory for this sort of measurement gives a height of 8 mm and a diameter of 18 mm.

Infrabasals pentagonal with a height of 4 mm and an extreme breadth of 5.5 mm. Another specimen gives a height of 3 mm for one of these plates and an extreme breadth of 4.8 mm. Infrabasals in this specimen in a better state of preservation than in the type specimen.

Basals, with the exception of the posterior and the right posterolateral, hexagonal, one of them having a height of 6 mm and an extreme breadth of 7 mm, the greatest breadth being above the center of the plate. Posterior basal heptagonal supporting the left posterior radial, the radianal and anal *x*. Right posterolateral basal supports the radianal on its upper left shoulder.

Radials pentagonal; one of them with an extreme breadth of 7.5 mm and a height to the facet of 4.3 mm. Facet occupying a variable amount of the upper face of the radial; usually, however, extending nearly the entire breadth of the upper face. In the case of a radial of another specimen the upper face of which measures 7.5 mm, the facet has a breadth of 7 mm. In many cases facet asymmetrical as to the median line of the radial plate. In such cases it runs to the extreme margin of the plate on one side and falls short of reaching the other extremity by a space of variable width. This permits the second primibrach or even the primaxil to rest upon the radial on that side. This condition obtains in one or more rays of all the adult individuals examined.

Radianal fully as large as the basals; hexagonal, supporting the middle and right tube plates. Abuts at the right against the right posterior radial.

Anal *x* somewhat smaller than the radianal, supporting the left and middle tube plates and perhaps a small tube plate to the left of the left tube plate. Abuts laterally against the left posterior radial.

Tegmen. Radianal and anal *x* apparently succeeded by four plates as noted above. Three of these plates of fairly large size, forming the base of the ventral sac which is of remarkable dimensions. On plate 49, figure 4, a specimen of medium size is shown, the dorsal cup measuring no more than 8 mm in height. Ventral sac with a length of not less than 82 mm and a maximum breadth as it lies flattened on the rock of 17 mm. Distal portion of sac of this specimen concealed by another specimen; in the figure restored without shading. Form given the distal portion probably fairly accurate having been reconstructed from the other specimens which though imperfect, still seem to indicate the true structure of the organ. All ventral sacs crushed flat. It would appear in all cases where the sac is attached to the cup that the anterior side alone is exposed; composed of regular rows of thin, comparatively wide low plates marked by characteristic ridges or plications. Up to the center of each row following the long axis of the sac is a median beaded ridge. From the center of each plate to the lateral edges are fine, sharp folds or ridges; either two or three of these on either side of the plate giving the appearance of minute, two- or three-tined forks. A retouched photographic enlargement of a portion of the surface is shown on plate 49, figure 5. As the sac lies crushed flat upon the rock it appears that along each margin is a range composed of somewhat heavier plates which perhaps give rigidity to the sac. Whether the posterior surface of a sac has been examined can not be told with certainty. It seems probable however that both surfaces are essentially similar in character, rigidity being given as noted above by lateral rows of somewhat heavier plates. No openings observed in the ventral sac.

Arms. Primibrachs three, varying considerably in size and shape. First primibrach normally occupies nearly the entire surface of the radial. This condition apparently obtains constantly in young individuals. In some cases, however, the facet as elsewhere noted begins at one margin of the radial and reaches but a portion of the way across the plate. In such cases the first primibrach is overlapped by the second primibrach. The second primibrach at times has its normal position upon the first primibrach, not touching the radial at either side. At times it reaches down on one side and rests upon the radial. In one case both first and second primibrachs overlapped by the primaxil which comes to rest upon the radial on one side. Primaxil quite variable in shape; frequently has the normal, straight, horizontal, lower margin characteristic of most crinoids, and at times, as noted above, overrides the brachials below it and comes to rest upon the radial itself. Upper sloping faces of the primaxil at a low angle or more steeply inclined. In one case it has a pinched form, pushing up as a sharp wedge between the succeeding brachials.

Above the main bifurcation of the ray the arms branch in an irregular dichotomy (unilateral heterotomy). This gives a peculiar form of arm structure and one apparently which largely influenced Jaekel in considering ornatissimus as falling within his German genus Cosmocrinus. Arms give off to the inner side of the ray nonbifurcating branches of extraordinary dimensions, the proximal ones attaining a length in a specimen of medium size of not less than 75 mm and practically reaching the ultimate tips of the arms themselves. First bifurcation of the arms after the main axil falls either on the eleventh, thirteenth, or fifteenth brachial so far as observed. Subsequent bifurcations fall on the tenth, twelfth, or fourteenth brachial after the next preceding axillary. Axillaries are of no little interest. In the distal portions of the arms the upper faces are equilateral, the most distal bifurcation consisting of branches of equal dimensions. Proceeding proximad this symmetrical axillary gradually gives way to a highly asymmetrical type in which the face supporting the nonbifurcating inner branch is much smaller than the other. In one case the axillary does not extend completely across the arm.

Pinnules comparatively short and slender; a number of measurements give a maximum length of no more than 12 mm. Dorsal surface of the pinnules somewhat like that of Maragnicrinus portlandicus

Whitfield. In the latter species the pinnule ossicle has a sharp keel with lateral grooving extending to the edges of the plate; in this case backs of the pinnules more nearly wedge-shaped although frequently the structure noted in Maragnicrinus is suggested. Near the base of some of the pinnules the dorsal surface appears to be rounded.

Column in its proximal portion distinctly stellate in cross section; distad becomes round. No specimen seen in which the stem is preserved for any considerable distance; so far as shown, however, composed of comparatively low columnals which are alternately wide and narrow. In the proximal portion of a large individual diameter of column 7 mm. In this region the columnals had a height which gave a rate of 12 ossicles to 10 mm. Articular face of a columnal in the proximal stellate portion has a series of marginal articulating ridges suggesting those of the more primitive Pentacrinidae. In the dissociated stem fragments which are found associated with the crowns in great numbers and which are assumed to belong to this species, the columnals are strongly biconcave and have a peripheral row of articulating ridges. The shape of the axial canal can be ascertained only with difficulty and with a considerable degree of uncertainty as secondary calcification has largely altered the material. A section made through the stellate portion of a column seemed clearly to show a pentalobate axial canal. The dissociated round columnals appear to have circular canals.

Ornamentation. As noted elsewhere surface sculpture of specimens has in most cases partially or wholly been obliterated by treatment of the material with acid. Plates of the cup seem to be covered with roughly radiating vermiform lines which run perpendicular to the faces of the plates. Same general type of ornamentation observed in an incipient form on the brachials where lines follow the long axis of the arms. Distad brachials finely pitted.

No specimens observed in which those portions of the column attached to the crown show any sculpturing. The great mass of crinoid stems that largely goes to make up the lenticular sheet of limestone on the surface of which the crinoids are found exhibit the greatest variation in ornamentation. Presumably these columns pertain to Hallocrinus although there is always the possibility that in part they are referable to Maragnicrinus portlandicus Whitfield. The latter possibility is scarcely to be considered seriously however as authentic columns of the latter species were examined for some distance distad from the crown and bear no resemblance to the dissociated stems in question.

A typical segment of column such as is found on the slabs is shown on plate 50, figure 4. There is great variation in ornamentation from that seen in this specimen. In some cases each columnal is marked by a median peripheral ring which may be either continuous or broken up into beads. On either side of this ring and running parallel to the long axis of the column are vermiform markings. When longitudinal markings alone occur these may be fine or coarse and closely crowded or widely spaced as the case may be. At times the vermiform markings give way in part to dots or cancellations. No two stem fragments seem to be identical and even within a distance of a few centimeters on the same stem the ornamentation of the columnals differs appreciably. Largest round columnal observed has a diameter of 6.5 mm.

Ontogeny. Among the numerous specimens of this species in the American Museum of Natural History two young specimens (plate 50, figures 2, 3) were found that cast an interesting light on the development of the organism. It will be noted that there are several points wherein the young specimens differ materially from the adults.

Dorsal cup in the youngest specimen (figure 3) more conical than in adult specimens. As to the relative proportions of the plates it will be noted that the infrabasals are decidedly smaller, scarcely appearing beyond the stem, whereas in the adult specimens they form an appreciable part of the dorsal cup. In the case of the radials the arm facet extends almost completely across the upper face of the radial; entirely occupied by the first primibrach which has straight, subparallel faces. Second primibrach and primaxil of equal width with the first primibrach and in no case tend to reach down and touch the radial. Arms in the smallest individual comparatively much stouter than in the adult, a feature much less pronounced in the next larger specimen (plate 50, figure 2). Pinnules in the youngest individual not preserved, but in the other specimen comparatively heavier and longer than in the case of adult specimens. The most interesting feature in connection with the arms is the fact that they bifurcate in a regular dichotomy, the upper faces of the axillaries being of equal dimensions as they are in the distal portions of the arms in the adults. In the smallest specimen there is no appreciable development of the ornamentation, but in the next larger specimen there is an obscure rather coarse radiating ornamentation. Column as shown by the smallest specimen clearly stellate.

The features noted above are those which are to be expected and are more or less common to all ontogenetic series of crinoids. Of special interest however are the changes to be observed in the posterior interradius. A comparison of figures 1, 2 on plate 50 and plate 51, will show notable differences in structure. It is to be regretted that the posterior interradius of the youngest individual is not exposed and can not be reached. In the young individual the radianal plate supports the anal *x* and the right tube plate alone. In the case of an adult the radianal supports the anal *x*, middle and right tube plates. The anal *x* in turn in the young specimen supports the left, middle, and right tube plates instead of the middle and left tube plates, and at times possibly a tube plate to the left of the left tube plate. The plate styled middle tube plate in discussing the young individual is a plate destined to become the middle tube plate in later development and would receive this designation if this specimen alone were being studied. It is evident that this plate, potentially the middle tube plate, is in this small specimen one of the next higher range of tube plates. It is of relatively small size and rests upon the upper inner faces of the anal *x* and right tube plate. With the increase in size of the crinoid and the concomitant broadening of the posterior interradius, the middle tube plate gradually worked down between the anal *x* and the right tube plate. Eventually it comes to rest upon the radianal. It is to be noted that the middle tube plate still bears almost the same relative position to the anal *x*, showing that the union of the middle tube plate and the radianal was brought about mainly by the mutual growth of these two plates, of partial resorption, and change in outline of the affected portion of the anal *x*. The right tube plate was pushed to one side. Apparently the greatest relative growth of any of the plates concerned is that of the radianal which in the case of a young specimen is but slightly larger than the middle tube plate and considerably smaller than either the anal *x* or the right tube plate. In the adult specimens the radianal plate is of equal size with or somewhat larger than the anal *x*. It is very considerably larger than either the middle or right tube plate. It will thus be seen that a change of very marked character took place in the ontogenetic development of an Inadunate in which a shifting and mutation of the constituent elements is a marked character.

Horizon and locality. All of the authentic specimens of this species known have been obtained from a single locality on the shore of Lake Erie, Portland, N. Y. The crinoids apparently occurred in a small lens of Portage limestone which was largely made up of comminuted crinoidal remains. The limestone mass lay in the midst of calcareous shales. In the collection of the New York State Museum there is a small slab from the Portage beds, Mount Morris, Livingston county, N. Y., which shows a portion of a crown of a young specimen and fragments of columns which apparently are referable to this species.

Types in the American Museum of Natural History, number $\frac{5850}{1}$.

Remarks. The genus Cosmocrinus was defined by Jaekel (1898, pp. 28, 29). In the genus he included three species, Poteriocrinus dilatatus Schultze, Cyathocrinus ornatissimus Hall, and a new species which he called Cosmocrinus holzapfeli. None of the species was chosen by Jaekel as the genotype. Poteriocrinus dilatatus is certainly generically distinct from Cyathocrinus ornatissimus Hall. The status of the other species referred to the genus may not be ascertained with certainty as both the specific description and the material are far from satisfactory.

As noted above the new species holzapfeli was given a very inadequate description by Jaekel. Indeed, relying simply on his description which is but three lines in length, it would be impossible to recognize the species. To all intents and purposes holzapfeli might be regarded as little else than a *nomen nudum.* Jaekel considered Hall's figure of Cyathocrinus ornatissiums which was the only means he had of studying the species as schematic and incorrect. Poteriocrinus dilatatus has been splendidly figured and described (Schultze 1867, p. 161, pl. 5, fig. 5). Only the dorsal cup of this species is known. Of the last two species dilatatus alone agrees with the generic diagnosis of Cosmocrinus.

Bather (1906, p. 104) in discussing the genus says:

> C. holzapfeli Jaekel, Poteriocrinus dilatatus Schultze and Cyathocrinus ornatissimus Hall were referred to this genus by Dr. Jaekel, and of these the first should be made genolectotype. A good figure of the cup has been given only for C. dilatatus, and this, though marked with exceptionally strong folds, appears to have the characteristic Botryocrinus structure. Redescription of C. ornatissimus is much needed.

Haarmann in a recent paper (1920, pp. 31–33) on the Botryocrinidae discusses the genus Cosmocrinus. He agrees with Bather in selecting C. holzapfeli as the type of the genus, but doubts the validity of the genus. He, too, finds Poteriocrinus dilatatus showing characteristic Botryocrinus structure, and shows that neither this species nor Cyathocrinus ornatissimus Hall can be placed in the genus Cosmocrinus; nor are they congeneric. A study of squeezes of the original material has shown that C. holzapfeli was based upon fragmentary material, and only part of the calyx is known; hence Haarmann believes that, even if this species does not belong to another genus, more material is needed to establish the genus Cosmocrinus for it.

For the species Cyathocrinus ornatissimus a new genus Hallocrinus is here proposed.

Genus MARAGNICRINUS Whitfield 1905

The genus Maragnicrinus as defined by Whitfield contained but a single species, portlandicus, two specimens of which were found associated with "Cyathocrinus" ornatissimus Hall. Whitfield did not include ornatissimus in his new genus, but referred it to Cyathocrinus or possibly Cosmocrinus.

It seems that Hall in his examination of the original material did not differentiate between the two genera, but referred both types to Cyathocrinus ornatissimus. This is shown by the fact that there is now a specimen of Maragnicrinus portlandicus in the museum of Williams College bearing Hall's manuscript label "Cyathocrinus ornatissimus."

Dorsal cup of the genus obconical, infrabasals large. Posterior interradius contains a large radianal and anal in the cup, supporting two or three tube plates, one of the type specimens having two and the smaller specimen three. It is possible that two is the usual number for the adult individuals. These plates support a large plicated ventral sac. Radial facet occupies nearly three-fourths the upper face of the radial. Arms sharply distinct from the theca, and divide into two rami which have extraordinary long pinnules. Column round, and as far as observed composed of short columnals.

Genotype. Maragnicrinus portlandicus.

Distribution. Upper Devonian (Portage) of New York.

Maragnicrinus portlandicus Whitfield

Plate 48; plate 49, figures 1–3

1843 Incl. in Cyathocrinus ornatissimus Hall. Nat. History N. Y., pt. 4, Geol., p. 247

1903 Scytalocrinus ornatissimus (in err.) Clarke. N. Y. State Mus. Mem., 6, p. 348, pl. *F*

1905 Maragnicrinus portlandicus Whitfield. Bul. Amer. Mus. Nat. Hist., v. 21, art. 2, pp. 17–20, pls. 1–4

1905 Scytalocrinus ornatissimus Clarke & Ruedemann. N. Y. State Mus. Bul. 80, p. 44

The original description of the type and only species of the genus was based upon two specimens in the American Museum of Natural History. A third specimen is in the museum of Williams College. Both type specimens somewhat distorted and broken. Otherwise the preservation is good, and all essential structural details may be seen without difficulty. Unfortunately both specimens have been treated with acid which to some extent has injured them. Description of species taken from type specimens. Such measurements as are given are taken from the larger of the two specimens as this is in a more favorable state of preservation for such work.

Dorsal cup of the species subconical, with a maximum breadth across the arm bases of 17 mm. Height of cup to arm bases 12 mm.

Infrabasals pentagonal with a breadth greater than the height. Height of one plate 4 mm; greatest breadth 5 mm.

Basals hexagonal in shape, with exceptions as noted hereafter. Height 7 mm and breadth approximately the same. Left posterior basal heptagonal, slightly larger than the other basals; supports the left posterior radial, anal *x* and radianal on its upper faces. Right posterior basal heptagonal; supports the radianal on its left upper shoulder.

Radials with a breadth considerably in excess of the height. Left posterior radial gives a maximum breadth of 6.5 mm and a height to the facet of 4 mm. Facet in this plate with a width of approximately 4.5 mm. In the other specimens the facet seems proportionally to occupy an even wider space. Facets inclined somewhat at an angle giving the arms a slightly outward inclination.

Radianal pentagonal with its greatest breadth below the middle of the plate. Height of this plate 6 mm; greatest breadth 6.5 mm. It extends upward to approximately the base of the radial facets. In the larger specimen it supports the anal *x* and the right tube plate. In the smaller specimen another tube plate comes to rest upon the radianal to the right of the right tube plate. Anal *x* somewhat smaller than the radianal and hexagonal, supporting upon its upper shoulders the left and right tube plates. In the smaller specimen where three tube plates immediately succeed the radianal and anal *x* they may perhaps best be designated as left, middle (equivalent to the right tube plate in the foregoing description) and right tube plate.

Tegmen. Ventral sac in this species only poorly known, as nothing but the base is preserved. So far as may be ascertained it seems to be composed of regular rows of plates somewhat smaller than the proximal tube plates. Plates marked by high sharp ridges passing from plate to plate at right angles to the sutures.

Arms. Primibrachs three, relatively short and approximately equal in height. They stand out distinctly from the cup and are given a somewhat outward direction by the angle of the facet.

Arms bifurcate but once, each ray giving rise to two remarkably long rami; comparatively slender and composed of slightly wedge-shaped ossicles. The extreme length of one of these rami would not fall short of 90 mm. Pinnules, likewise, remarkably long and slender. In the upper portion of one arm several pinnules were found sufficiently well preserved so that their length could be ascertained with comparative accuracy. A measurement of these pinnules gave a length of 33 mm. Pinnule ossicles longer than wide; each ossicle grooved on either side of the long axis, producing a sharp median keel, a structure strikingly similar to that found in "Cyathocrinus" ornatissimus.

Column apparently round throughout its length, although the larger specimen gives evidence in its proximal portion of being slightly pentagonal. About 60 mm of stem preserved in the larger specimen, measuring 6 mm in diameter at the base of the calyx. From this point the stem tapers rather rapidly distad to a point about 12 mm from the cup where it measures 4.4 mm in diameter. In the distal portion of the column as preserved one has a diameter of 3.4 mm. In the other type specimen portions of the stem may be represented for a distance of about 20 cm. Segments of the stem are missing but from impressions left on the surface of the rock and from the general direction of the column as it lies it would appear that the fragments were at one time continuous. Diameter of the column of this specimen in its proximal portion 4.5 mm; in its distal portion only 3 mm. Column of this species composed of alternating wide and narrow columnals which have crenulated margins. In the larger specimen the proximal columnals have a height which gives a rate of 20 columnals for 10 mm. In the more distal portion, about 40 mm from the cup, the height gives a rate of 26 columnals for 10 mm. In the smaller specimen relative height compared with the breadth considerably greater in the distal portion of the stem than in the proximal portion. As noted above, periphery of columnals sharply crenulated; faces deeply concave. In the larger specimen about 12 mm from the calyx and extending for a distance of about 10 mm distad is a curiously tesselated area which does not appear in the other specimen.

Axial canal of medium size and apparently round, although satisfactory sections could not be made.

Ornamentation. Calyx plates covered with irregular anastomosing vermicular ridges and points; apparently varies considerably within the species as the two specimens differ to a marked degree. These vermicular ridges extend up onto the arms and the base of the ventral sac in a modified form. On the basals and infrabasals markings have a roughly radial arrangement running from the centers of the plates. In the case of the radials ornamentation somewhat more reticulate, although this varies in the two specimens. Columnals irregularly beaded. Whether any of the curiously marked columnals associated with this species belong to it or pertain to "Cyathocrinus" ornatissimus it is not possible to state. As will be noted in the description of the latter species, there is the greatest diversity of ornamentation in the fragmentary columns which largely make up the limestone. As far as may be judged from actual observation of the attached columnals of Maragnicrinus portlandicus, however, the evidence seems to point to columnals of different character, at least for individuals of this size.

Horizon and locality. Maragnicrinus portlandicus occurs on slabs of Portage limestone associated with specimens of "Cyathocrinus" ornatissimus. Found on the shores of Lake Erie, near the town of Portland, N. Y.

Types in the American Museum of Natural History, number $\frac{5849}{1}$. They occur on two separate slabs of limestone. The only other fossil associated with these crinoids besides "C." ornatissimus is a small pelecypod, for which a new genus and species was erected by Whitfield, Onychocardium portlandicum. Specimen described as the type of Scytalocrinus ornatissimus (Clarke, 1903, p. 348, pl. F) in the collection of Williams College; plastotype of this specimen in the collection of the New York State Museum, number $\frac{4530}{1}$.

Remarks. Clarke (1903, p. 348, pl. F) referred a specimen belonging to this species to "Scytalocrinus" ornatissimus (Hall). The generic designation was given by Springer after having examined the drawings reproduced by Clarke. The specimen was found in the museum of Williams College with a label in Professor Hall's handwriting "Cyathocrinus ornatissimus." Having been told by Professor Hall that his original figure of "Cyathocrinus" ornatissimus was in large part a reconstruction and that the material from which the figure was made belonged to a collector whose specimens had gone to Williams College, Clarke considered this specimen when found to be the type of the species. Whitfield (1905) showed that the original of Hall's figure was in the American Museum of Natural History. This is the specimen here figured on plate 50, figure 1. Clarke (1905) acknowledged the probable truth of Whitfield's statement and explained the circumstances under which the mistake had been made. It is evident that Hall in examining the original material from Portland had not differentiated between the two genera represented. There can be no doubt however that his specific description applied to "Cyathocrinus" ornatissimus as here defined.

For purposes of clearness, unessential details of the mass of stems and crinoid fragments surrounding the specimens have been omitted in the drawings.

Family GLOSSOCRINIDAE nov.

This family has been created to contain the new genera Glossocrinus, Liparocrinus, Catactocrinus and Charientocrinus. It agrees more closely with the Poteriocrinidae than with any of the other families. Structure of the cup is that characteristic of Poteriocrinus, Decadocrinus, etc., among the Poteriocrinidae; and, as in Poteriocrinus, the radial facet does not occupy the entire width of the radial. Tegmen visible in one species, Liparocrinus halli. It does not agree with the tegmen characteristic of the Poteriocrinidae, Botryocrinidae or Cyathocrinidae, though it bears closer resemblance to that of the Cyathocrinidae. The radial facets are not narrow enough or curved sufficiently for the Cyathocrinidae or Botryocrinidae. Arms pinnulate as in the Poteriocrinidae. Taking all these characteristics into consideration, together with the primitive character of the anal tube, the creation of a new family seems warranted.

Genus GLOSSOCRINUS nov.

[Ety. γλοσσός, *tongue;* κρινον, *lily*]

Genus created with Glossocrinus naplesensis as genotype. Crown in this genus long and slender. Dorsal cup has a structure like that of Poteriocrinus. Both right posterolateral and posterior basals heptagonal. Five infrabasals. Radial facet not as wide as the upper face of the radials and slightly curved. Anal plate extends to, or slightly above, the upper edge of the radials.

Anal tube long and slender, almost as long as the arms; supported on the dorsal (posterior) side by a median line of quadrangular plates, the first of which rests upon the radianal and touches on the anal x on the left, the right posterior radial on the right. Median row of plates flanked on each side by a row of plates provided with comparatively high thin folds, four or five to a plate, which gives the tube a plicated appearance. Ventral (anterior) side the same, except that the median row of quadrangular ossicles is replaced by a median row of small interlocking plates.

Arms branch twice and are dichotomous; composed for the most part of quadrangular to wedge-shaped brachials which bear long pinnules alternately on each side.

Column strongly pentangular. Cirriferous in one of the species of the genus, and better material may show that the other is also.

Genotype. G l o s s o c r i n u s n a p l e s e n s i s sp. nov.

Distribution. Upper Devonian (Portage and Chemung) of New York.

Glossocrinus naplesensis sp. nov.

Plate 52, figures 1–5; text figure 59

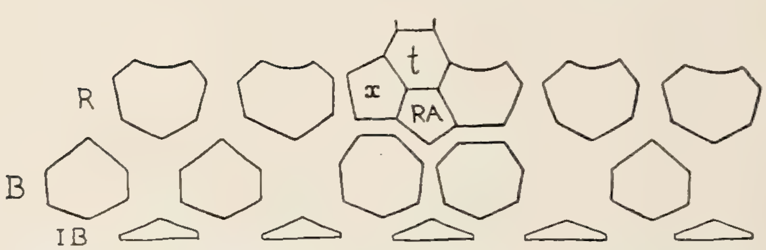

Figure 59 Analysis of calyx of G l o s s o c r i n u s n a p l e s e n s i s, the genotype; *t*, first plate of the median, dorsal, armlike series of plates of the ventral tube.

This new species is represented by material from the Portage (Grimes sandstone and West Hill flags) and from the Chemung. The description is mainly based upon three specimens, two of which (plate 52, figures 1, 2) are from the Portage beds (West Hill flags). In one of the Portage specimens the mold only is preserved; in the second specimen, the rock has been split through the specimen so that the mold of both sides is seen. One side shows part of the anal tube and the lower part of one arm of the specimen itself. Gutta-percha squeezes have been made from the molds and the specimens have been studied from these squeezes. Only the gutta-percha squeezes of the third specimen are in our possession. The squeezes were with the squeezes of material from Chemung Narrows, but the original can not be found. This specimen is only used because it shows the anterior side of the ventral tube; otherwise, it is very poorly preserved. I do not hesitate to place this specimen in the Chemung of Chemung Narrows, for like all the other squeezes of this material it has bits of the weathered specimen all through the squeeze. In addition there has been found in this material a fragment of this species showing a small piece of column, the dorsal cup, about a quarter of an inch of ventral tube and portions of the arms. The Chemung specimen is somewhat larger than the Portage forms, but there is no reason for separating it from that species.

This is a beautiful, graceful little species. In the Portage specimens the crown is not preserved to its full length, but it must have measured in the neighborhood of 45 mm to 50 mm. The Chemung specimen illustrated has a crown measuring about 55 mm. The measurements given hereafter, unless otherwise stated, will be taken from the Portage forms figured on plate 52, figures 1, 2.

Dorsal cup with a height of 3.5 mm and a width at the top of the radials of about 6 mm.

Infrabasals five, an average one having a height of .8 mm and a width of 2.2 mm.

Basals pentagonal with the exception of the posterior and right posterolateral. An average one has a height of 2 mm and a width of about 2.2 mm. Posterior basal heptagonal, supporting the anal and radianal upon its upper faces; right posterolateral basal heptagonal, supporting upon its three upper faces the radianal, right posterior and right anterolateral radials.

Radials shield-shaped, heptagonal. Right posterior hexagonal, bordering the right posterior basal, the radianal, first tube plate and right anterolateral radial (*see* text figure 59). Radial facet does not occupy the entire width of the upper face of the radial and is slightly curved. An average radial has a height to the radial facet of 2 mm and a width of 2.6 mm.

Radianal pentangular, situated obliquely; resting upon the posterior and right posterior basals and bordered above by the anal *x*, right tube plate and right posterior radial. Anal *x* pentagonal, small, of about the size of the radianal and extending somewhat above the radials. On its upper right hand face it supports the first tube plate.

Tegmen. Anal tube very striking and characteristic; long and slender, and probably measured between 40 mm and 45 mm. Greatest width about 5.5 mm. Tube similar to that of Iocrinus and Merocrinus (Bather, 1900, pp. 120, 178). A median line of quadrangular, supporting ossicles extends up the dorsal (posterior) side of the anal tube, giving the appearance of a simple uniserial arm. This supports the view that the dorsal median line of ossicles represents the proximal left ramus of the right posterior arm (Bather, 1900, p. 119). On each side of the median line of plates is a row of wide plates, each of the height of the neighboring plate of the axial row, each provided with folds, usually four or five, which give a plicated, accordion plaited appearance to the tube. Along the margin of the tube on each side these plates are thickened and strengthened. Ventral (anterior) side of the tube shown only in the Chemung specimen of which we have the squeeze alone. Corresponding to the dorsal median line of plates is a ventral median line of interlocking plates, similar to the ambulacrals of an arm. Otherwise the ventral side of the tube resembles the dorsal side.

Arms probably had a length of at least 50 mm. They show two dichotomous bifurcations. Second bifurcation so near the tips of the arms that, though it can not be definitely ascertained, it does not seem probable that a later branching occurs. Primibrachs at least five or six. Brachials quadrangular and bear pinnules alternately on each side. Pinnules below the first bifurcation particularly strong. All the pinnules long and made up of ossicles somewhat longer than wide.

Column. One of the Portage specimens has preserved 7.5 cm of stem. The stem is decidedly pentangular and composed of nodes and internodes. In the most proximal internodes are seen three different sizes of columnals;

in the distal portions of the stem the columnals become more nearly of the same thickness. Columnals thickened at the angles into little nodes which serve to heighten the pentangular effect of the stem. Nodals thicker than any of the other columnals and projecting out beyond the rest of the column in a very conspicuous manner. Nodals cirriferous, each bearing two (or three ?) long cirri, which alternate with those of the nodal immediately above and below.

Ornamentation. Plates of the dorsal cup conspicuously ornamented with ridges or folds which extend from basal to radial and from radial to radial across the suture lines. Also present on the anal *x*, radianal and, slightly developed, upon the first median tube plate. Ridges of the column continued up on the infrabasals. Columnals, as noted above, have the thickenings or nodes at the five angles, and the anal tube has the thin parallel ridges or folds which give the plicated appearance to the tube.

Horizon and locality. From the Portage (West Hill flags), Italy hollow, Naples, and from the Portage (Grimes sandstone) of Deyo basin, two miles south of Naples, N. Y. In both these localities the specimens were collected by D. Dana Luther. Also found in the lower Chemung beds at Chemung Narrows.

Types. Cotypes in the collection of the New York State Museum.

Remarks. Williams (1882, p. 19) under "Poteriocrinus" cornellianus describes the plates bordering the median dorsal row in the anal tube as extensions of these plates. Williams' material was not as well preserved as the specimens of this species in which these lateral plates appear plainly to be separate.

One of the Portage specimens shows an abnormal condition in the left posterolateral interradius where there are two small plates instead of the one large basal. This is shown on plate 52, figure 5.

At first I was inclined to consider the specimens here described as belonging to "Poteriocrinus" cornellianus Williams. Williams' specimens show only a little of the column, so we do not know how the two species compare in this respect. The radiating folds on the plates of the dorsal cup, so characteristic and prominent in G. naplesensis are lacking in "Poteriocrinus" cornellianus (plate 52, figures 6, 7). Even the most weathered material of G. naplesensis shows these ridges, and Williams' specimens of Poteriocrinus clarkei from the Chemung show the radiating folds on the plates of the calyx; so that it does not seem that their absence in "P." cornellianus could be due to weathering. The arm ossicles in "P." cornellianus show a decided wedge-shaped character even in some of the brachials below the first bifurcation. For comparison with Liparocrinus batheri see *Remarks* under that species.

Named from the locality near which the majority of the specimens were collected.

Glossocrinus cornellianus (Williams) n. comb.

Plate 52, figures 6, 7

1882 Poteriocrinus cornellianus Williams. Proc. Acad. Nat. Sci. Phila., v. 34, pt. 1, pp. 18–20, pl. 1, figs. 1, 2, 3

1886 Poteriocrinus cornellianus Wachsmuth & Springer. Rev. Palaeocr., pt. 3, p. 234 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 38:158

1889 Poteriocrinus cornellianus S. A. Miller. N. Amer. Geol. & Pal., p. 273

1896 Poteriocrinus cornellianus Kindle. Bul. Amer. Pal., no. 6, p. 34

The type material of this species was not available. One figure has been taken from a gutta-percha squeeze of one of the types in the collection of Doctor Springer, the other has been copied from the original figure. The description, therefore, has in part been based upon the original description.

G. cornellianus has a cup-shaped calyx, very long arms which give a slender, graceful effect to the crown, and a pentagonal column which expands beneath the calyx.

Dorsal cup. Infrabasals five, small, pentagonal.

Basals large, hexagonal, with very nearly equal height and breadth. Posterior basal, in contact with the anal plates, heptagonal.

Radials the largest plates in the cup; roughly pentagonal and slightly broader than high. Williams describes them as longitudinally convex and incurving toward the tegmen, the edges of two adjacent radials forming a deep groove which terminates upon the upper part of the basals. He also notes a broad, convex ridge beginning on the radials and continuing on the arms to the first bifurcation. Radial facet straight, occupying a little more than two-thirds the breadth of the radial.

Three anals within the cup. Radianal the largest and pentagonal; in contact with the right posterior radial, the posterior and right postero-lateral basals, and the anal *x* and supporting on its upper face a large tube plate. Anal *x* comparatively small, pentagonal; it rests upon the truncated posterior basal, is bordered at the left by the left posterior radial and at the right by the radianal and the large tube plate. This tube plate rests almost directly above the radianal, touches the radial at the right and is succeeded by a series of plates which in dorsal view very much resemble the lower arm plates.

Tegmen. Ventral tube only part of the tegmen that has been preserved; long, apparently as long as the arms. Williams gives a detailed description (1882, pp. 19, 20) of the structure, as follows:

In the typical specimen, what is preserved of this tube is one-third the length of the arms; laterally it is beset on both sides by a fringe, about the width of the plates themselves, of narrow ridges and furrows perpendicular to the axis of the tube. There are four to six of these furrows in the length of each plate, and they continue uninterruptedly the whole length of the tube. In another specimen the tube has been preserved lying mainly outside the arms, and thirty-one plates can be distinctly seen, making a tube whose length is six times the diameter of the calyx; final plate about half the size of the first one. A study of the specimens at command, although all but one are in the condition of molds in fine sandstone from which the original material is entirely removed, has enabled us to make out the general details of structure of this "tube."

The dorsal aspect is that of a cylinder, from a little below the center of which extend outward and downward lamellae which on each side are continuous; the junction at each joint of the plates is not visible, and transversely they are marked by narrow furrows. A section shows these fringelike lamellae to be lateral expansions of the axial plates, thickened at the outer margins and on the ventral side terminating at a narrow, median, longitudinal keel, which appears to be composed of two series of minute plates alternately arranged. The transverse striae do not continue over the outer margins to the ventral side, but reappear in the furrow at the base of the ventral keel.

From the study of specimens of Glossocrinus naplesensis and Liparocrinus batheri and halli, which show the same type of ventral tube, I have come to a different interpretation of the structure of the ventral tube. The dorsal median, longitudinal line of plates is flanked on each side by a row of plates (not lateral extensions of the axial plates) with several transverse thin folds to each plate and thickened at the outer margin. The median, longitudinal keel apparently composed of two series of small alternating plates I have also found in a specimen of G. naplesensis shown on plate 52, figure 4, where there is a striking resemblance to the ambulacrals of the ventral side of the arm. In this specimen the transverse folds on the ventral side continue to the outer margin, just as on the dorsal side, and I believe this probably would be found to be true in well-preserved specimens of G. cornellianus, though Williams only noted them in the furrow at the base of the ventral keel.

Arms very long; bifurcating for the first time on the eighth or ninth brachial, thus giving eight or nine primibrachs, which bear pinnules alternately on each side beginning with the second or third plate. Primibrachs wider than high; the lower ones quadrangular, the upper ones with a slight tendency to wedge-shape. Arms bifurcate a second time higher up. Above the primaxil brachials wedge-shaped and shorter, and like the primibrachs bear the pinnules alternately on each side. Pinnules slender and composed of long ossicles.

Column, as noted above, pentagonal, so far as preserved. It expands at the top, just beneath the calyx, and here is composed of very thin columnals. Williams' figures show only this portion of the column, and in his description he does not touch upon the character of the lower portion. There may have been no specimens to show this.

Horizon and locality. Cited by Williams from the lower Chemung, 200 feet above the base, Ithaca, N. Y. There is in the New York State Museum a specimen very much weathered, which to all appearances is a Glossocrinus cornellianus. It was collected from the Portage (Ithaca) beds, Glenwood ravine, west side of Cayuga lake, four miles north of Ithaca.

Types. Cotypes in the collection of the late Doctor H. S. Williams, Cornell University, Ithaca, N. Y.

Remarks. A new genus Glossocrinus has been created to contain this species and the new species Glossocrinus naplesensis. For comparison of this species with Glossocrinus naplesensis and Liparocrinus batheri see *Remarks* under each of those species.

Genus LIPAROCRINUS nov.

[Ety. λιπαρος, *beautiful;* κρινον, *lily*]

Genus similar to Glossocrinus, but much larger. Character of dorsal cup and anal tube the same as in Glossocrinus, though dorsal cup lower in proportion to size of the specimen. In proportion to its size, anal tube more slender and tapering; brachials shorter with a tendency toward wedge-form even in the proximal part of the arms. Each brachial bears a pair of long pinnules, one on each side.

Genotype. Liparocrinus batheri sp. nov.

Distribution. Upper Devonian (Chemung) of New York.

Liparocrinus batheri sp. nov.

Plate 52, figure 8

There is just one specimen of this splendid species in the New York State Museum, and it is preserved as a mold in the sandstone. A gutta-percha squeeze has been made from the mold and the details of the description taken from this squeeze. If the arms were complete to the tips the crown probably would have measured between 85 mm and 90 mm.

Dorsal cup rather low for the size of the specimen; height 5 mm., width at the top of the radials 10 mm.

Infrabasals five, small, having a height less than 1 mm.

Basals pentagonal except the posterior and right posterior which border the anal plates. An average basal shows a height of 2.2 mm and a width of 3 mm.

All the radials shield-shaped, roughly pentagonal; of about the same size as the basals, an average one having a height to the radial facet of 2.4 mm and a width of 3.2 mm. Radial facet almost straight; occupies nearly the entire width of the upper face of the radial.

Anal *x* of about the size of the radials, pentagonal, bordering the first large tube plate and the radianal in addition to the posterior basal and the left posterior radial. Radianal pentagonal, situated obliquely. First plate of the median dorsal line of ossicles in the tube rests upon the anal, radianal, and right posterior radial and is of about the same size.

Tegmen. Anal tube long, slender and coiled at the tip. If uncoiled, tube would have a length of about 82 mm. In its widest part it measures approximately 9 mm. Anal tube of this species tapers more than that of Glossocrinus naplesensis.

Only the dorsal (posterior) aspect of tube preserved. It shows the median line of large, quadrangular ossicles flanked on either side by the plates provided with sharp, thin folds or ridges which give a plicated appearance to the tube. Folds or ridges not as prominent as in Glossocrinus naplesensis. These narrow plates are thickened and strengthened at the margin on each side.

Arms, when complete, probably had a length of between 80 mm and 85 mm. They bifurcate on the sixth brachial in two of the rays, but whether this is true of all the rays can not be ascertained. Some of these first brachials show a tendency to wedge-shape and the upper ones at least are pinnule-bearing. The arms branch once more, usually about half way between the first bifurcation and the tips of the arms.

Arms composed of short brachials; usually quadrangular, but a few, even low down in the arms, show a tendency toward wedge-shape. Each brachial bears a pair of long pinnules, one on each side.

Column. About 15 mm preserved here; and, so far as can be judged from the small portion preserved, similar to that of Glossocrinus naplesensis. Strongly pentangular; columnals thickened, almost nodose, at the angles, thus giving five longitudinal ridges between which the stem is concave. Composed of nodes and internodes. First internode and part of the second visible. Internodes made up of alternately thick and thin plates. Nodal columnal thicker than the others; extends out beyond the rest of the stem and bears long cirri. No cirri exposed, except in fragments. Molds of cirri are preserved, and some idea of the length was obtained by running a wire up through these molds. The most proximal ones have a length of at least 75 mm; more distal ones apparently were longer and heavier, one showing a diameter of 1.2 mm.

Ornamentation. Plates of the dorsal cup ornamented with prominent ridges or folds which pass from plate to plate, crossing the suture lines. Only other ornamentation consists in the thin folds ornamenting the plates of the anal tube, and the nodes on the columnals at the angles of the stems.

Horizon and locality. From the lower Chemung beds at Brown hill, Cohocton, N. Y.

Type. Genoholotype in the collection of the New York State Museum.

Remarks. This species may be readily distinguished from Glossocrinus naplesensis and Glossocrinus cornellianus. It is of very much greater size. The anal tube is more tapering and the sharp folds on the lateral plates are not so prominent. The brachials are shorter with a tendency in some to wedge-shape, even in the lower part, and each bears a pair of pinnules, one on each side, instead of alternately as is the case with G. naplesensis and G. cornellianus. G. cornellianus lacks the radiating ridges on the plates of the dorsal cup. For comparison with Liparocrinus halli see *Remarks* under that species.

Named in honor of Dr F. A. Bather of the British Museum.

Liparocrinus halli sp. nov.

Plate 52, figures 9-11

I was at first inclined to place this species as a variety of the new Chemung species, Liparocrinus batheri, and further material may still prove it to be only of varietal rank; but the detailed study of the two specimens in our possession brings out characters which seem to be sufficient to permit the making of a new species. Both specimens of the species are molds in the sandstone, one showing the dorsal cup and portions of three arms, the other showing the tegmen, part of the ventral tube and the ventral aspect of parts of three arms.

Dorsal cup shaped like a broad-based, inverted cone; narrow at the base, widening rapidly with slightly concave, flaring sides. Width at the base 3 mm, at the top of the radials 8.6 mm or slightly over; height 5.2 mm.

Infrabasals five, low, pentagonal, with a height of 1.4 mm and a width of 2.5 mm.

Three of the basals, right and left anterior and left posterolateral hexagonal; posterior basal and right posterolateral heptagonal, coming in contact with the anal plates of the posterior side. Slope of the upper faces of the infrabasals so slight that these basal plates appear hexagonal; larger than the other basals. An average basal, the right anterior, has a height of 2.2 mm and a width of 2.4 mm.

Radials roughly pentagonal; radial facet straight and occupying almost the entire width of the radial. Radials broader than high, an average one having a height of 2.5 mm and a width at the top of 4.2 mm.

Anal *x* and radianal slightly smaller than posterior basals. Radianal pentagonal; rests between the posterior and right posterolateral basals; bordered at the left by the anal *x*, at the right by the right posterior radial, and above by the first plate of the median dorsal line of plates of the ventral tube. Anal *x* pentagonal, bordering at the left the left posterior radial, at the right the first median tube plate and radianal, and below resting upon the truncated posterior basal.

Tegmen. One specimen (plate 52, figure 11) shows the mold of the tegmen and the ventral (anterior) aspect of the ventral tube. Tegmen composed of many small interambulacrals; covering plates of the ambulacral areas small and interlocking. Ambulacral areas appear to be raised as ridges above the concave interambulacral areas; but this may be due to the mode of preservation. The lines of ambulacrals meet in the middle of the tegmen. No orals visible and no enlarged ambulacrals in the region of the mouth, so far as can be ascertained from the specimen, except at the posterior side where there is a comparatively large plate which to all appearances is a madreporite.

About 10 mm of the ventral tube preserved in this specimen; in the other specimen, showing the dorsal (posterior) side, about 8 mm preserved. Tube appears to have been slender, for it shows a width at the base of 4 mm. In the dorsal view, only the armlike median dorsal line of plates visible, the first of these resting upon the anal *x*, radianal, and left shoulder of the right posterior radial. The ventral view shows the characteristic plates with the ridges and furrows. Of the median line of small interlocking plates on the ventral side only one or two remain or can be distinguished.

Arms. Eight comparatively short, more or less wedge-shaped brachials before the first bifurcation. Very little of the arms preserved, so it is not possible to tell how many bifurcations there are above this. No brachials above the first bifurcation are shown in the dorsal view; from the ventral view, the brachials appear to be quadrangular. Small interlocking covering plates of the ambulacral groove shown as far up as the bifurcation. Brachials from the second or third up each provided with a pair of pinnules. No pinnules preserved.

Column. Only a couple of columnals preserved; very thin. Column decidedly pentalobate, appearing star-shaped in cross-section. Axial canal small, round. Whether or not the stem was provided with cirri cannot be ascertained; no evidence of cirri in the rock.

Ornamentation. Only ornamentation consists in the faint depressions between the basal plates of the dorsal cup and the incipient ridges at the very borders of the radials and, particularly, the anal *x* and radianal, unless the ridges and furrows on the plates of the ventral tube be regarded as part of the ornamentation.

Horizon and locality. From the Chemung beds, near Tracy Creek, Broome county, N. Y.

Types. Cotypes in the collection of the New York State Museum.

Remarks. The other species of this genus, L. batheri sp. nov. does not show the tegmen. The differences between that species and L. halli are readily seen. Dorsal cup in L. batheri broader and lower with decidedly smaller infrabasals and more strongly developed radial ridges on the plates. Number of primibrachs in L. halli greater and anal tube much more slender.

Named in honor of E. B. Hall by whom the specimens were collected and donated to the Museum.

Genus CHARIENTOCRINUS nov.

[Ety. χαρίεις, *graceful;* κρινον, *lily*]

Charientocrinus may be readily distinguished from the other genera of the family. Character of the dorsal cup and anal tube (so far as can be judged) the same as in Glossocrinus. There may be two dichotomous bifurcations of the arms which bear long pinnules on every second brachial alternately on each side. Brachials quadrangular in the proximal part to slightly wedge-shaped in the more distal portion. Column pentagonal. For details see the description of the genotype.

Genotype. Charientocrinus ithacensis sp. nov.

Distribution. Upper Devonian (Portage) of New York.

Charientocrinus ithacensis sp. nov.

Plate 53, figures 1–4

The specimens upon which this species is based occur on two slabs of rock from the Ithaca beds. Six specimens and a number of detached stems or molds of stems are shown; but in only one (plate 53, figure 2) is the calyx at all well preserved, though the plates can be identified in another (plate 53, figure 1). In two specimens the crown is so badly broken and weathered that they are of no use either for figures or description. In the other two specimens the calyces are almost entirely lost, but the character of the arms is shown. An arm of one of these specimens (plate 53, figure 3) has been drawn, since the branching and pinnules are best shown here. Except for stem characters, then, the description that follows is based upon three specimens.

Crown long and slender, measuring in the two specimens where the arms are shown almost to their tips about 80 mm.

Dorsal cup low and broad; height 3.5 mm; breadth at the base 2.5 mm, at the top of the radials 7.4 mm. This specimen is somewhat crushed. Another specimen has a height of 4 mm, a width at the base of 3.1 mm and a width at the top of the radials of 7.2 mm.

Infrabasals are very small and pentagonal, with a height of about .5 mm.

Basals hexagonal except the posterior and right posterolateral, which are in contact with the anal plates of the posterior side and heptagonal. Broader than high, an average basal having a height of 1.6 mm and a breadth of 2.4 mm.

Radials pentagonal, broader than or as broad as high. Two average radials give the following measurements: height 1.8 mm, width 2 mm; height 2 mm, width 2 mm. Radial facet slightly curved; occupies about three-quarters the width of the radial

Posterior side showing the anal plates somewhat crushed, but the arrangement is that characteristic of the genus Glossocrinus (*see* text figure 59). Radianal smaller than the basals and pentagonal. Anal *x* pentagonal, of about the size of the radianal. First plate of the median dorsal line of plates almost as large as the radials.

Tegmen not preserved. Only a few plates of the armlike, dorsal median line of plates are seen — the first and four a short distance above.

Arms very long, about 20 times as long as the dorsal cup. First bifurcation takes place some distance above the cup. When it can be determined, it has been found on the seventeenth, eighteenth and twentieth brachial; variable in a single individual. Arms may bifurcate again above this point as shown in figure 3, plate 53, but that does not seem to be the rule. Brachials quadrangular in the more proximal portions of the arms with increasing tendency to wedge-shape proceeding distad. Third brachial above the radial bears a pinnule; above this point pinnules borne by the second of every pair of brachials alternately on each side of the arm. This gives a pinnule every fourth brachial on each side. Each pinnule-bearing brachial projects at the point where the pinnule is borne; and the pairs of brachials extend to the right and left alternately, thus giving a conspicuous zigzag appearance to the arms. Pinnules long and slender; composed of long, quadrangular ossicles.

Column. Various parts in lengths of 60 mm, 70 mm, 80 mm, and less preserved, though not in good condition throughout. Mold of one stem preserved for a distance of about 140 mm. Column pentagonal, the pentagonal effect being increased by thickenings or nodes at the angles of the columnals. In the proximal portion pentagonal character very pronounced, the stem being almost sharply pentalobate. Column composed of nodals and internodals. Nodals thicker and more projecting; angles very conspicuously thickened. Nodals closer together in the most proximal part. Usual number of internodals seven; the middle one, though smaller than the nodals, is more pronounced than the other internodals. In the more distal portion pentagonal character less pronounced, becoming even subpentangular; nodals less conspicuous, and both nodals and internodals longer (plate 53, figure 4). Some of the nodals bear long stout cirri. As far as can be ascertained, the cirri borne at every second, sometimes every fourth node. On none of the stems is there any evidence of more than two cirri to the node, and they are not always from the same two faces. Each pair of cirri apparently borne by different faces than the pair immediately above and below.

Horizon and locality. Portage (Ithaca) beds, Ithaca, N. Y.; from the first quarry on South hill above the south end of the Stewart avenue bridge.

Types. Cotypes in the collection of the New York State Museum.

Remarks. Charientocrinus ithacensis can be readily distinguished from other similar species. The size, the long slender crown and the alternate arrangement of the pinnules from every pair of brachials will distinguish it from either Liparocrinus batheri or L. halli. There is more resemblance shown to Glossocrinus naplesensis and G. cornellianus. However, the arms are shorter in proportion to the size of the calyx in these two species, and the pinnules are borne alternately by every brachial. The dorsal cup in G. naplesensis is ornamented with conspicuous ridges and furrows, and the column bears cirri at every node.

Genus CATACTOCRINUS nov.

[Ety. κάτακτος, *fragile;* κρινον, *lily*]

This new genus has been created to contain a species represented by a large number of specimens from the Chemung sandstone. Rather delicate specimens, with long and slender crown. Character of dorsal cup and anal tube like that of Glossocrinus. Radial facet slightly curved and less than the width of the radial. Arms simple, uniserial, with long, strong pinnules, borne by each brachial above the primibrachs alternately on each side of the arm. Ventral tube slender, considerably shorter than the arms. Stem pentagonal in the upper part, becoming subpentagonal to rounded below. Cirri borne on the more distal portion of the column.

Genotype. Catactocrinus leptodactylus sp. nov.

Distribution. Upper Devonian (lower Chemung) of New York.

Catactocrinus leptodactylus sp. nov.

Plate 53, figures 5–9

This rather delicate species is represented by molds in the Chemung sandstone. Gutta-percha squeezes have been made, and the description is based upon these. Crown long and slender. In some of the specimens it has a length of from 30 mm to about 40 mm. Some of the larger specimens show a length of at least 50 mm.

Dorsal cup obconic, broader than high. In one specimen (plate 53, figure 6) the cup has a height of 2.7 mm, breadth at the base of 1.3 mm and a breadth at the top of the radials of 3.4 mm; in a second (plate 53, figure 6) the cup has a height of 2.8 mm, breadth at the base of 1.4 mm and breadth at the top of the radials of 3.6 mm; in a third (plate 53, figure 7) the cup has a height of 3.1 mm, a breadth at the base of 2 mm and a breadth at the top of the radials of 5 mm. In this last specimen the measurements for breadth are exaggerated due to slight crushing.

Infrabasals pentagonal, low, and of practically the same width at top and bottom. Average ones have, one, a height of .5 mm and width of .75 mm; another, a height of .65 mm and width of .95 mm.

Basals, except the posterior and right posterolateral which are heptagonal, hexagonal; longer than wide, a characteristic slightly more pronounced in one of the specimens. A characteristic basal gives the measurements: height 1.5 mm, width .95 mm. Posterior basal somewhat larger than the others. Basals slightly wider at the top than at the bottom; in some specimens only a slight difference between the height and width.

Radials pentagonal; of about equal height and width, two average ones giving the measurements of 1.2 mm and 1.3 mm respectively. Radial facet slightly curved and less than the width of the radials.

Radianal pentagonal, usually a little larger than the infrabasals. Anal *x* not well shown; of the same size or smaller than the radianal, resting upon the truncated posterior basal.

Tegmen. Only the ventral tube visible; slender, not so long as the arms; in one specimen (plate 53, figure 6) only about half as long. The width varies slightly in the three specimens, being respectively 2.8 mm, 2.8 mm and 3.5 mm in the widest part. As in the other genera belonging to this family, radianal followed by an armlike median dorsal (posterior) series of ossicles (plate 53, figures 8, 9). Vertical rows of plates bordering this median line of plates likewise ornamented with several transverse, thin folds which give a plicated effect to the tube. One specimen (plate 53, figure 7) shows rather poorly the ventral (anterior) line of small interlocking plates. Sides of the tube strengthened by a thickening of the edges of the plates. Ventral tube appears to end rather bluntly.

Arms five, long and slender, from 10 to 15 times the length of the calyx. Two appears to be the regular number of primibrachs. Both long; first primibrach the longer, and usually about twice as long as wide. The third, sometimes the second, brachial bears a long, rather stout pinnule, and from this point strong pinnules are borne by all the brachials alternately on each side. Pinnules noticeably long and strong, reaching well up toward the arm tips; some of the lower ones at least 15 mm long. Brachials above the primibrachs quadrangular and longer than wide. Pinnule ossicles are long and quadrangular.

Column decidedly pentagonal in the proximal portion, becoming subpentagonal to rounded in the more distal portion. Columnals in the proximal part short and distinctly divided into nodes and internodes; in the most distal part preserved, columnals longer and there is only a slight distinction between the nodals and internodals. Seven internodals between the nodals, the middle one projecting more than the others, thus giving three sizes of columnals. Pentagonal aspect in the proximal part heightened by the slight extension of the columnals and thickening at the five angles. In one specimen 4.5 cm of column are preserved, in another 9 cm. A third specimen shows 19 cm of column bearing long, delicate cirri on the nodals in the distal portion. There appear to be two cirri to a nodal in some places, but whether this is true of all the nodals can not be ascertained.

Ornamentation of this species very slight. Shallow depressions or pits at the angles between the plates of the dorsal cup and incipient ridges on the basals and radials, shown only at the edges. Specimens vary in the extent to which they show this ornamentation; it may be so faint as to be practically lacking.

Horizon and locality. From the lower Chemung beds, Cotton hill, one mile north of Avoca, Steuben county, N. Y.

Types. Cotypes in the New York State Museum.

Remarks. A new genus has been created for this species. The five simple, uniserial arms, with the very long pinnules make this genus quite distinct from the others of the family.

Family POTERIOCRINIDAE Roemer (em. W. & Sp.)

Subfamily POTERIOCRININAE Springer

Genus POTERIOCRINUS Miller 1821 (em. W. & Sp. 1881)

Springer (1913, p. 222) states that the Devonian species referred to this genus are probably Parisocrinus. I have placed, provisionally, a number of species under this genus, either because their generic designation can not exactly be determined through lack of sufficient arm characters, or because the arm characters definitely do not agree with those of Parisocrinus.

Poteriocrinus (?) **diffusus** Hall

Plate 54, figure 1

1862 Poteriocrinus diffusus Hall. 15th Ann. Rep't N. Y. State Cab. Nat. Hist., p. 121

1868 Poteriocrinus diffusus Shumard. Trans. Acad. Sci. St Louis, 2:391

1872 Poteriocrinus diffusus Hall. N. Y. State Mus. Bul. 1, pl. 1, figs. 1, 2. (Photographic plates distributed privately.)

1877 Poteriocrinus diffusus S. A. Miller. Amer. Pal. Foss., p. 88

1878 Poteriocrinus diffusus Bigsby. Thesaurus Dev.-Carb., p. 19

1879 Pot. (Decadocrinus) diffusus Wachsmuth & Springer. Rev. Palaeocr., pt. 1, p. 119 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 31:342

1889 Poteriocrinus diffusus S. A. Miller. N. Amer. Geol. & Pal., p. 274

1903 Poteriocrinus diffusus Clarke & Ruedemann. N. Y. State Mus. Bul. 65, p. 77

1904 Poteriocrinus diffusus Clarke & Luther. N. Y. State Mus. Bul. 63, p. 52

Dorsal cup small, turbinate, comparatively broad at the base. Width at the base 2.2 mm, at the top of the radials 5 mm. Cup only slightly higher than the greatest width.

Infrabasals all pentagonal, of about the same width and with the lower lateral faces the longer.

Basals about equal in height and width or slightly longer than wide. Posterior and right posterolateral basals heptagonal, being in contact with the anal plates; the others hexagonal. Right posterolateral longer than the others and divided transversely, the upper portion being the smaller.

Radials smaller than the basals, wider than high, the upper margins thickened and projecting in the region of the radial facet which is less than the width of the radial.

Three plates visible in the anal area. Radianal large and pentagonal. Anal *x* hexagonal, smaller than the radials and extending above them. It rests upon the truncated posterior basal, and is bordered at the left by the left posterior radial, at the right by the radianal and right tube plate which also borders the radianal and right posterior radial.

Tegmen unknown.

Arms. Three primibrachs, all of them generally wider than long; the third axillary, giving rise to ten rami which are long and slender and composed of rather long, quadrangular brachials. Brachials tend to curve alternately on opposite sides which gives a zigzag effect to the arms. Strong armlets given off at every second or third brachial, usually the third; slender and made up of proportionately longer brachials. Brachials giving off armlets longer than the others. No pinnules observed.

Column round, and appears to be slightly expanded just below the base of the calyx. Three of the most proximal columnals preserved; the first slightly larger than the others. All have rounded edges.

Ornamentation. Plates of the dorsal cup granulose.

Horizon and locality. From the Hamilton (Moscow) shales, Ontario county, N. Y. Holotype collected at Vincent, N. Y.

Types. Hall's cotypes in the collection of the New York State Museum numbers $\frac{4472}{1}$, $\frac{4472}{2}$. Number $\frac{4472}{2}$ is not a diffusus (*see Remarks*).

Remarks. The left posterior radial in the specimen illustrated (plate 54, figure 1), is compound. Hall does not mention this characteristic, and it is very probable that it is only individual. The other specimen, number $\frac{4472}{2}$, figured by Hall as Poteriocrinus diffusus (1872, plate 1, figure 2) does not belong to that species. In his plate description Hall designates the figure of this specimen as " View of three of the rays of another individual showing the tentacula, the calyx having been broken away." The calyx is small but, with the exception of the infrabasals, is all there. The specimen is apparently a small Decadocrinus nereus, to which it is here referred.

This species has been placed by authors in Poteriocrinus and, Decadocrinus. The shape of the cup, the narrow radial facets the quadrangular brachials and the presence of armlets make it quite evident that this species does not belong under Decadocrinus. It has been placed here in the genus Poteriocrinus with a query. So far as the cup characters are concerned it might be a Parisocrinus, but the radial facet and the arm characters do not agree.

Poteriocrinus nassa Hall

Plate 54, figures 2, 3

1862 Poteriocrinus nassa Hall. 15th Ann. Rep't N. Y. State Cab. Nat. Hist., p. 120

1868 Poteriocrinus nassa Shumard. Trans. Acad. Sci. St Louis, 2:392

1872 Poteriocrinus nassa Hall. N. Y. State Mus. Bul. 1, pl. 1, fig. 5. (Photographic plates distributed privately.)

1877 Poteriocrinus nassa S. A. Miller. Amer. Pal. Foss., p. 89

1878 Poteriocrinus nassa Bigsby. Thesaurus Dev.-Carb., p. 20

1879 Poteriocrinus nassa Wachsmuth & Springer. Rev. Palaeocr., pt. 1, p. 120 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 31:343

1889 Poteriocrinus nassa S. A. Miller. N. Amer. Geol. & Pal., p. 274
1900 Poteriocrinus nassa Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 3, p. 198

Only the dorsal cup of the specimen representing this species is preserved, but judging from that it must have been of fairly large size. Dorsal cup turbinate with a comparatively broad pentagonal base; height 12.9 mm; width at the base 4.7 mm, at the top of the radials 17 mm.

Dorsal cup. Infrabasals large, pentagonal, height and greatest width about equal, gradually widening from the base upward. Anterior infrabasal has a height of 3.9 mm, and a width at the top of 3.6 mm. Posterior infrabasals larger than the others.

Three of the basals hexagonal — the right and left anterior and the left posterolateral; longer than wide. Right anterior has a width of 4.7 mm and a height of 7 mm. Posterior and right posterolateral basals heptagonal, coming in contact with the anal plates; larger than the other basals and as broad or broader than high. Basals prominent and subangular along the middle and somewhat abruptly depressed at the sides.

Radials short, heptagonal except the right posterior which is hexagonal, resting upon the truncated right posterolateral basal; wider than high, an average one having a height of 4.9 mm and a width of 5.9 mm. Two posterior radials smaller than the others. Upper margin of the radials thickened for the attachment of the strong arm plates. Radial facet occupies about two-thirds the width of the radial.

Anal *x* and radianal the smallest plates in the cup, being about two-thirds the size of the infrabasals. Radianal pentagonal; anal *x* smaller than the radianal, pentagonal, resting upon the truncated posterior basal and bordered at the sides by the left posterior radial and the radianal. No tube plates shown.

Tegmen unknown.

Arms. First primibrach preserved in one ray; short, heavy, quadrangular, wider than high. Suggests strong arm plates.

Column missing. Cicatrix strongly marked, pentagonal.

Ornamentation. Surface of dorsal cup smooth or finely granulose.

Horizon and locality. From the Hamilton (Moscow) shales, near Canandaigua, N. Y.

Types. Holotype in the collection of the American Museum of Natural History, number $\frac{5035}{1}$.

Poteriocrinus clarkei Williams

Plate 54, figures 4, 5

1882 Poteriocrinus clarkei Williams. Proc. Acad. Nat. Sci. Phila., v. 34 pt. 1, pp. 21, 22, pl. 1, fig. 4

1886 Poteriocrinus clarkei Wachsmuth & Springer. Rev. Palaeocr., pt. 3, p. 234 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 38:158

1889 Poteriocrinus clarkei S. A. Miller. N. Amer. Geol. & Pal., p. 273

1903 Poteriocrinus clarkei Clarke & Ruedemann. N. Y. State Mus. Bul. 65, p. 77

Calyx of this species small and obconical, expanding gradually from the top of the stem.

Dorsal cup. Infrabasals five, pentagonal, of medium size and as high as wide.

Basals large, hexagonal, higher than wide; about twice the height of the infrabasals.

Radials of medium size, somewhat broader than high, and roughly pentagonal. Radial facet slightly curved, and occupies about two-thirds (or less) of the upper face of the radial.

The specimens studied by Williams did not show the anal area, and it was so noted in the original description. One of the specimens, recently acquired, from the Chemung of Erie, Pa., shows the anal *x*, radianal and right tube plate, in the arrangement typical of Poteriocrinus.

Tegmen. No part preserved.

Arms. Two primibrachs, the second axillary. First quadrangular, wider at the bottom than at the top, height equal to or greater than the greatest width. Primaxil pentagonal. At the base it has the width of the first primibrach, and joins it by an almost straight face; near the top it flares out and becomes one-half or more wider. The two primibrachs together have a slightly hour-glass appearance. The joints gap between the first primibrach and radial and between the first primibrach and primaxil.

Arms comparatively long and composed of quadrangular brachials which have a length twice (or more) the width, and in some specimens gap at the joints. Williams, in the original description, states that the arms do not branch, so far as determined from the specimens, but I have found in one of the types (number $\frac{4471}{1}$) what appears to be a bifurcation above the primaxil. Only fragments of pinnules preserved; their place of attachment to the brachials not conspicuously prominent.

Column pentagonal just beneath the calyx, slightly expanding and composed of thin columnals of different sizes. Below gradually becomes subpentagonal and rounded, and the columnals lengthen. I have seen no specimen of column with cirri, but Williams notes that the cirri are frequent in the rounded portion of the column and stand at right angles to it.

Ornamentation. Plates of the dorsal cup ornamented with radiating folds or ridges with deep depressions between; only slightly developed on the infrabasals, but quite pronounced on the basals and quite strong upon the anal plates.

Horizon and locality. Types from the Chemung, Haskinsville, Steuben county, N. Y.; collected by and named for Dr John M. Clarke. A small slab from the upper Chemung, Erie, Pa., shows two much weathered specimens of this species.

Types. Three of the cotypes in the New York State Museum, numbers $\frac{4471}{1}$, $\frac{4471}{2}$, $\frac{4471}{3}$.

Poteriocrinus clarkei var. **alpha** Williams

Plate 54, figures 6, 7

1882 Poteriocrinus clarkei *var.* alpha Williams. Proc. Acad. Nat. Sci. Phila., v. 34, pt. 1, p. 22, pl. 1, fig. 5

1886 Poteriocrinus clarkei *var.* alpha Wachsmuth & Springer. Rev. Palaeocr., pt. 3, p. 234 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 38:158

1896 Poteriocrinus clarkei *var.* alpha Kindle. Bul. Amer. Pal., no. 6, p. 34

Variety based by Williams upon the impression of part of the dorsal cup (plate 54, figure 6) found in the lower part of the Chemung group at Ithaca, N. Y. About twice the size of P. clarkei; ridges and depressions more strongly marked. In shape and proportion of plates, differences so slight that Williams made it provisionally a variety of clarkei, and it seems well to keep it so.

A slab of rock from the Chemung, Erie, Pa., shows three calyces and a number of stems. Specimens crushed and very much weathered, but there seems to be no doubt that they belong to variety alpha. One of the specimens, though so poorly preserved, is figured here on plate 54, figure 7, since it is more complete than the original material.

Column similar to that of P. clarkei. In the proximal portion very strongly pentagonal, with three sizes of columnals; in the more distal portions subpentagonal to rounded. Cirri borne by the column in its distal portion.

Horizon and locality. From the lower part of the Chemung beds, Ithaca, N. Y., and in the upper Chemung of Erie, Pa.

Type in the collection of the late Doctor H. S. Williams of Cornell University. Drawing used here taken from a plastotype in the Springer collection.

Poteriocrinus zethus Williams

Plate 54, figure 8

1882 Poteriocrinus (Decadocrinus) zethus Williams. Proc. Acad. Nat. Sci. Phila., v. 34, pt. 1, p. 27, pl. 1, fig. 9

1886 Decadocrinus zethus Wachsmuth & Springer. Rev. Palaeocr., pt. 3, p. 239 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 38:163

1889 Poteriocrinus zethus S. A. Miller. N. Amer. Geol. & Pal., p. 276

1896 Poteriocrinus (Decadocrinus) zethus Kindle. Bul. Amer. Pal., no. 6, p. 34

A very small species with turbinate calyx, which with the arms forms a narrow, elongate head with subparallel sides. Width of calyx 2.2 mm; height 1.5 mm.

Dorsal cup. Infrabasals five, small, pentagonal and of about equal height and width.

Basals hexagonal and of about equal height and width, giving a rounded hexagonal appearance.

Radials pentagonal, larger than the basals, broader but of about the same height. Radial facet straight, and occupies practically the entire width of the radial.

Anals not known.

Tegmen not preserved.

Arms. Two long primibrachs, subequal in length and together giving an hour-glass effect, since the first primibrach is broader at its lower face than its upper and the primaxil broadens out at the top just below the bifurcation.

Arms rather short and slender; composed of long brachials, at least twice as long as wide. In the original description Williams states: "The arm bears a pinnule at the third joint (or bifurcates at this point, the specimen is too imperfect to determine which)." The original material was not available; and the species has been refigured from a squeeze in the Springer collection in which one of the arms bifurcates on the third plate above the primaxil.

Column has a diameter of .8 mm; round and does not expand beneath the calyx. Two kinds of columnals which alternate regularly from above, first a thin, then a much longer, subglobular columnal. Just beneath the calyx both kinds thinner, but below they do not vary much in size or proportion for the length of the stem exposed.

Horizon and locality. In a loose slab near the top of the Portage, supposed to have fallen from the rocks just above where it was found, Ithaca, N. Y.

Types. Holotype part of the S. G. Williams collection, Cornell University, Ithaca, N. Y.

Remarks. This species was compared by Williams with Poteriocrinus nycteus Hall to which he thought it bore a resemblance. "P." nycteus has proved to be a Botryocrinus. It has three primibrachs which are shorter than in P. zethus, the radial facets are curved and narrower and the radials project slightly in this region.

Poteriocrinus (?) **dignatus** sp. nov.

Plate 54, figures 9, 10

Only one specimen of this species. Most of the arms are broken away, but one arm is preserved practically to the tip. Calyx has been worked free so that all sides may be studied. Anal tube visible only from the anterior side.

Dorsal cup with regularly sloping sides from the infrabasals to the tops of the radials. Height of 6.5 mm from the base to the top of the radials; width at the base about 2.8 mm, at the radials (the greatest width) 7.2 mm. Faint, low ridges extend up the middle of the radial series giving a faintly pentagonal section to the cup, and a subpentagonal stem cicatrix.

Infrabasals large, pentagonal, having a height of 2.3 mm to 2.5 mm and a width at the top of 2 mm to 2.2 mm.

Basals large, one of them having a height of approximately 3.5 mm and a width at the top of about 3 mm. Posterior basal, upon which the anal *x* and the radianal rest, heptagonal; all other basals hexagonal.

Radials not as high as the basals, pentagonal. One gives the measurements: height to facet 2.2 mm, breadth 3 mm; another has a height to the facet of 2.3 mm and a breadth of 2.5 mm. Facets for the reception of the primibrachs curved, and occupy a little over two-thirds of the width of the radials.

Radianal fairly large, almost as large as the anal *x*. Pentagonal; three upper faces bordered by anal *x*, right tube plate, and right posterior radial, two lower faces resting upon the right and left posterior basals. Anal *x* extends above the upper line of the radials. Hexagonal; bordered at the left by the left posterior radial, at the right by the right tube plate and the radianal; below it rests upon the posterior basal, and above it bears the middle and left tube plates. Above this are shown three rows of tube plates of three plates each, the plates being roughly hexagonal.

Tegmen. Only a few rows of the tube plates seen from the posterior side, but almost the full extent of the tube seen from the anterior side. Anal tube or sac approximately 15 mm long; at its broadest part about 3.5 mm wide. It does not taper very much and has a blunt termination. Composed of short, broad, hexagonal plates, arranged in vertical rows. Edges of plates rather difficult to make out, but where they can be distinguished the plates are hexagonal. Toothed or serrated appearance seen at the left in figure 10, plate 54, due to crushing in this part of the tube which has made one row of plates lap over on the next row, causing a break which has brought into evidence the edges of the hexagonal plates. Tube apparently slightly longer than the arms.

Arms. Not possible to make out the number of primibrachs in all the arms because they are too imperfect. One arm preserves two, the second axillary; in the only ray (left posterior) where an arm is preserved almost entire there are three, the third axillary. All except the primaxils short, the first ones being about twice as wide as high. In the ray with two primibrachs, primaxil comparatively long, having a height (2.1 mm) slightly exceeding the width (1.8 mm). Primaxil partially concealed in the ray with three primibrachs, so that no measurements can be taken; but from the portion exposed it seems to show little difference in width and height.

Brachials rather squarish in appearance, and join by straight sutures. Third and eighth brachials above the primaxil, in the one arm preserved, bear a short slender armlet or pinnule on the outer side. From here the arm tapers more rapidly, the fourth brachial up being axillary and giving rise to two slender divisions. Brachials giving rise to the armlets or pinnules are more elongated.

Column missing. Cicatrix subpentagonal due to the faint ridges on the radial series.

Ornamentation. No ornamentation of any kind. Ridges on the radial series so faint as not to attract attention, and can hardly be considered as ornamentation.

Horizon and locality. From the Hamilton (Skaneateles shale) beds, east side of Owasco lake, Cayuga county, N. Y.

Types. Holotype in the collection of the New York State Museum.

Remarks. There is some question as to the generic designation of this species. The narrow radial facets exclude it from the other genera of the Poteriocrinidae, and the character of the arms exclude it from the other families, Cyathocrinidae and Botryocrinidae, in which the character of the calyx might permit it to be placed.

The species can be readily distinguished. There is no close resemblance to any other species unless it be to P. nassa. The latter is a much larger form and the dorsal cup is relatively broader and more flaring at the radials.

Nomina Nuda

Poteriocrinus verticillus Hall

Poteriocrinus indentus Hall

Hall (1862, p. 122) described two species of Poteriocrinus, P. verticillus and P. indentus without any figures. The types have not been located, and no specimens have been identified with the descriptions. The descriptions are not sufficient, without figures, for purposes of identification, so that, unless the types should be found, these two species must be relegated to the position of *nomina nuda*.

Genus DECADOCRINUS Wachsmuth & Springer 1879

Decadocrinus nereus (Hall) n. comb.

Plate 54, figures 11–15

1862 Poteriocrinus nereus Hall. 15th Ann. Rep't N. Y. State Cab. Nat. Hist., p. 121

1878 Poteriocrinus nereus Bigsby. Thesaurus Dev.-Carb., p. 20

1879 Pot. (Parisocrinus) nereus Wachsmuth & Springer. Rev. Palaeocr., pt. 1, p. 115 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 31:337

1889 Poteriocrinus nereus S. A. Miller. N. Amer. Geol. & Pal., p. 274

1903 Poteriocrinus nereus Clarke & Ruedemann. N. Y. State Mus. Bul. 65, p. 78

1904 Poteriocrinus nereus Clarke & Luther. N. Y. State Mus. Bul. 63, p. 52

Dorsal cup small, subpentagonally turbinate. Height in the type specimen 2.6 mm; width at the base 1.2 mm, at the top of the radials 3.8 mm.

Infrabasals short, minute, forming a narrow rim around the base of the body. Height in the type .5 mm or less, in an older specimen about .35 mm. Shorter, thickened and project slightly in the older form.

Basals hexagonal, longer than wide, an average one in the type giving the following measurements: height 1.4 mm, greatest width 1 mm. Slightly wider at the bottom and the lower lateral faces the longer, thus bringing the greatest width near the top of the basal.

Radials short, pentagonal; wider than high and thickened at their upper margins. An average one in the type has a height of about 1 mm and a breadth of 1.5 mm. Radial facet occupies practically the entire width of the upper face of the radial.

Posterior side not visible in the type specimen; shown in the older specimen (plate 54, figures 13–15). Radianal large, pentagonal and obliquely situated. Anal *x* pentagonal, only a little larger than the radianal; rests between the left posterior radial and the radianal. Probably an individual variation as the anal *x* usually rests upon the truncated posterior basal. Left posterior radial, for this reason, larger than the others. Anal x and radianal followed by a few rows of large hexagonal tube plates.

Tegmen. Most proximal part of the anal tube the only part preserved.

Arms. Two primibrachs. First short and quadrangular, as wide or wider than high; second, the primaxil, much longer and thickened at the extremities. No bifurcations above the primaxil, giving ten arms to the crown. Brachials long, usually nearly twice as long as wide, quadrangular or with a tendency to wedge-shape; thickened at the extremities and giving rise alternately on each side of the arm to slender, long-jointed pinnules.

Column missing in all the specimens figured; apparently obtusely subpentagonal near the base of the calyx. A fragmentary specimen shows a portion of the column a few millimeters from the base of the calyx. It is round and composed of joints of unequal thickness.

Ornamentation. Surface of dorsal cup and arms granulose or granulose-striate, though sometimes it appears to be smooth.

Horizon and locality. From the Hamilton (Moscow) shales. Holotype collected at Vincent, Ontario county; other specimens from Vincent and North Bristol, Ontario county, N. Y.

Types. Holotype in the collection of the New York State Museum, number $\frac{4473}{1}$.

Remarks. One of Hall's types of Poteriocrinus diffusus, number $\frac{4472}{2}$, does not belong to that species. It shows the characteristics of Decadocrinus nereus, and has been placed with this species (plate 54, figure 12). D. nereus shows characteristics which suggest the genus Decadocrinus rather than either Poteriocrinus or Parisocrinus, genera to which it has previously been assigned.

Decadocrinus gregarius Williams

Plate 54, figures 16, 17

1882 P o t e r i o c r i n u s (D e c a d o c r i n u s) g r e g a r i u s Williams. Proc. Acad. Nat. Sci. Phila., v. 34, pt. 1, pp. 22–27, pl. 1, figs. 6–8

1889 P o t e r i o c r i n u s g r e g a r i u s S. A. Miller. N. Amer. Geol. & Pal., p. 274

1896 P o t e r i o c r i n u s (D e c a d o c r i n u s) g r e g a r i u s Kindle. Bul. Amer. Pal., no. 6, p. 34

The material from which this species was described has not been available. Williams' original figures have been reproduced here, and the following description is based upon these figures and Williams' description.

Dorsal cup low and expanded due to the rapid enlargement of the consecutive series of plates.

Infrabasals pentagonal, minute.

Basals hexagonal, twice the size of the infrabasals, of about equal height and width and with the angles not sharply defined.

Radials pentagonal, broader than the basals but of about the same height. Radial facet almost straight, occupying the entire upper face of the radial.

Anals, and succeeding plates of the ventral tube not seen in all the specimens; but Williams concluded that the arrangement of the proximal plates is that characteristic of the genus P o t e r i o c r i n u s , except that the origin is frequently higher up in the calyx. One well-preserved specimen, without distortion, shows the normal arrangement of anals, three plates in contact with the plates of the cup; above the anals are shown distinctly three or four plates in each of the two series of the ventral tube. In several specimens the anals do not reach the basals. Various irregularities of the anals were noted by Williams but he thinks it may be accounted for by distortion of the specimens in preservation.

Tegmen not preserved.

Arms. Two primibrachs. First quadrangular, almost as broad as long and expanding slightly toward the top. Primaxil pentagonal; expands noticeably at the top so that the width here is about equal to the height. The two upper edges stand almost at right angles to each other and are subconcave.

Arms unbranched, long and spreading; an occasional specimen being found by Williams spread out radiately upon the surface of the slab. Brachials longer than wide, and bear pinnules alternately on each side. Occasionally a plate appears without a pinnule, but alternate order of pinnules not broken. After the first five or six plates the side of the brachial which bears the pinnule is slightly higher and extends laterally more than the other, showing a tendency toward wedge-shape. At the tenth or twelfth brachial, which Williams places as the center of the length of the arms, brachials a third longer than the average width; pinnules strong, gradually tapering to a point and composed of ten or twelve plates, the first about half the size of the base of the arm plate from which it starts. Shorter pinnules have six to eight ossicles.

Column expands a little just beneath the calyx; and here appears slightly pentagonal, but the angles are rounded and within an inch of the base of the calyx all trace of them is lost. Columnals convex externally and serrate at their union; just beneath the calyx, where they are thinnest, arranged in two sets, one thinner than the other in alternating order. According to Williams' description this alternation of columnals extends farther down the stem, but his figures do not show it. With distance from the calyx, size of the stem slightly diminishes; length of columnals increases until the difference between the two sets becomes obliterated and they reach a length equal to their diameter and are subglobular. Subglobular columnals of uniform size characteristic of the central part of the stems; serrate union inconspicuous here. Slender cirri present all along the stem; observed by Williams within an inch of the calyx; generally found rather closely coiled at their ends.

Horizon and locality. From the lower Chemung beds, 30 feet above the base, Ithaca, N. Y.

Types in the collection of the late Doctor H. S. Williams of Cornell University, Ithaca, N. Y.

Remarks. Williams distinguishes three varieties of this species, taken from the same stratum as the type specimen. His descriptions of them follow:

1 *Var.* alpha is distinguished by its smaller size, and the arms shorter and composed of fewer, more slender plates.

Those characters of the stem, peculiar to the terminal portion just under the calyx, are seen for only a very short distance.

The calyx and its plates do not differ, to any appreciable degree, from those of the specific type, in number, arrangement, relative size or shape.

2 *Var.* beta. The calyx is large, the plates well developed, the stem as large as in the typical form, and up to the base of the arms this variety appears identical with the type of the species, but the arms are exceedingly short — not more than six plates appearing in the longest arm preserved.

One of the arms begins with two full-size plates, starting out, and in shape like the typical form, but these plates are followed by three very slender plates the base of the first not filling completely the facet at the top of the preceding one. The arm adjoining it has one normal-sized plate, followed by four slender plates. The other arms, as far as they can be examined, show a like arrangement, and the explanation is unavoidable that the original arms were broken off and were being replaced by new arms not fully developed when growth and life were stopped and the hard parts buried and thus preserved to tell the story.

3 *Var.* gamma. A third variety is worth mentioning. In general characters it corresponds with *var.* alpha, but differs conspicuously in the plates of the ventral tube. At the base the anals are arranged as in the normal specimen, while the upper part appears to have special development.

There appears on the right side of the normal series of anal plates, beginning about half way up, a third series of plates about the same size as those at the corresponding height in the other series. The series, beginning lowest down, thus becomes the central one at the top, and eight plates can be counted in it. The lateral series have fewer plates, and the upper part loses itself in minute granulations at the base of the arms. (1882, pp. 24, 25.)

This species, represented by many specimens taken from a small locality, was found by Williams to show " considerable variation in length of arms, in the number, relative size and shape of the arm joints, in the character of the stem joints at the base of the calyx and a short distance below until the normal characters of the stem are reached, and in the number and arrangement of the more distal part of the plates following the anals. In these several respects the specimens under examination present hardly two which are uniform, and single specimens show more or less variation in the several rays." With this wide variation it hardly would be possible to recognize only three varieties; it seems as though many must be recognized, which is out of the question, or none.

Williams noted a strong resemblance of this species to Poteriocrinus diffusus Hall and P. ("Scaphiocrinus") aegina Hall from the study of the figures and descriptions, since he had not had access to the types; and suggests that specimens may eventually be found uniting all three species into one. This species with the ten pinnuliferous, unbranched arms belongs to the genus Decadocrinus and is quite distinct from the Hamilton Poteriocrinus (?) diffusus both in the character of the calyx and the arms. The species is likewise readily distinguished from the Waverly species, Decadocrinus aegina.

Decadocrinus decemnodosus sp. nov.

Plate 55, figure 6

This description is based upon a gutta-percha squeeze made from the mold of a single specimen from the Ithaca beds. The specimen as it stands shows a length for the crown of about 29 mm. The tips of the arms, however, are missing probably for a distance of about 12 mm, which gives a total length to the crown of approximately 40 mm or 41 mm.

Dorsal cup low and spreading with a height of 4 mm and a greatest width (at the radials) of 7 mm.

Infrabasals pentagonal, small, not more than .5 mm high, and almost concealed by the prominent basals.

Basals hexagonal, an average one having a height of 1.8 mm and a width of 2.3 mm; rendered very prominent by the presence of a strong node on each. Nodes project downward and outward; confined more to the lower portion of the basals.

Radials pentagonal, so far as observed; posterior radials not visible. An average radial has a height of 2 mm and a width of 3 mm. Radial facets slightly curved and do not occupy the entire upper face of the radials.

Tegmen. No part of tegmen or anal tube visible.

Arms. Two primibrachs of about equal height. First quadrangular; second, the primaxil, gives rise to two equal, pinnulate rami which do not branch. Arms when complete probably measured about 25 mm or 26 mm. First few brachials above the primaxil quadrangular; other brachials wedge-shaped. Pinnules borne on the longer alternating sides of the brachials; long and composed of many short ossicles. An average one measures about 8 mm.

Column. About 6.5 mm preserved; pentagonal with a diameter of 2.3 mm, and composed of thin columnals.

Ornamentation of this species consists in nodes and broad ridges. As mentioned above, there is a conspicuous, blunt node on each basal. From each basal a short broad ridge runs to the radial on each side where it joins a central broad low ridge on the radial. Each primaxil bears at the upper margin a rather sharp tubercle or node, central in position.

Horizon and locality. From the Portage (Ithaca) beds, in an outcrop in the highway three miles west of Morris, N. Y., on the road to New Berlin. D. D. Luther, collector, 1900.

Types. Holotype in the collection of the New York State Museum.

Remarks. The very characteristic ornamentation of this species makes it readily distinguishable. It has been referred to Decadocrinus though the radial facet is slightly curved and does not occupy the whole upper face of the radial, as in Poteriocrinus. This variation may be quite possible. All the other characters fulfil the requirements of this genus; and, since there is only one specimen to judge from, it seems better to place the species in the genus with which it shows the most agreements.

D. decemnodosus is readily distinguished from multinod o s u s , which it most resembles, by the absence of nodes on the arms, the absence of the short, wrinkled lines or striae on the plates of the cup and the arms and the presence of ridges or folds on the dorsal cup. Arms of m u l t i n o d o s u s have a more zigzag, irregular appearance.

Decadocrinus insolens sp. nov.

Plate 56, figures 3–5

As far as I am aware this is the only species of this genus from the Genesee beds; and there are in the New York State Museum just three representatives. One is in the form of a mold and shows the crown and about 10 mm of column; another shows the dorsal cup and 1.3 mm of column; in the third, the column is missing but the dorsal cup is free and though crushed shows the character of both sides and the proximal portion of the arms in the two rays. In all cases the dorsal cup is more or less crushed.

Dorsal cup in all the specimens so crushed that no accurate measurements can be taken. Various heights of the dorsal cups in the three specimens 3.7 mm, 4 mm and 4.1 mm; widths in the case of the last two respectively 6.2 mm and 7 mm. First specimen too crushed to consider its measurement in width; width in the other two specimens exaggerated. However, allowing for the crushed condition, dorsal cup undoubtedly noticeably wider than high.

Infrabasals pentagonal, small, average ones giving heights of .9 mm and 1 mm.

Basals hexagonal, except the posterior and right posterolateral which are heptagonal. Posterior truncated above for the support of the anal *x*, and bears the radianal on the right shoulder; right posterolateral truncated for the support of the right posterior radial, and bears the radianal on its left shoulder. Average basals give the measurements: height 2.1 mm, width 2.4 mm; height 2 mm, width 2.2 mm; height 1.8 mm, width 2 mm. Posterior and right posterolateral basals tend to be the largest.

Radials pentagonal, broader than high. Average radials give the measurements: height 1.4 mm, width 2.1 mm; height 1.3 mm, width 2.2 mm; height 1.4 mm, width 2.2 mm. Radial facet practically straight and occupies almost the entire width of the radial.

Radianal large and pentagonal. In the best preserved specimen height and greatest width 2 mm. Anal *x* hexagonal and of about the same size as the radianal. First tube plates large; right tube plate almost as large as the radianal and anal *x*.

Tegmen not preserved beyond the first few large plates of the anal tube.

Arms. Two primibrachs, both short and broader than high. First quadrangular; second, the primaxil, pentagonal, broadening out at the top and giving rise to two equal arms. Ten arms to the crown. Arms have a length of about 22 mm; composed of short, wedge-shaped brachials bearing pinnules alternately on each side of the arm.

Column rather large for the size of the specimen. Expands slightly just beneath the dorsal cup; subpentagonal in the most proximal portion, becoming rounded below. Throughout its length, so far as preserved, composed of thin columnals all of the same size.

Horizon and locality. From the Genesee (West River shale) beds (Melocrinus clarkei layer), at Blacksmith gully, Bristol, N. Y.

Types. Cotypes in the New York State Museum.

Remarks. Species quite characteristic and may be readily recognized. It differs from D. nereus in a number of respects. In nereus, infrabasals smaller and basals relatively longer and narrower. In insolens, primibrachs shorter, brachials comparatively much shorter and pronouncedly wedge-shaped. Column in insolens large for the size of the specimen and entirely composed of thin columnals all of the same size. No surface ornamentation present in the species.

D. insolens differs from D. rugistriatus in its larger size, comparatively larger infrabasals, broader basals and shorter primibrachs. Brachials in the former much shorter and more strongly wedge-shaped. Column larger for the size of the specimen; columnals thin and all of the same size, whereas in rugistriatus they vary in size and the column has a beaded appearance. No striking surface ornamentation as in the case of D. rugistriatus.

The name insolens is given to this form because of its unusual, rare occurrence.

Decadocrinus killawogensis sp. nov.

Plate 54, figures 18, 19

Description based upon two specimens from the Portage beds, which occur in the form of molds. Details of description taken from gutta-percha squeezes, and based mainly on the more perfect specimen. Arms not spreading, giving a narrow, elongated appearance to the crown. Crown, when the missing arm tips were present, probably measured about 40 mm.

Dorsal cup low, having a height of 2.6 mm and a width at the radials of 4.4 mm.

Infrabasals small, measuring about .5 mm in height.

Only one basal, the right posterior, entirely visible; heptagonal, with a height of 1.1 mm and a width of 1.3 mm. Posterior basal which borders the anal and radianal heptagonal also. Other basals probably hexagonal, as usual.

Radials pentagonal, an average one giving the measurements: height 1.1 mm, width 1.4 mm. Radial facet occupies the entire upper face of the radial.

Anal area only partially exposed, but it shows the pentagonal radianal and the anal *x*.

Tegmen. Only a small portion of base of the anal tube exposed. Plates comparatively large and hexagonal.

Arms. Two primibrachs. First quadrangular, with a width and height of about 1.2 mm. Primaxil broadens out in its distal portion, having a height of 1.8 mm and a width at the top of 2.1 mm; gives rise to equal, pinnulate rami which remain unbranched throughout. The appearance of the brachials is rather difficult to get in a figure. Brachials short, varying little in height, wedge-shaped. Pinnules borne alternately on each side; each brachial extended in this part into a slight protuberance for the support of the pinnule, which in the specimen gives a more irregular, slightly zigzag, effect to the arms than appears in the figure. An average pinnule measures about 2.8 mm in length. Pinnules composed of comparatively long ossicles.

Column. In the more complete specimen only 5 mm preserved; character not well shown. The less perfect specimen shows a little over 20 mm well preserved; strongly pentagonal and composed of three sizes of columnals. Every eighth columnal is a nodal, enlarged and projecting. Midway between these two nodals is a middle-sized, slightly projecting columnal; and between this and the nodal immediately above and below are three internodals. Nodals, and to a slight extent the internodals, thickened at the angles of the column, increasing the pentagonal effect.

Horizon and locality. One specimen comes from the Portage (Ithaca) beds, Killawog creek, west of Killawog; the other from the Grimes sandstone (Portage), Parrish gully, near Naples, N. Y.

Types. Holotype and paratype in the collection of the New York State Museum.

Remarks. Specific name taken from the locality in which the most perfect specimen of the species was found.

The species is quite distinctive. The general long, slender character of the calyx, the low cup and the slightly wedge-shaped brachials with rather stout pinnules make it readily distinguishable.

Decadocrinus multinodosus sp. nov.

Plate 55, figures 7–11

Description based upon five specimens from the Hamilton shales of Cashong creek, Yates county, N. Y. Two specimens are free calyces; two, incomplete crowns imbedded in the rock. In these last specimens the distal portions of the arms are missing; but when they were present the crown probably had a length of approximately 40 mm. The fifth specimen shows a portion of the arms of an older specimen.

Dorsal cup low and broad; height 4 mm or 5 mm, greatest width (at the radials) 9.5 mm.

Infrabasals very small and hidden by the projecting nodes on the basals.

Basals pentagonal and very conspicuous owing to the presence of very strong nodes. Height of average basal 2.6 mm, breadth 3 mm.

Radials shield-shaped, roughly pentagonal, an average one having a height of 2.3 mm and a breadth of 3.2 mm. Radial facet almost straight, occupying nearly the entire width of the radial.

Radianal pentagonal, as large as the basals. Anal *x* hexagonal, smaller than the radianal and projecting above the radials.

Tegmen. Only a few plates of the anal tube present. Right tube plate hexagonal, as large as the anal *x*. Succeeding plates become smaller; hexagonal.

Arms. Two primibrachs. First quadrangular and of about equal width and height; primaxil longer and pentagonal. No bifurcations above this point. Brachials more or less wedge-shaped, the wedge-shaped character more conspicuous in more mature forms. Pinnules borne on alternating sides; composed of long ossicles, and with a dorsal keel running the entire length of each.

Column. No part present. Judging from the cicatrix pentagonal.

Ornamentation. Each basal provided with a very prominent blunt-pointed node which extends outward and slightly downward. A strong, rather sharp node also borne by each of the primaxils, just below the point of bifurcation. A faint, blunt node, not always very distinct, occurs on each first primibrach, on the anal *x*, radianal, and on the lower tube plates. Each brachial provided with a small, sharp node near its upper border; from this a keel slopes down to the next lower brachial. Nodes and keels arranged in a zigzag line which gives an irregular, serrated appearance to the arms. On the arms of older specimens (plate 55, figures 10, 11) character of ornamentation somewhat changed. Keel on brachials less prominent; nodes blunter and broader in some cases, giving the effect of a thickened, projecting rim at the upper (distal) edge of the brachials.

In addition to the nodes, plates of dorsal cup further ornamented with short wrinkled lines or striae. On the basals they radiate in from the edges even up on the basal node; on the radials and primibrachs they are more or less longitudinal; and on the brachials they break up into a granulose state. In one specimen (plate 55, figures 8, 9) the calyx plates in general show a tendency to granulose surface markings.

Horizon and locality. From the Hamilton (Moscow) shales, Cashong creek, near Bellona, N. Y. One specimen (plate 55, figure 7) on slab with types of Botryocrinus sentosus and Logocrinus geniculatus.

Types. Cotypes in the New York State Museum.

Remarks. The species which most nearly resembles D. multinodosus is the Portage species D. decemnodosus. The latter only has the nodes on the basals and primaxils. It lacks the wrinkled lines or striae characteristic of multinodosus, while the latter does not possess the ridges of decemnodosus. The arms of multinodosus have a more irregular, zigzag appearance due to the presence of the keeled nodes on the brachials.

Decadocrinus multinodosus var. **serratobrachiatus** nov.

Plate 56, figures 1, 2

Variety based upon a single well-preserved and very characteristic specimen. Specimen of average size, the crown measuring, with the arms extended, about 50 mm.

Dorsal cup somewhat lower than in D. multinodosus; somewhat crushed, but appears to have a height to the top of the radials of about 3 mm and a width at the radials of between 8 mm and 9 mm. Primibrachs shorter and broader and in contact in all the rays, giving an appearance of greater depth to the cup.

Ornamentation of this variety very striking. The most noticeable ornamentation is that of the basals (if present), primaxils and arms. There is every reason to believe that the basals of this specimen were each provided with a spinelike node. The specimen is imperfect in this respect, but the basals show the cleavage surfaces where the nodes or spines have been broken off. One of the specimens of Decadocrinus multinodosus shows just such a cleavage surface where one basal has lost its node. Each primaxil, just below the point of bifurcation bears a tooth-like spine about 1.5 mm long. Each brachial, also, provided with a short tooth-like spine, the spines pointing alternately to one side and then to the other, giving a very pronounced saw-toothed appearance to the arms. In addition to spines, the specimen is further ornamented with strong granulose-striate markings on the plates of the cup and arms. These markings have a longitudinal arrangement on the plates of the dorsal cup and the primibrachs; on the primaxil the striae extend up onto the spine, converging toward the tip. On the brachials above this point these markings have a transverse arrangement, becoming more granulose in the distal portions of the arms. Some of the proximal ossicles of the pinnules slightly granulose.

Horizon and locality. From the Hamilton (Moscow shale) beds, Cashong creek, near Bellona, N. Y.

Types. Holotype in the collection of the New York State Museum.

Remarks. I was at first inclined to regard this specimen as an old form of D. multinodosus and a fuller series of specimens may yet prove it so. At present, however, I feel justified in maintaining it as a variety, particularly on account of the striking character of the arms. In D. multinodosus, so far as can be ascertained from the few specimens at hand, the tendency in the older forms is for the keels on the brachials to disappear and the nodes or spines to become blunter and broader.

Decadocrinus rugistriatus sp. nov.

Plate 55, figures 1–5

This graceful little species is represented in the New York State Museum by a number of specimens from the Portage rocks of the western part of the State. The crown probably had a length, with the arms extended, of from 17 mm to 18 mm in the smaller specimens to about 25 mm in the larger specimen.

Dorsal cup low and spreading, with an average height of 2 mm and a width at the radials of 4 mm. Measurements of the dorsal cup vary slightly, but in general the cup has a width nearly twice the height.

Infrabasals small, scarcely visible in some specimens.

Basals hexagonal, except the posterior and right posterolateral which are heptagonal, being in contact with the plates of the anal area. Narrow at the base and widen upward; subequal, an average one having a height and greatest width of about 1 mm.

Radials pentagonal, larger than the basals, slightly thickened at the radial facet. An average radial, in the same specimen from which the measurements of the basal were taken, has a height of about 1 mm and a greatest width of about 1.6 mm. Posterior radials slightly smaller than the others. Radial facet occupies about three-quarters of the upper face of the radial.

Anal *x* hexagonal, smaller than the radials and extending above them. Radianal pentagonal.

Tegmen. Lower part of anal tube cylindrical, of narrow diameter, composed of rather large-sized hexagonal plates; distal part expanded. Tube not visible to any extent except in one specimen in which it is incomplete; so it is impossible to determine the length.

Arms. Two primibrachs. In most of the specimens, first primibrach short and primaxil elongated. In one specimen (plate 55, figure 4) there is no very noticeable difference. Arms do not bifurcate above the primaxil. Brachials in general have a tendency to wedge-shape. In a few of the specimens (plate 55, figures 1, 2, 5) the brachials seem to be longer and more slender with less tendency toward wedge-shaped. The figures for these specimens were made from gutta-percha squeezes taken from the molds of the specimens. Pinnules borne by the brachials alternately on each side of the arm; brachials project slightly on the side on which the pinnule is borne, thus giving a slightly zigzag appearance to the arms.

Column just below the calyx subpentagonal, but it soon becomes round. Composed of two kinds of columnals, thin ones with rounded edges and thick subglobular ones. The first few proximal columnals ar thin, then the thin and thick ones alternate, or sometimes there will be two or three thin columnals between two thick ones. This gives the stem a beaded appearance. Distal portion of the stem cirriferous, and here the columnals are all more nearly of the same thickness. Margins of all columnals crenulate.

Ornamentation shown particularly well on two of the specimens (plate 55, figures 3, 4). Primibrachs and the higher brachials to the tips of the arms give the appearance of a shriveled, young twig. Striae weaker or lacking on the cup plates, or the effect may be granulose-striate.

Horizon and locality. Majority of specimens collected by D. Dana Luther from the Portage (West Hill flags) beds, Italy hollow, near Naples, N. Y. Several smaller specimens of the species found on slabs from the Ithaca beds, near Ithaca.

Types. Cotypes in the collection of the New York State Museum.

Remarks. The only species which these specimens resemble at all closely is Decadocrinus nereus. There are enough differences, however, to keep them distinct as a species. Basals and infrabasals in nereus longer and more slender. Radials in nereus smaller than the basals; in rugistriatus larger. The result of all this is that rugistriatus has a lower more spreading cup. Arms of rugistriatus strongly striate to the tips, and have more of a zigzag effect due to the wedge-shaped tendency of the brachials. In very much weathered specimens the striations on the arms are scarcely visible, but there are enough distinctive characters without this.

Genus COREMATOCRINUS nov.

[Ety. κόρημα, *brush;* κρινον, *lily*]

This genus has been created to contain a new species which shows some of the characteristics of Decadocrinus, but which will not fit into that genus. Calyx rather low and broad. Anal plates (*see* analysis of cup, text figure 60) somewhat similar in arrangement to those of the genus Zeacrinus (Bather, 1900, p. 180), but the radianal is hexagonal, coming in contact with the radial on each side as well as with the posterior and right posterior basals below and the anal *x* and right tube plate above. Arms strictly isotomous, branching but once and giving ten arms to the ray. Brachials quadrangular in the lower part, becoming wedge-shaped above; they bear pinnules alternately on each side. Column strongly pentagonal.

Genotype. Corematocrinus plumosus sp. nov.

Distribution. Upper Devonian (Portage and lower Chemung) of New York.

Corematocrinus plumosus sp. nov.

Plate 56, figures 6–9; text figure 60

Species based upon specimens from the Portage (Gardeau) and Chemung beds. Three of the figures (plate 56, figures 6, 7, 8) were made from the Chemung specimens. The specimens from the Gardeau beds are not in very good condition, though most of the crown is preserved. One specimen, though only a poor squeeze was obtained from it, is figured on plate 56, figure 9, to show the character of the distal parts of the arms and the pinnules, which are not shown in the Chemung forms. The crown probably had a length of about 50 mm in an average specimen.

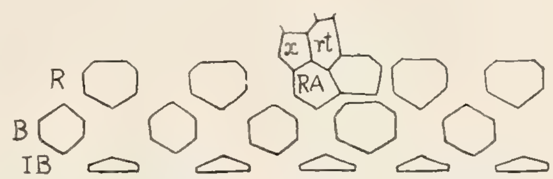

Figure 60 Analysis of the calyx of Corematocrinus plumosus, the genotype.

Dorsal cup low and spreading, having a width about twice its height. Height in one specimen 4 mm, width 7.5 mm; in a second specimen, height 3.1 mm and width 6.3 mm; in a third, height 3 mm and width 6 mm.

Infrabasals very small, pentagonal; vary from .5 mm to 1 mm in height in different specimens.

Four of the basals hexagonal, the fifth, the right posterolateral, heptagonal (*see* analysis of cup, text figure 60). Subequal in height and width, and almost as large as the radials. Posterior basal and right postero-lateral a little larger than the others.

Three radials roughly pentagonal; two, the right and left posterior, hexagonal. Right posterior radial borders the radianal, the right tube plate, the right anterolateral radial, and right posterolateral basal; left posterior radial borders the left anterolateral radial, the posterior and left posterolateral basals, the radianal and anal *x*. Radials average about 2 mm in height and 2.5 mm in width.

Radianal large, hexagonal, having in the largest specimen (plate 56, figure 6) a height of 2.4 mm and a width of 2 mm. It rests between the posterior and right posterolateral basals, is bordered at the left by the left posterior radial, at the right by the right posterior radial, and above by the anal *x* at the left and the right tube plate at the right. Anal *x* smaller than the radianal, pentagonal; rests upon the left posterior radial and the radianal below, bordered above by the tube plates.

Tegmen. Lower tube plates large and hexagonal; tube of narrow diameter. After a short distance, the tube broadens out; the plates become smaller and are arranged in rows. This is shown in one of the Portage specimens, though it is in a very poorly preserved condition. Lower plates of the tube shown in a drawing (figure 9) of one side of this specimen which was introduced to show the characteristics of the arms not shown by the others.

Arms. Two primibrachs, each of about equal height and breadth. First quadrangular; the second pentagonal. Arms, so far as known, do not branch above the primaxil. First two or three brachials above the primaxil quadrangular; then they become wedge-shaped, a character more pronounced in the upper parts of the arms. Pinnules long and fairly stout, composed of long ossicles; borne alternately on each side of the arm.

Column strongly pentagonal, composed of columnals of alternating thicknesses, with rounded edges and somewhat thickened at the angles. At variable distances, occurs a conspicuously thicker columnal, the nodal.

Nodals closer together proximally, but the usual number of internodals is seven, making every eighth columnal a nodal. As far as preserved, stem bears no cirri.

Ornamentation of this species very slight. Plates of the dorsal cup show incipient ridges and furrows at their borders, but never strongly developed. Lower plates of the anal tube show the same characteristic. A few disconnected plates of the higher portion of the tube, shown in one specimen, would indicate that ridges are more strongly developed there.

Horizon and locality. From the lower Chemung beds, Chemung Narrows, Chemung county, N. Y.; and from the Portage (Gardeau sandstone) beds, Deyo basin, two miles south of Naples, N. Y.

Types. Cotypes in the possession of the New York State Museum.

Remarks. This species can readily be distinguished from other species. Without the posterior side it can be distinguished from P. clarkei, to which it bears a resemblance, by the shorter basals and infrabasals, giving a lower dorsal cup, and by the fainter ridges and furrows on the plates of the cup; the second primibrach, the primaxil, is longer and more expanded at the top in P. clarkei, and the brachials are quadrangular.

Genus LOGOCRINUS nov.

[Ety. λόγος, *a relation;* κρινον, *lily*]

Genus created to contain the two species Logocrinus geniculatus and Logocrinus infundibuliformis. They would fit into the genus Scytalocrinus except for the character of the pinnulation. Calyx of the Scytalocrinus type; elongate as in that genus. Arms cylindrical, strictly isotomous, branching but once; pinnules given off from every pair of brachials alternately on each side. Brachials quadrangular to wedge-shaped. Column round.

Genotype. Logocrinus geniculatus sp. nov.

Distribution. Devonian (Hamilton-Chemung) of New York.

Logocrinus geniculatus sp. nov.

Plate 57, figures 1–6

Species based upon ten specimens, nine from Cashong creek, near Bellona, N. Y., and one from Canandaigua lake, in various stages of preservation. One specimen shows a crushed calyx, but the arms are very well preserved; four specimens, one partly imbedded in matrix, three free, are calyces; and five specimens partially imbedded in the rock show the calyx and varying portions of the arms; two of them show the anal region very well. One of these last (plate 57, figure 1) shows about 35 mm of stem. The cup appears to have a different shape from that of the other specimens partly because of the view, partly because it is slightly crushed. Crown with the arms extended probably measured about 35 mm.

Dorsal cup of average size and bell-shaped; shown very well in figure 2.

Infrabasals pentagonal, wider at the top than at the base; large, over half as long as the basals.

Three of the basals hexagonal; two, the posterior and right postero-lateral, heptagonal, since they border the plates of the anal area. Posterior basals larger than the others. Basals about as wide as long, as large or slightly larger than the radials.

Radials pentagonal, the two posterior ones smaller than the other. They flare out slightly near the tops which, with the bulging at the base of the cup, gives the characteristic bell-shape. Radial facet straight, occupying practically the entire upper face of the radial.

Radianal pentagonal, fairly large, of about the size of the infrabasals. It rests upon the posterior and right posterior basals and is bordered above by the anal x, the right tube plate and the right posterior radial. Anal x hexagonal, smaller than the posterior radials, not much larger than the radianal; its upper edge on a level with, or slightly above, the upper edge of the radials.

Tegmen. Only the lower plates of the anal tube exposed; large, hexagonal and arranged in vertical rows.

Arms. In two specimens showing the arms on the anterior side there are three primibrachs in the anterior and right and left anterolateral rays. The arm of the right posterior ray, in the only specimen where this arm is preserved, shows three primibrachs. Another specimen (plate 57, figure 3) shows the arms of the left posterior and right anterolateral rays with two primibrachs each. Where there are two primibrachs to the ray they are longer. First primibrach wide at the base, approximately as wide as the radial; narrows down to half that width at its upper edge. Second primibrach narrow; primaxil (third or second primibrach) widens slightly just below the bifurcation. Arms apparently do not branch above the primaxils; very characteristic.

Arms composed of more or less wedge-shaped brachials which in pairs have a somewhat hourglass shape. The lower member of each pair has a broad lower face from which the sides of the brachial slope to a narrow upper face in contact with the narrow lower face of the second and upper member of the pair. From this latter face the second brachial of the pair broadens out to a broad upper face similar to the broad lower face of the first member of the pair. The lower face of the first brachial of the pair and the upper face of the second have a decided slope in opposite directions. Pairs of brachials joined together so that they make very decided and conspicuous knee- or elbow-like bends, first in one direction and then in the other, thus giving to the arms an exaggerated angular, zigzag appearance. Pinnules borne by every pair of brachials, at the large joints only, alternately on each side of the arms; long and slender and made up of long ossicles. One pinnule, fairly complete, measures about 10 mm in length.

Column slightly subpentagonal just at the base of the calyx, but quickly becomes round. Columnals all thin with rounded edges. Two sizes of columnals; one or two very thin ones sometimes occur between the heavier ones.

Horizon and locality. From the Hamilton (Moscow shale) beds; Cashong creek, near Bellona, and at Menteth's point, Canandaigua lake, N. Y. Two of the Cashong creek specimens occur on the slab with

Botryocrinus sentosus sp. nov. and Decadocrinus multinodosus sp. nov.

Types. Cotypes, and the rest of the Cashong creek specimens, in the collection of the New York State Museum. Canandaigua lake specimen in the collection of Rochester University.

Remarks. This species may, in general, be distinguished from all the other similar species by the shape of the cup and the very characteristic arms. In case the arms were missing the shape of the cup and broad arm facets would distinguish it from Poteriocrinus diffusus, dignatus, and nassa. Poteriocrinus nassa is a larger form, and the basals are narrower in proportion to their height.

Logocrinus infundibuliformis sp. nov.

Plate 57, figures 7–11

Species represented by molds in the Chemung sandstone; description based on gutta-percha squeezes made from the molds.

Dorsal cup funnel-shaped when seen from the anterior side; bulges in the anal region, so that a posterolateral view gives a more bowl-shaped appearance. Height in one specimen 4.2 mm, width at the base 1.3 mm and at the radials 4.2 mm; in another specimen, height 4.6 mm, width at the base 1.8 mm and at the radials 4.7 mm.

Infrabasals large, pentagonal, lateral faces the longest. An average one has a height of 1.6 mm and a width at the top of 1.3 mm.

Three of the basals hexagonal. Posterior and right posterolateral larger and heptagonal, being bordered by the anal plates in addition to the others. An average basal has a height of 2 mm and a width of 1.4 mm.

Radials pentagonal, the two lateral faces the longest. An average plate has a height and greatest width of about 2 mm. Posterior radials smaller than the others. Radial facet as wide as the radial.

Anal area visible in two specimens. Radianal pentagonal, large; anal *x* pentagonal, sometimes smaller than the radianal.

Tegmen. Anal *x* and the radianal followed by several large, hexagonal plates. Anal tube long and slender, probably reaching almost to the arm tips; after the first few large plates, apparently composed of vertical rows of short, broad plates. A median dorsal ridge seems to extend the full length of the tube. Specimens poorly preserved in this region, and squeezes consequently do not show the features clearly.

Arms. Two primibrachs, which together have an hourglass appearance. First primibrach has the appearance of a truncated triangle, the upper face being about one-half as wide as the lower face. Primaxil pentagonal; gradually broadens out from the base until at its broadest part, just below the point of bifurcation, it has a width one-third greater than at the base. In one specimen (plate 57, figure 7) the arms on the ventral side show only a couple of brachials above the primaxil and these are quadrangular. In other specimens (figures 8, 9, 10) arms better preserved, though still very imperfect. Brachials quadrangular to slightly wedge-shaped; every second one bears a pinnule alternately on each side of the arm, giving a slightly zigzag effect to the arms. Pinnules composed of long ossicles.

Column round and slender; 30 mm preserved in one specimen. Diameter at base of calyx 1.6 mm; slightly angled; columnals very short. Gradually tapers until at a distance of 4 mm from the calyx it has a diameter of .7 mm which it maintains, practically, for the rest of its extent. This gives a very characteristic appearance to the stem. Columnals in the more distal part of the stem longer than the proximal ones; fairly constant in length throughout.

Horizon and locality. From the lower Chemung beds, Chemung Narrows, Chemung county, N. Y.

Types. Cotypes in the collection of the New York State Museum.

Remarks. Logocrinus infundibuliformis bears a resemblance to Scytalocrinus vanhornei. It may be distinguished by the character of the column, the shape of the primibrachs and the pinnulation. The brachials in S. vanhornei are wedge-shaped and each is pinnule-bearing.

INCERTAE SEDIS

Family (?)

Genus ASPIDOCRINUS Hall 1859

Aspidocrinus scutelliformis Hall

Plate 59, figures 6, 7

1859 Aspidocrinus scutelliformis Hall. Pal. N. Y., 3:122, pl. 5, figs. 15–18

1868 Aspidocrinus scutelliformis Shumard. Trans. Acad. Sci. St Louis, 2:355

1877 Aspidocrinus scutelliformis S. A. Miller. Amer. Pal. Foss., p. 71

1889 Aspidocrinus scutelliformis S. A. Miller. N. Amer. Geol. & Pal., p. 226

1899 Aspidocrinus scutelliformis Whitfield & Hovey Bul. Amer. Mus. Nat. Hist., v. 11, pt. 2, p. 88

1900 Aspidocrinus scutelliformis Schuchert. Bul. Geol. Soc. Amer., 11:280

1905 Aspidocrinus scutelliformis Talbot. Amer. Jour. Sci., 20:31

1910 Aspidocrinus scutelliformis Grabau & Shimer. N. Amer. Index Foss., 2:569

This species and the two following represent basal expansions of crinoid columns. Base scutelliform, concavo-convex, depressed hemispheric, with a smooth or finely granulated surface. Column unknown; point of attachment small and circular. In describing this form Hall says:

These bases of this species of Aspidocrinus are extremely abundant in the upper part of the shaly limestone of the Lower Helderberg group, and sometimes form by themselves mainly, and with other fragments of crinoids, a stratum which, from the abundance of these forms, was originally designated in the Annual Geological Reports of New York as the "Scutella limestone." This rock is so filled with these remains that many thousands may be counted in the space of a few yards; and the other portions of the rock are made up in great measure of these broken cups and other crinoidal remains. In some parts of the rock they become rare, and in its western and northwestern extension are at present unknown. Although fragments of undetermined columns are abundant in the formation, I have not thus far been able to identify any of them as belonging to this species.

Horizon and locality. From the upper part of the New Scotland limestone and the Becraft limestone in the Helderberg mountains and Schoharie; from the Becraft limestone, Becraft mountain, near Hudson, N. Y.

Types. Cotypes in the American Museum of Natural History, number 2291.

Remarks. This species was originally described by Hall as the basal disk of a crinoid of which the radial plates and arms were unknown, and in a paper Miss Talbot (1905, p. 31) inclines to the same view. All the species of Aspidocrinus are generally regarded as roots or basal expansions of crinoidal columns. They were doubtfully listed as such by Wachsmuth and Springer (1882, p. 402). Bather (1900, p. 201) lists them as crinoidal roots; Grabau and Shimer (1910, v. 2, p. 569) cite them as roots or bases; and Kirk (1911, p. 63) refers to them as "basal expansions of some apparently adult crinoid column."

Aspidocrinus digitatus Hall

Plate 59, figures 8, 9

1859 Aspidocrinus digitatus Hall. Pal. N. Y., 3:123, pl. 5, figs. 19, 20
1868 Aspidocrinus digitatus Shumard. Trans. Acad. Sci. St Louis, 2:355
1877 Aspidocrinus digitatus S. A. Miller. Amer. Pal. Foss., p. 71
1889 Aspidocrinus digitatus S. A. Miller. N. Amer. Geol. & Pal., p. 226
1899 Aspidocrinus digitatus Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 2, p. 88
1900 Aspidocrinus digitatus Schuchert. Bul. Geol. Soc. Amer., 11:280
1903 Aspidocrinus digitatus Clarke & Ruedemann. N. Y. State Mus. Bul. 65, p. 65
1905 Aspidocrinus digitatus Talbot. Amer. Jour. Sci., 20:31

This basal expansion smaller than scutelliformis, concavo-convex, and depressed conical in side view. From about the middle made up of a number of finger-like radiating divisions which terminate abruptly. Point of attachment of column small, circular and sunk in a small depression.

Horizon and locality. From the New Scotland limestone, Schoharie, N. Y.

Types. Holotype in the New York State Museum.

Remarks. See *Remarks* under Aspidocrinus scutelliformis.

Aspidocrinus callosus Hall

Plate 59, figures 10–12

1859 Aspidocrinus callosus Hall. Pal. N. Y., 3:123, pl. 5, figs. 13, 14
1868 Aspidocrinus callosus Shumard. Trans. Acad. Sci. St Louis, 2:355
1877 Aspidocrinus callosus S. A. Miller. Amer. Pal. Foss., p. 71
1889 Aspidocrinus callosus S. A. Miller. N. Amer. Geol. & Pal., p. 226
1899 Aspidocrinus callosus Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 2, p. 88
1900 Aspidocrinus callosus Schuchert. Bul. Geol. Soc. Amer., 11:280
1905 Aspidocrinus callosus Talbot. Amer. Jour. Sci., 20:31

A very small base, rounded or somewhat quadrangular in outline, slightly convex, with a shallow central depression at the base of which is the small circular place of attachment of the column. Margin with prominent round points or nodes which are thickened.

Horizon and locality. From the New Scotland limestone, Helderberg mountains and Schoharie, N. Y.

Types. Holotype in the American Museum of Natural History, number 2289.

Remarks. See *Remarks* under Aspidocrinus scutelliformis.

Aspidocrinus onondagensis sp. nov.

Plate 59, figure 13

A single specimen of Aspidocrinus has been found in the Onondaga limestone. While recognizing it as the root or base of a crinoid, a name has been given to it here as a means of separation from the other forms placed in this genus. Species quite similar to A. scutelliformis, but more flattened, less concavo-convex and the point of attachment for the column large and circular and deeply sunk into the base. Margin of base very irregular, and may be best described as extended into irregular lobes or processes.

Horizon and locality. From the Onondaga limestone, Limerock, Genesee county, N. Y.

Types. Holotype in the New York State Museum.

Remarks. See *Remarks* under Aspidocrinus scutelliformis.

Family EDRIOCRINIDAE S. A. Miller (Talbot)

Genus EDRIOCRINUS Hall 1859 (em. Springer 1920)

The genus Edriocrinus has recently been revised by Springer (1920, pp. 443–448) in connection with the Crinoidea Flexibilia. Through his courtesy I have had, for reference, the proof sheets covering this genus and a photographic reproduction, natural size, of his Plate 76, some of the figures from which are reproduced here in text figures 61–63.

Springer describes nine species (pocilliformis, occidentalis, explicatus, dispansus, sacculus, becraftensis, adhaerans, pyriformis, holopoides), four new ones in addition to the five previously described; and shows by unquestionable evidence in four of them (occidentalis, explicatus, dispansus, holopoides) that Edriocrinus is a monocyclic crinoid with four basals, as in Melocrinus and associated genera (*see* text figures 61–63). His generic description is as follows:


A B

Figure 61 Bases of Edriocrinus showing the four basals. A, E. occidentalis Springer, ventral view, x 2; B, E. explicatus Springer, dorsal view, x 3/2. (After Springer 1920; see text figures 62 and 63).

Crinoids without stem; either permanently attached directly by the base, or free in the adult stage. Monocyclic; basals four, fused into a more or less hollow mass (hereinafter simply called the base) with sutures usually obliterated by secondary growth. Radials in contact all around except at the anal side. Anal plate in line with radials, usually projecting above their level. Radial facets filling distal face of radials. Arms dichotomous. Pinnules probably wanting.

Three of the new species described by Springer are from the Helderbergian, Linden formation, of Tennessee — occidentalis (also in equivalent New Scotland formation of Virginia), explicatus, adhaerans (associated with dispansus, smaller, similar, but sessile). The fourth species, E. holopoides, occurs in the Oriskany sandstone, Cumberberland, Md., associated with E. sacculus, but, unlike that form, sessile in the adult stage. All of these Oriskany specimens were previously regarded as belonging to E. sacculus.

The genus Edriocrinus is divided by Springer into two groups: (1) species free in the adult stage with fused basals rounded below; (2) species attached through life by encrusting base adapted to the form of the objects to which attached. In the first group are found pocilliformis, occidentalis, explicatus, dispansus, sacculus, becraftensis; in the second group, adhaerans, pyriformis, holopoides. From this it is seen that the majority of the species are free in the adult stage. Of the species occurring in New York State, pyriformis is the only one attached throughout life, and Springer points out that this species is not quite constant in the sessile base (*see* description of species).

The discovery of the structure of the base of Edriocrinus by Springer definitely removes the genus from connection with the Flexibilia as now limited. He notes the remarkable superficial resemblance to the recent Holopus, pointing out that Austin Clark does not think it possible that Edriocrinus can be closely related to this genus. In the course of his discussion he states (ref. cit., p. 447):

The two doubtless represent parallel modifications of independent stocks, resulting from their encounter with similar physical conditions. There is no evident connection between Edriocrinus and any other Devonian or pre-Devonian form, unless the newly discovered fact of the four basals may suggest some remote relation to the Melocrinoidea.

The diagnosis of the family Edriocrinidae, established by

Miss Talbot (1905, p. 20), as well as her emended generic description, was based chiefly upon specimens of *E. pocilliformis* to which she gave an erroneous interpretation.

Edriocrinus pocilliformis Hall

Plate 58, figures 9–15

1859 *Edriocrinus pocilliformis* Hall. Pal. N. Y., v. 3, pl. 5, figs. 8–10

1868 *Edriocrinus pocilliformis* Shumard. Trans. Acad. Sci. St Louis,, 2:368

1868 *Edriocrinus pocilliformis* Meek & Worthen. Rep't Geol. Surv. Ill., 3:370, pl. 7, figs. 5*a*, 5*b*

1877 *Edriocrinus pocilliformis* S. A. Miller. Amer. Pal. Foss., p. 77

1886 *Edriocrinus pocilliformis* Wachsmuth & Springer. Rev. Palaeocr. pt. 3, p. 266 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 38:190

1889 *Edriocrinus pocilliformis* S. A. Miller. N. Amer. Geol. & Pal., p. 242

1894 *Edriocrinus pocilliformis* Keyes. Geol. Surv. Mo., 4:221, pl. 30, fig. 7

1899 *Edriocrinus pocilliformis* Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 2, p. 90

1900 *Edriocrinus pocilliformis* Schuchert. Bul. Geol. Soc. Amer., 11:279

1903 *Edriocrinus pocilliformis* Schuchert. Proc. U. S. Nat. Mus., 26:422

1905 *Edriocrinus pocilliformis* Talbot. Amer. Jour. Sci., 20:23, pl. 4, figs. 1–6

1913 *Edriocrinus pocilliformis* Ohern. Md. Geol. Surv., Lower Dev., p. 257, pl. 40, figs. 13–15

1920 *Edriocrinus pocilliformis* Springer. Crin. Flex., p. 448.

Springer's description. Type of the genus.

A small species, known only by the calyx. Base small, low hemispheric, broadly convex, expanding upward; height to width about as 1 to 1.3; specimens ranging in size from 4 to 15 mm high and 7 to 20 mm wide at basi-radial suture. Radial circlet cylindrical, longer than wide, and slightly longer than the base; anal plate narrower than radials. Traces of a narrow indented scar are occasionally seen on the rounded base, and radiating ridges on the ventral surface.

Horizon and locality. From the New Scotland limestone, Helderberg mountains, near Clarksville and Schoharie, N. Y.; from the same formation at Bailey's landing, Perry county, Mo.

Types. Cotypes in the collection of the American Museum of Natural History, number 2300.

Remarks. Talbot (1905, p. 23) gave an emended description of this species based upon specimens which she believed showed basals and infrabasals,— the basals five in number. Two very beautifully preserved specimens figured by Miss Talbot are refigured here on plate 58, figures 9–12. As pointed out by Springer (1920, p. 445) they do not show any indication of two rings of plates or any means of determining the number of plates below the radials, which he (ref. cit.) has shown in other species to be four. The raised collar noted on some specimens and taken by Talbot to represent the basal ring is shown in the specimen figured on plate 58, figures 9, 10. This Springer interprets as a "mere irregular phase of secondary growth without definite structure, seen occasionally on specimens of different species. Also the lines seen at the inner surface of some of the fused bases are not interbasal sutures, as the author thought, but are lines or ridges marking the superimposed radials and anal plate; they are always six in number, instead of five as they would be if dividing five basals."

The base in some specimens (plate 58, figures 13, 14) appears to be rather elongated, resembling somewhat in appearance *Edriocrinus occidentalis* (Springer, 1920, p. 449, pl. 76, figs. 6–12).

Edriocrinus sacculus Hall

Plate 58, figures 1–8

1859 *Edriocrinus sacculus* Hall. Pal. N. Y., 3:143, pl. 87, figs. 1–22
1868 *Edriocrinus sacculus* Shumard. Trans. Acad. Sci. St Louis, 2:368
1877 *Edriocrinus sacculus* S. A. Miller. Amer. Pal. Foss., p. 77
1878 *Edriocrinus sacculus* Bigsby. Thesauras Dev.-Carb., p. 17
1886 *Edriocrinus sacculus* Wachsmuth & Springer. Rev. Palaeocr., pt. 3, p. 266 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 38:190
1889 *Edriocrinus sacculus* S. A. Miller. N. Amer. Geol. & Pal., p. 242

1892 Edriocrinus sacculus Beecher & Clarke. Amer. Jour. Sci., v. 44, ser. 3, p. 410

1899 Edriocrinus sacculus Weller. Ann. Rep't Geol. Surv. N. J., p. 43

1900 Edriocrinus sacculus Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 3, p. 196

1900 Edriocrinus sacculus Schuchert. Bul. Geol. Soc. Amer., 11:292, 313

1903 Edriocrinus sacculus Weller. Ann. Rep't Geol. Surv. N. J., Pal., 3:342, pl. 45, figs. 3, 4, 5

1910 Edriocrinus sacculus Grabau & Shimer. N. Amer. Index Foss., 2:515

1911 Edriocrinus sacculus Kirk. Proc. U. S. Nat. Mus., no. 1846, p. 112, pl. 11, figs. 14, 15

1913 Edriocrinus sacculus (in part) Ohern. Md. Geol. Surv., Lower Dev., p. 256, pl. 40, figs. 10–12, only.

1920 Edriocrinus sacculus Springer. Crin. Flex., p. 450

Springer's description. The largest species; represented by the complete crown. Base inverted conical, usually asymmetric with the upper edge oblique, broadly spreading from a narrow rounded apex, enclosing a large cavity of similar form; walls thick, double, with space for fibrous structures between. Radial circlet cylindrical; radials rectangular, enclosing wide anal plate projecting above them between arm bases. Arms broad and flat, with well defined food-groove; dichotomous, branching two or three times, curving outward and distal ends closely inrolled, forming a rounded cluster exceeding the calyx in diameter. Primibrachs ten to twelve, occasionally more; short, transversely linear, with beveled sutures. Height to width of base in average of forty large and small specimens, about 1 to 1. Maximum crown from rounded base to top of recurved arms 65 mm high and 40 mm wide at greatest width of arm cluster; calyx at arm bases 44 mm high by 28 mm wide; base 27 by 26; maximum free base, 42 mm high by 35 mm wide; minimum free base 10 mm high by 12 mm wide. Still smaller specimens occur attached to other objects singly or in clusters having about ten primibrachs as in this species.

Horizon and locality. From the Oriskany (Glenerie) limestone, Glenerie, Ulster county, N. Y., and from the Oriskany of Cumberland, Md.

Types. Cotypes in the American Museum of Natural History. The New York specimens figured here in the collection of the New York State Museum.

Remarks. This is the most common crinoid of the Oriskany. The arms are usually broken off and the radials frequently missing. We have no New York specimens showing the arms, and therefore some of the Maryland specimens are figured here on plate 58, figures 1, 2. Hall's description and account of the habits of the genus were based upon collections from Cumberland.

The character of the wall of the base is well shown in two of our New York specimens (figures 3 and 4). Figure 3 shows the double wall; the median wall and transverse septa give a cellular, honey-combed appearance to it. In figure 4 are shown the thickened character of the wall and the inner surface of the base.

Many small specimens have been found attached to some hard object, either singly or in clusters. Such forms have been figured by Hall (1859, plate 87) and by Kirk (1911, plate 11), and are shown here on plate 58, figures 6–8. Kirk in discussing this form (ref. cit., p. 112) states:

This species likewise combines an eleutherozoic and statozoic habit. The species is constantly attached in the young forms, as may be noted in plate 11, figure 14 (*see* plate 58, figure 8). The young apparently were often associated in groups or clusters as here indicated. A number of these clusters have been noted where the young are cemented to brachiopod or gastropod shells. In certain individuals it appears that attachment was maintained throughout life. In the majority of cases, however, detachment from the bottom took place. Detachment became effective through the resorption of the stalk near the base. This resulted in the freedom of the organism. Detachment in the case of these crinoids apparently occurred at widely different periods in the development of the animals, for attached forms of widely different sizes may be observed. Figure 14, plate 11 (*see* plate 58, figure 8) probably represents the approximate size at which detachment normally occurs, for the majority of attached individuals seem to be of about this size or smaller.

This view of Kirk's has also been shared by previous writers: that all these Oriskany specimens belonged to one species, the young sessile and the adult free or attached. Springer (1920) has shown that this Oriskany material comprises two species, one free in the adult stage, E. sacculus; the other sessile, E. holopoides (text figure 63). The sessile form is somewhat smaller and has uniformly much shorter rays. The free form has, constantly, ten or more primibrachs, the sessile, five (or at the most six or seven). Excluding very young forms, out of sixty-three specimens of varying sizes, entirely complete or with one or more rays preserved, Springer found forty-two free specimens showing the characters of E. sacculus and twenty-one with attached bases.

The manner of locomotion of E. sacculus after detachment is a matter of much interest and some question. Kirk states (ref. cit., p. 113):

Subsequent to detachment Edriocrinus moved from place to place by crawling on its stout arms. The position assumed by the specimen of E. sacculus as given on Plate 11, figure 15 (*see* plate 58, figure 2) is probably the natural one. As here shown Edriocrinus is crawling over the surface of a large gastropod. It does not seem possible with the comparatively feeble musculature of this genus and the stout arms that are borne that the animal could have been capable of very effective swimming movements.

Edriocrinus pyriformis Hall

Plate 58, figures 16, 17

1862 Edriocrinus pyriformis Hall. 15th Ann. Rep't N. Y. State Cab. Nat. Hist., p. 115, figs. 1, 2; p. 116, pl. 1, figs. 23, 24

1868 Edriocrinus pyriformis Shumard. Trans. Acad. Sci. St Louis, 2:368

1877 Edriocrinus pyriformis S. A. Miller. Amer. Pal. Foss., p. 77

1878 Edriocrinus pyriformis Bigsby. Thesaurus Dev.-Carb., p. 17

1886 Edriocrinus pyriformis Wachsmuth & Springer. Rev. Palaeocr., pt. 3, p. 266 (authors' ed.); Proc. Acad. Nat. Sci. Phila., 38:190

1889 Edriocrinus pyriformis S. A. Miller. N. Amer. Geol. & Pal., p. 242

1900 Edriocrinus pyriformis Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., v. 11, pt. 3, p. 196

1904 Edriocrinus pyriformis Clarke & Luther. N. Y. State Mus. Bul. 63, p. 43

1911 Edriocrinus pyriformis Kirk. Proc. U. S. Nat. Mus., v. 41, no. 1846, p. 112, pl. 10 (after Hall)

1920 Edriocrinus pyriformis Springer. Crin. Flex., p. 451, pl. 76, figs. 19–21

Springer's description. A medium-sized species, known only by the calyx. Base elongate, cylindrical, with concave scar for attachment.

Radials long, expanding upward, giving a turbinate aspect to the radial circlet; contracting toward the upper margin which is more or less abruptly bent in, so that the diameter at the radial facets is considerably less than that of the expanded portion below. Anal plate narrow, projecting above radials.

Hall's figures 1 and 2, on page 115 (87) of the 15th Report were drawn from three specimens — figure 1 being a composite based upon a flattened calyx and two perfectly rotund sets of radials, and figure 2, a distal view of one of the latter. They show the form and proportions of the species with entire accuracy. Measurements of six specimens give the following average dimensions: Height of calyx, 33 mm, of radials, 18 mm, of base, 15 mm; width at zone of greatest expansion, 18 mm, contracting to 13 mm at radial facets; at basi-radial suture 10 mm; base at surface of attachment, 10 mm. The extremes depart but little from this mean. This species is not quite constant in the sessile base, as, among six specimens with base preserved, five have a broad concave scar, one has the scar almost completely overgrown; while a seventh, detached base only, associated with the others, is rounded.

Horizon and locality. From the Lower Helderberg, Coeymans limestone, Eastman's quarry, southeast of Utica, Oneida county; also at Babcock hill, Bridgewater, Onondaga county, N. Y.

Type in the American Museum of Natural History, number $\frac{2980}{1}$.

Remarks. The rather slender base or peduncle (Kirk, 1911, p. 111) of this species has somewhat the appearance of a short, stout column. This form represents one extreme in the genus in which E. dispansus and the associated E. adhaerans represent the other. The other species are structurally intermediate between these extreme forms.

This species was described by Hall from the Upper Helderberg (Onondaga limestone) and specimens are so listed in the old locality catalogue of the New York State Museum and in the type catalog of the American Museum of Natural History. Springer's specimens, originally in the Lyon collection, were obtained by exchange from Hall and were similarly labeled. In his discussion of the horizon and locality of this species he points out the error of this citation:

Eastman's quarry, as known at the time when these specimens were collected, was located ten or twelve miles southeast of Utica, in the region of Litchfield, where the Coeymans limestone of the Helderbergian is we developed and has yielded important collections of fossils lithologically similar to these.

Edriocrinus becraftensis Clarke

Plate 58, figure 18

1900 Edriocrinus becraftensis Clarke. N. Y. State Mus. Mem. 3, p. 62, pl. 9, figs. 12, 13

1903 Edriocrinus becraftensis Clarke and Ruedemann. N. Y. State Mus. Bul. 65, p. 68

1920 Edriocrinus becraftensis Springer. Crin. Flex., p. 451

Springer's description. A rather large species, known by the base only. Base very elongate, narrowly conical, slightly widening upward. Height to width about 1 to .75; type specimen 30 mm high, 15 mm wide at upper end, and 8 mm near the lower rounded extremity.

Horizon and locality. From the Oriskany limestone, Becraft mountain, Hudson, N. Y.

Types. Holotype is in the New York State Museum, number $\frac{4160}{1}$.

Remarks. E. sacculus also comes from the Oriskany beds (Glenerie limestone) of New York, but no difficulty could be encountered in distinguishing the two forms. As pointed out in the original description (Clarke, 1900, p. 62):

The calyces of this species may be distinguished from those of Edriocrinus sacculus Hall from the Oriskany sandstone of Cumberland, Md., in their elongate, much more slender and very gradually enlarging form, and generally quite small size. They are blunt, but not broad at the base, and enlarge upward with gently incurving sides. In one instance only has the upper edge of the calyx been observed, and except for this edge no specimen shows traces of the component plates. The casts of the calyx are not infrequent.

Edriocrinus dispansus Kirk

Plate 58, figures 19–21; text figure 62

1911 Edriocrinus dispansus Kirk. Proc. U. S. Nat. Mus., v. 41, no. 1846, p. 112, pl. 11, figs. 1, 2

1920 Edriocrinus dispansus Springer. Crin. Flex., p. 449, pl. 76, figs. 1–5

Springer's description. A medium-sized species, known only by the calyx. Base low, discoid, usually with remnant of indented scar of attachment at younger stage. Calyx with radials in position in form of an obscurely hexagonal, truncated pyramid, contracted at the top of the radials to less than half its diameter at the base. Radials narrowing upward to short distal faces. Anal plate long, narrow, projecting in an angular apex above the line of radials. Height of base about one-tenth its width; height to width of calyx about 1 to 1.8, varying in eight specimens from 6 to 15 mm high and 12 to 30 mm wide at the base; width of calyx at base two and a half times its diameter at the radial facets, where it ranges from 7 to 10 mm. Parts above radials not known.

Figure 62 Edriocrinus dispansus. Ventral view, x 3/2, of a base showing the suture lines of the basals and the ridges marking the former position of the superimposed radials and anal plate. (After Springer, 1920).

Horizon and locality. From the Lower Helderberg, Linden formation, Benton county, Tennessee.

Types. Holotype in the U. S. National Museum, number 27757. Other specimens in the collection of Doctor Springer.

Remarks. E. dispansus is introduced here for comparison with the other species of Edriocrinus. It is free in the adult stage. This form, as well as the similar, smaller, attached form associated with it, described by Springer as E. adhaerans, represents one extreme structurally of which E. pyriformis represents the other. In the specimen here figured the individual is attached to the shell of Leptaena rhomboidales, which it entirely covers and extends beyond. In his study of these forms Springer found that "the disk is usually marked by a shallow concavity or an indented scar of much less than its own width, in which a small shell or other foreign object is sometimes still attached — showing that the base before becoming free often outgrew its surface of attachment" (1920, p. 446).

Springer has figured (plate 76, figure 3) a detached basal disk showing at the ventral side four perfectly distinct basal plates. This figure is reproduced here in text figure 62. The interbasal sutures in the specimen are marked by lines of infiltrated matter of different color from that of the plates.

Edriocrinus holopoides Springer

Text figure 63

1913 Edriocrinus sacculus (in part) Ohern. Geol. Surv. Md., Lower Dev., pl. 40, figs. 7, 8, 9 only

1920 Edriocrinus holopoides Springer. Crin. Flex., p. 452, pl. 76, figs. 22 *a, b;* 23 *a, b*

I have added this species here for comparison with Edriocrinus sacculus under which species this associated form was originally figured (Ohern, 1913). The species was separated by Springer (1920) after studying a large series of specimens in which he found that the free

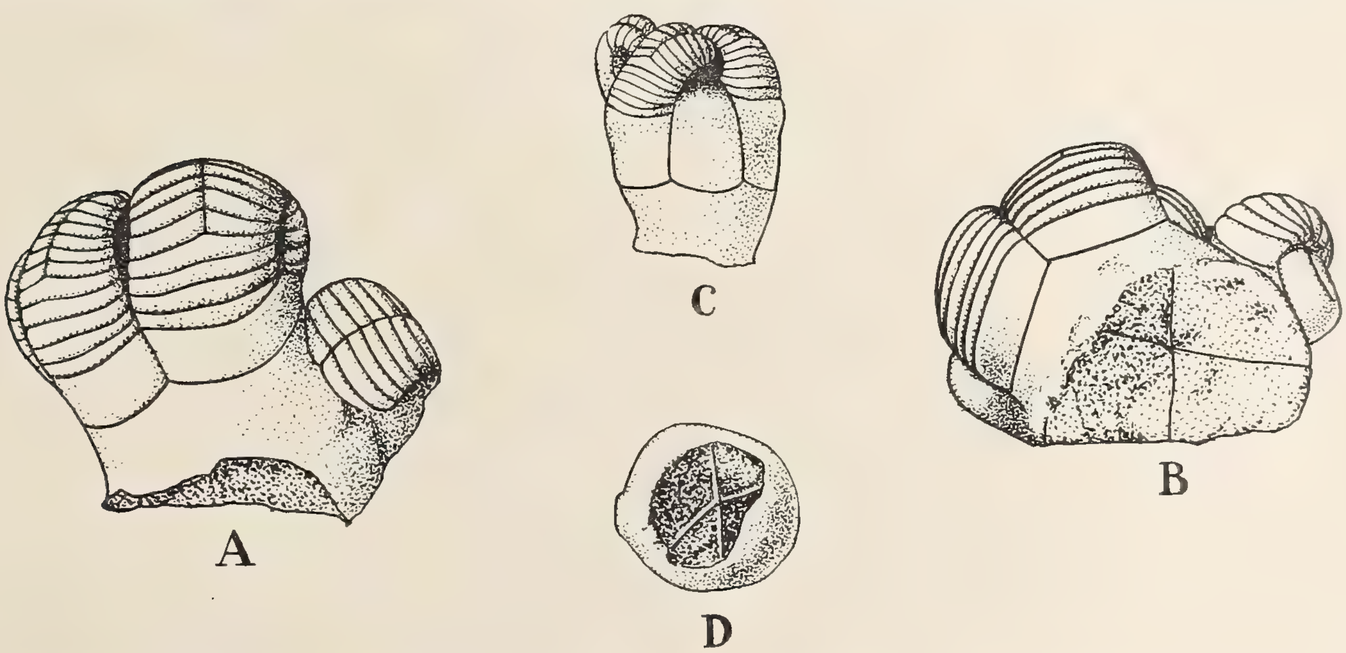

Figure 63 Edriocrinus holopoides. A, lateral view, x 3/2, of the type specimen; B, dorsal view, x 3/2, of the same specimen showing the four basals; C, posterior view of another specimen showing the anal plate; D, dorsal view of the same specimen showing the four basals. (After Springer 1920).

adults (E. sacculus) constantly showed ten or more primibrachs, the sessile adults five (or at the most six or seven). The species so far has been found only in the Oriskany sandstone, Cumberland, Maryland. Springer's description of the species follows:

Springer's description. A large species, but smaller than E. sacculus, and with a shorter base; represented by the complete crown. Base low and broad, usually standing oblique to the surface of attachment;

wall thin, enclosing a broad, bowl-shaped cavity not contracting downwards; expanding slightly towards the radials. Calyx and arms otherwise similar to these of E. sacculus, except that the arms are shorter and their inrolled cluster relatively not so wide. Primibrachs five or six, exceptionally seven or eight. Height to width of base in average of twenty-one large and small specimens, about 1 to 1.25. Dimensions of maximum crown: 45 mm high and 35 mm wide at greatest expansion of arm cluster; calyx, 28 mm high by 25 mm wide at the arm bases; base, 17 mm high by 19 mm wide; minimum crown, 8 mm high by 7 mm wide; minimum base, 4 mm high by 6 mm wide. Thus up to their maximum the specimens of this species range in size about like those of E. sacculus, but the latter becomes considerably larger.

Horizon and locality. From the Oriskany sandstone, Cumberland, Md.

Types in the collection of Doctor Springer. The specimen chosen as chief type by Doctor Springer, text figure 63 A, B, is the one figured by Ohern (1913, plate 40, figures 7–9).

Family (?)

Genus ANCYROCRINUS Hall 1862

Ancyrocrinus bulbosus Hall

Plate 59, figure 14

1862 Ancyrocrinus bulbosus Hall. 15th Ann. Rep't N. Y. State Cab. Nat. Hist., p. 118, pl. 1, figs. 25, 26

1868 Ancyrocrinus bulbosus Shumard. Trans. Acad. Sci. St Louis, 2:354

1878 Ancyrocrinus bulbosus Bigsby. Thesaurus Dev.-Carb., p. 15

1887 Ancyrocrinus bulbosus Whiteaves. Contr. Can. Pal., v. 1, pt. 2 (advance sheets), p. 103; 1889, pl. 13, fig. 5

1889 Ancyrocrinus bulbosus S. A. Miller. N. Amer. Geol. & Pal., p. 246

1898 Ancyrocrinus bulbosus Whiteaves. Contr. Can. Pal., v. 1, pt. 5, p. 375, pl. 48, figs. 8, 9

1899 Ancyrocrinus bulbosus Grabau. Bul. Buff. Soc. Nat. Sci., v. 6, nos. 2, 3, 4, p. 147, fig. 28

1901 Ancyrocrinus bulbosus Shimer & Grabau. Bul. Geol. Soc. Amer. 13:185

1904 Ancyrocrinus bulbosus Clarke & Luther. N. Y. State Mus. Bul.39, p. 52

1910 Ancyrocrinus bulbosus Grabau & Shimer. N. Amer. Index Foss., 2:569

1911 Ancyrocrinus bulbosus Kirk. Proc. U. S. Nat. Mus., v. 41, no. 1846, p. 46

Original description. Bulbiform below, with four lateral, obliquely ascending processes of the character of jointed or solid spines, which are more or less thickened according to age. Column above the bulb often elongated, rounded in the lower part and obtusely quadrangular above in older specimens, which preserve but a small part of the column as a thickened process. Body and arms unknown.

Horizon and locality. Holotype from the Hamilton (Moscow) shales, Lake Erie, New York. Other localities are Canandaigua lake; vicinity of Geneseo; Bellona; Norton's landing, Cayuga lake; south of Skaneateles lake; Eighteen Mile creek, Erie county. Species also found in the Ludlowville shale at Ludlowville and Eighteen Mile creek, and in the Hamilton shales, Thedford, Ontario.

Types. Holotype in the New York State Museum, number $\frac{4016}{1}$.

Remarks. The spurs of Ancyrocrinus are modified radicular cirri in which all traces of the original segmentation has been obliterated by secondary deposition (Kirk, 1911, p. 46). This four fluked grapnel was regarded by Bather (1900, pp. 134, 177) as the distal end of the stem of Myrtillocrinus. Kirk (loc. cit.), in his discussion of the genus Ancyrocrinus, differs from Bather's conclusion and says:

> This reference is quite unsupported by known facts. Myrtillocrinus is found in America in the Onondaga limestone where no signs of Ancyrocrinus have been seen, while in the Hamilton, where Ancyrocrinus is fairly abundant, no trace of Myrtillocrinus has yet been found. Moreover, the stem of Ancyrocrinus is quadrangular in cross-section, while that of Myrtillocrinus is round. Furthermore, the size of these grapnels and that of the column is out of all proportion to that of any known Myrtillocrinus theca.
>
> We may hold, I think, that this grapnel of Ancyrocrinus served rather as a drag and ballast than as a true anchor. In a quiet sea, the animal no doubt was steadied and maintained in a fairly stable state by the weight of the terminal organ. If affected by current or wave activity,

however, the grapnel might be dragged along the bottom and aid appreciably in controlling the motion of the animal. As will be noted subsequently, it is quite conceivable that the Paleozoic stalked Crinoidea, as well as their modern representatives, often lived well within the zone of wave activity. Under such conditions the advantage of such a drag is immediately obvious.

Springer (1917, p. 10) agrees with Kirk in the statement that the reference of these grapnels or anchors to Myrtillocrinus is without the slightest authority. He believes that a more plausible supposition would be that they belonged to Arachnocrinus. Here there is a similar quadripartite canal, and one species — very rare — occurs in the same horizon at Louisville, Ky.

Ancyrocrinus quinquepartitus sp. nov.

Plate 59, figures 15, 16

The New York State Museum has recently acquired a single specimen of a new species of Ancyrocrinus, from the Oriskany beds, with five spurs or radicular cirri instead of four as in A. bulbosus. Radicular cirri stout at the bases; the ends are broken so as to show the axial canal which appears to be elliptical. Column above the spurs rounded.

Horizon and locality. From the Oriskany (Glenerie) limestone, Glenerie, N. Y.; collected by Alfred Simmons of Saugerties, N. Y.

Types. Holotype in the collection of the New York State Museum.

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LIST OF SPECIES ACCORDING TO LOCALITIES

Alden (Erie co.)
- Gennaeocrinus eucharis
- Megistocrinus depressus

Alfred (Allegany co.)
- Eutaxocrinus pulcher

Angola (Erie co.)
- Melocrinus clarkei

Athol Springs (Erie co.)
- Gennaeocrinus carinatus

Avoca (Steuben co.)
- Arthracantha granosa
- Catactocrinus leptodactylus
- Cradeocrinus elongatus
- Eutaxocrinus alpha
- Eutaxocrinus curtus
- Iteacrinus flagellum
- Iteacrinus robustus

Bailey's landing (Perry co.), Mo.
- Edriocrinus pocilliformis

Bainbridge (Ross co.), Ohio
- Melocrinus bainbridgensis

Bath (Steuben co.)
- Arthracantha splendens

Beargrass creek, Ky.
- Dolatocrinus ornatus

Becraft Mt., Hudson (Columbia co.)
- Aspidocrinus scutelliformis
- Edriocrinus becraftensis

Bellona (Yates co.)
- Ancyrocrinus bulbosus
- Dolatocrinus insignis
- Dolatocrinus liratus
- Gennaeocrinus eucharis
- Megistocrinus depressus

Bellona (Yates co.)
- Rhodocrinus nodulosus
- Saccocrinus (?) hamiltonensis
- Synaptocrinus nuntius

Belmont (Allegany co.)
- Eutaxocrinus pulcher

Bethany (Genesee co.)
- Thylacocrinus clarkei

Big Sandy river (Benton co.), Tenn.
- Edriocrinus dispansus

Binghamton (Broome co.)
- Eutaxocrinus amplus
- Melocrinus splendens

Bloomfield (Ontario co.)
- Cyttarocrinus (?) jewetti

Bridgewater (Oneida co.)
- Edriocrinus pyriformis

Bristol (Ontario co.)
- Clarkeocrinus troosti
- Decadocrinus insolens
- Melocrinus clarkei
- Taxocrinus lobatus

Caledonia (Livingston co.)
- Myrtillocrinus americanus

Canandaigua (Ontario co.)
- Arthracantha eboracea
- Megistocrinus ontario
- Thylacocrinus clarkei

Canandaigua lake (Ontario co.)
- Acanthocrinus spinosus
- Ancyrocrinus bulbosus
- Aorocrinus cauliculus
- Aorocrinus praecursor
- Botryocrinus obconicus

Canandaigua lake (Ontario co.) — *Contd.*
Comanthocrinus indianensis
Deltacrinus clarus
Dolatocrinus glyptus
Dolatocrinus insignis
Dolatocrinus liratus
Dolatocrinus liratus var. parvulus
Gennaeocrinus carinatus
Gennaeocrinus eucharis
Gennaeocrinus kentuckiensis
Logocrinus geniculatus
Megistocrinus depressus
Megistocrinus ontario
Melocrinus clarkei
Melocrinus gracilis
Poteriocrinus nassa
Rhodocrinus nodulosus
Rhodocrinus nodulosus var. pernodosus
Stylocrinus (?) canandaigua
Thylacocrinus clarkei
Cascade Mills, Dundee (Ontario co.)
Aorocrinus longidactylus
Cashong creek, Bellona (Yates co.)
Aorocrinus armatus
Aorocrinus formosus
Botryocrinus sentosus
Comanthocrinus indianensis
Decadocrinus multinodosus
Decadocrinus multinodosus var. serratobrachiatus
Dolatocrinus liratus
Gennaeocrinus carinatus var. crassicostatus
Gennaeocrinus eucharis
Logocrinus geniculatus
Megistocrinus depressus

Cashong creek, Bellona (Yates co.) — *Contd.*
Melocrinus sp. nov.
Rhodocrinus nodulosus
Symbathocrinus subtrigonalis
Thamnocrinus springeri
Cazenovia (Madison co.)
Acanthocrinus spinosus
Charlestown, Ind.
Botryocrinus americanus
Comanthocrinus indianensis
Gennaeocrinus carinatus
Megistocrinus depressus
Chemung Narrows (Chemung co.)
Corematocrinus plumosus
Eutaxocrinus ithacensis (?)
Glossocrinus naplesensis
Logocrinus infundibuliformis
Pterinocrinus quinquenodus
Cherry Valley (Otsego co.)
Craterocrinus ruedemanni
Dolatocrinus lobatus
Dolatocrinus marshi var. glaber
Dolatocrinus ornatus
Dolatocrinus speciosus
Cheshire (Ontario co.)
Clarkeocrinus troosti
Clarence (Erie co.)
Mictocrinus robustus
Clarke co., Ind.
Ancyrocrinus bulbosus
Comanthocrinus indianensis
Gilbertsocrinus spinigerus
Clarksville (Albany co.)
Brachiocrinus nodosarius
Clidochirus schucherti
Edriocrinus pocilliformis

Helderberg Mountains — *Continued.*
    Clonocrinus (?) macropetalus
    Edriocrinus pocilliformis
Highland Mills (Orange co.)
    Lasiocrinus (?) schohariensis
Honeoye lake (Ontario co.)
    Melocrinus clarkei
Hopewell (Ontario co.)
    Dolatocrinus glyptus
Ithaca (Tompkins co.)
    Arthracantha ithacensis
    Charientocrinus ithacensis
    Decadocrinus gregarius
    Decadocrinus rugistriatus
    Eutaxocrinus alpha
    Eutaxocrinus curtus
    Eutaxocrinus ithacensis
    Glossocrinus cornellianus
    Melocrinus (Trichotocrinus) harrisi
    Melocrinus reticularis
    Poteriocrinus clarkei var. alpha
    Poteriocrinus zethus
Jaycox's run (Livingston co.)
    Corocrinus (?) calypso
    Dimerocrinus whitfieldi
Jerusalem hill (Herkimer co.)
    Cordylocrinus plumosus
    Cordylocrinus (?) ramulosus
    Lasiocrinus scoparius
    Melocrinus pachydactylus
    Melocrinus paucidactylus
Killawog (Broome co.)
    Decadocrinus killawogensis
Lake Erie (Erie co.)
    Ancyrocrinus bulbosus
Laona (Chautauqua co.)
    Anamesocrinus lutheri
Leicester (Livingston co.)
    Dolatocrinus liratus
Le Roy (Genesee co.)
    Arachnocrinus bulbosus
    Arachnocrinus extensus
    Arachnocrinus ignotus
    Comanthocrinus priscus
    Myrtillocrinus americanus
    Myrtillocrinus (?) levis
    Schultzicrinus (?) elongatus
    Schultzicrinus typus
Lima (Livingston co.)
    Halysiocrinus secundus
Limerock (Genesee co.)
    Acanthocrinus onondaga
    Arachnocrinus bulbosus
    Arachnocrinus extensus
    Aspidocrinus onondagensis
    Schultzicrinus typus
    Symbathocrinus sulcatus
Litchfield (Herkimer co.)
    Cordylocrinus plumosus
    Cordylocrinus ramulosus
    Lasiocrinus scoparius
    Mariacrinus plumosus
    Mariacrinus ramosus
    Melocrinus nobilissimus
    Melocrinus paucidactylus
Livonia salt shaft (Livingston co.)
    Arthracantha eboracea
    Dolatocrinus insignis
    Dolatocrinus liratus
    Megistocrinus depressus
    Megistocrinus ontario
Ludlowville (Cayuga co.)
    Ancyrocrinus bulbosus

Schoharie (Schoharie co.) — *Continued.*
  Edriocrinus pocilliformis
  Himerocrinus (?) polydactylus
  Mariacrinus plumosus
  Mariacrinus stoloniferus
  Marsipocrinus tentaculatus
  Melocrinus pachydactylus
Schoharie co.
  Arachnocrinus extensus
  Dolatocrinus speciosus
Seneca lake
  Megistocrinus ontario
Skaneateles lake, Borodino (Onondaga co.)
  Gennaeocrinus eucharis
South Otselic (Chenango co.)
  Cradeocrinus pergracilis
  Eutaxocrinus ithacensis
Stafford (Genesee co.)
  Arachnocrinus bulbosus
  Arachnocrinus ignotus
Steuben co.
  Arthracantha depressa
Thedford, Ontario
  Ancyrocrinus bulbosus
  Arthracantha carpenteri
  Botryocrinus crassus
  Gilbertsocrinus spinigerus
Thompson's lake (Albany co.)
  Dolatocrinus speciosus
Tracy Creek (Broome co.)
  Liparocrinus halli
Tully (Onondaga co.)
  Dolatocrinus liratus
Utica (Eastman's quarry, southeast of)
  Edriocrinus pyriformis
Vincent (Ontario co.)
  Acanthocrinus spinosus
  Aorocrinus cauliculus
  Botryocrinus nycteus
  Clarkeocrinus troosti
  Decadocrinus nereus
  Gennaeocrinus eucharis
  Gennaeocrinus nyssa
  Gilbertsocrinus spinigerus
  Megistocrinus depressus
  Poteriocrinus (?) diffusus
  Thylacocrinus clarkei
Wallace, Steuben co.
  Arthracantha granosa ?
  Arthracantha ithacensis ?
Western New York
  Arthracantha punctobrachiata
  Dolatocrinus lamellosus
Willet (Cortland co.)
  Melocrinus willetensis
  Melocrinus willetensis var. perstriatus
Worcester (Otsego co.)
  Gennaeocrinus decorus
York (Livingston co.)
  Arthracantha eboracea
  Dolatocrinus glyptus
  Dolatocrinus glyptus var. intermedius

INDEX OF GENERA

In this index are also included orders, families, subfamilies and subgenera; and the species are alphabetically listed under the genera. Synonyms and nomina nuda are given in *italics*.

INDEX OF SPECIES

In this index the names of the varieties are listed as species. The genera are listed under the specific names belonging to them. Where possible synonyms and nomina nuda are given in *italics*.

EXPLANATIONS OF PLATES

PLATE I

Genus DIMEROCRINUS Phillips

Dimerocrinus arborescens (Talbot) n. comb.

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1 Posterolateral view of the type. Collection Yale University Museum
Coeymans limestone, Litchfield

Dimerocrinus whitfieldi sp. nov.

Page 85

2 Lateral view. Collection American Museum Natural History, number $\frac{5026}{1}$, marked as type of Actinocrinus (Gennaeocrinus) eucharis Hall
Hamilton (Moscow) shale, Jaycox's run between Geneseo and Avon

Genus PTERINOCRINUS nov.

Pterinocrinus quinquenodus sp. nov.

Page 87

3 Lateral view of a specimen showing regular interradii and the character of the proximal portion of the arms
Lower Chemung, Chemung Narrows

4 Similar view of a younger specimen. A few of the tegminal plates are shown
Lower Chemung, Chemung Narrows

5 Specimen showing posterior side (x 2)
Lower Chemung, Chemung Narrows

6 Fragment of a very large specimen, showing an abnormal condition in which the primary interbrachial comes down between the radials and rests upon the truncated basal
Lower Chemung, Chemung Narrows

7 Lateral view of specimen showing the bifurcations of the right arm of a ray and the unbranched left arm
Lower Chemung, Chemung Narrows

8 Fragment of a ray showing the less usual condition of an unbranched right arm and a bifurcating left arm
Lower Chemung, Chemung Narrows

9, 10 Fragments of arms showing the uniserial character and the long, slender pinnules
Lower Chemung, Chemung Narrows

Originals, except as otherwise indicated, in the State Museum

Figures 3–10 were drawn from squeezes. Figure 1 was made from an enlarged photograph and wax impressions

DEVONIAN CRINOIDS

G. S. Barkentin del.

PLATE 2

Genus RHODOCRINUS J. S. Miller

Rhodocrinus nodulosus Hall

Page 89

1 Lateral view of a mature specimen showing nodose plates and obscure radiating ridges. Hall's type, number $\frac{4501}{1}$

Hamilton (Moscow) shale, Canandaigua lake

2 Lateral view of another specimen showing nodes well only on higher plates. In the interradius at the right the primary interbrachial does not meet the basal Collection of Doctor Springer

Hamilton shale, Falls of Ohio, Louisville, Ky.

3 Posterior view of a specimen showing the ornamentation very well. Collection of Doctor Springer

Hamilton (Moscow) shale, Cashong creek

4 Posterior view of a very young specimen. The basal nodes are very prominent even at this stage

Hamilton (Moscow) shale, Canandaigua lake

5 Lateral view of an old specimen showing the disappearance of the ornamentation. Nodes more conspicuous on the basals, less so on the other plates; the radiating ridges have practically disappeared.

Hamilton (Moscow) shale, Canandaigua lake

Rhodocrinus nodulosus var. **pernodosus** nov.

Page 91

6 Lateral view (right posterior ray), showing the dorsal cup less spreading than in R. nodulosus and the very prominent nodes which are almost spinose on the basals

Hamilton (Moscow) shale, Canandaigua lake

Genus ACANTHOCRINUS Roemer

Acanthocrinus spinosus (Hall) n. comb.

Page 92

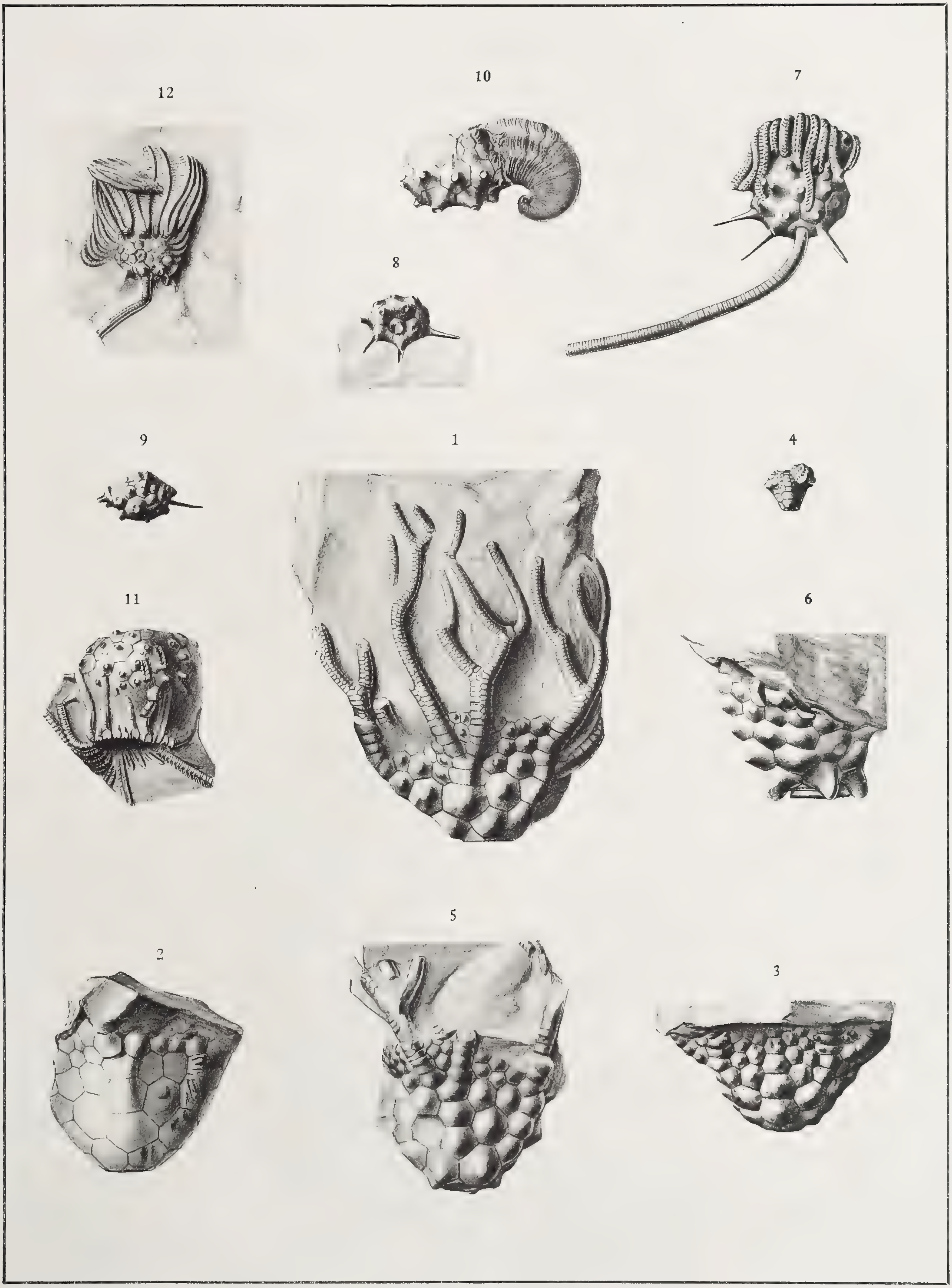
7 Lateral view showing long spines and sharply recumbent arms. Hall's type, number $\frac{4502}{1}$

Hamilton (Moscow) shale, Vincent

8 Basal view of another specimen. Hall's type, number $\frac{4502}{4}$

Hamilton (Moscow) shale, Vincent

9 Lateral view of the same specimen



G. S. Barkentin del.

10 Left anterolateral view of a very well preserved calyx, showing a Platyceras attached at the anal side. Collection of Ernest Brown, Rochester, N. Y.

Hamilton (Moscow) shale, Menteth's point, Canandaigua lake

11 Lateral view of a crushed and distorted specimen of which the calyx was difficult to figure. Introduced to show the sharply recumbent character of the arms and for this reason drawn reversed to bring out the effect better.

Hamilton (Moscow) shale, Vincent

Acanthocrinus onondaga sp. nov.

Page 94

12 Lateral view of a crushed specimen showing the basal spines and erect arms

Onondaga limestone, Limerock

Originals, except as otherwise indicated, in the State Museum

PLATE 3

Genus GILBERTSOCRINUS Phillips

Gilbertsocrinus spinigerus (Hall)

Page 96

1 Lateral view of a specimen (x 2) showing the tubular interradial appendages. The spines on the primary interbrachials were evidently removed in cleaning. The base of one is shown on the opposite side. Hall's type, number $\frac{4240}{2}$

Hamilton (Moscow) shale, Vincent

2 Lateral view of a crushed specimen which shows the spines on the primary interbrachials. Hall's type, number $\frac{4240}{1}$

Hamilton (Moscow) shale, Vincent

3 Anterior side of a very well preserved calyx. Collection of Doctor Springer

Hamilton beds, Clark county, Ind.

4 Posterior view of the same specimen

5 Tegmen (x 2) of the same specimen (oriented incorrectly)

6 Lateral view of another specimen showing the length of the spines. Collection of Doctor Springer

Hamilton beds, Clark county, Ind.

Genus SPHAEROTOCRINUS nov.

Sphaerotocrinus ornatus sp. nov.

Page 99

7 Anterior side (x 3)

Lewistown limestone (Lower Helderberg), Frankstown, Pa.

8 Basal view of the same specimen (x 3)

Originals, except as otherwise indicated, in the State Museum

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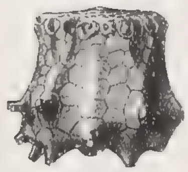

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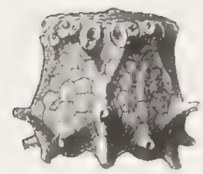

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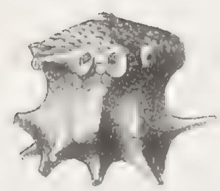

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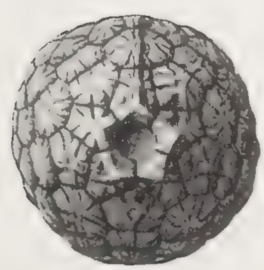

G. S. Barkentin del.

PLATE 4

Genus THYLACOCRINUS Oehlert

Thylacocrinus clarkei W. & Sp.

Page 105

1 Dorsal view of a very perfect specimen. The column shown at the right is the proximal part of the column of the species, if not the individual
Hamilton (Moscow) shale, Vincent

2 Lateral view of a badly crushed specimen, the type of the species, number $\frac{4560}{1}$
Hamilton (Moscow) shale, Canandaigua lake

3 Basolateral view of a very large specimen showing the ornamentation
Hamilton (Lower Moscow) shale, Bethany

4 Distal portion of a column showing the pentagonal outline due to the filling up of the reentrant angles seen in the stellate proximal portion
Hamilton (Moscow) shale, Canandaigua lake

Thylacocrinus gracilis (Hall) n. comb.

Page 102

5 Lateral view of the type specimen, an immature individual. The middle ray in the figure shows five arms instead of the usual four. Hall's type, number $\frac{4500}{1}$
Hamilton (Moscow) shale, North Bristol

All the originals in the State Museum

Memoir 16. N. Y. State Museum. Plate 4

G. S. Barkentin del.

PLATE 5

Genus MARIACRINUS Hall

Mariacrinus plumosus Hall

Page 109

1 Lateral view (x 2) of one of Hall's cotypes, number $\frac{4301}{1}$
Coeymans limestone, Wheelock's hill, Litchfield

2 Lateral view (x 2) of a larger specimen which has been so weathered that the ornamentation is scarcely visible
Coeymans limestone, Schoharie

Mariacrinus ramosus Hall

Page 111

3 Posterolateral view (x 2) showing the proximal part of the anal tube. Hall's type, number $\frac{4302}{1}$
Coeymans limestone, Wheelock's hill, Litchfield

4 Posterolateral view (x 2) of a smaller specimen with part of the dorsal cup broken away
Coeymans limestone, Wheelock's hill, Litchfield

Mariacrinus beecheri Talbot

Page 114

5 Posterolateral and lateral views (x 2) of the cotypes. Collection of Yale University Museum
Coeymans limestone, North Litchfield

Originals, except as otherwise indicated, in the State Museum

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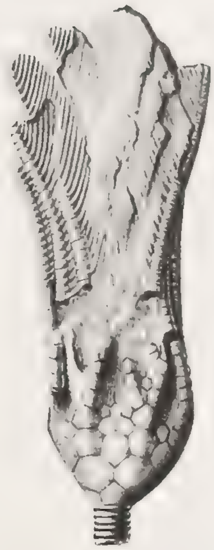

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PLATE 6

Genus MELOCRINUS Goldfuss

Melocrinus nobilissimus (Hall)

Page 117

1 Posterolateral view of Hall's type. Collection of American Museum Natural History, number $\frac{2297}{1}$

Coeymans limestone, Litchfield

2 Dorsal cup of the same specimen showing more of the posterior interradius

3 Portion of an arm of another specimen (x 2). Collection State Museum

Coeymans limestone, Litchfield

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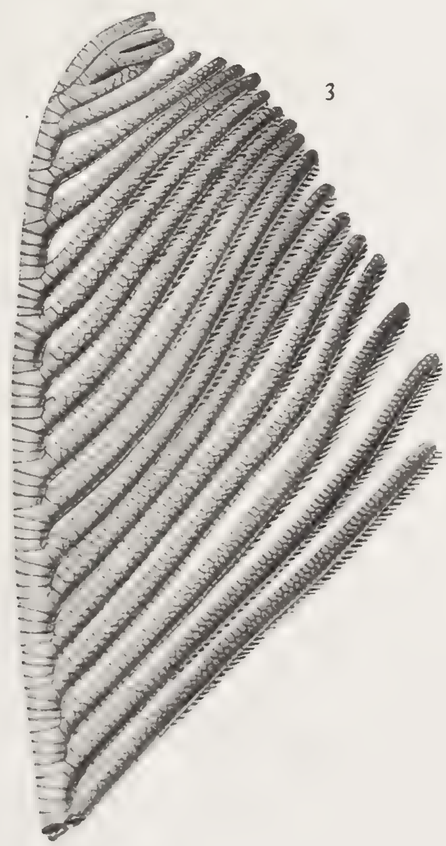

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PLATE 7

Genus MELOCRINUS Goldfuss

Melocrinus nobilissimus (Hall)

Page 117

Photographic reproduction (natural size) of portion of slab containing stems and crowns. Collection of Yale University Museum; type of Talbot, 1905

Coeymans limestone, North Litchfield

PLATE 8

Genus MELOCRINUS Goldfuss

Melocrinus pachydactylus (Conrad)

Page 119

1 Lateral view of one of the types of Hall's description showing a large part of the crown and several centimeters of column. Collection of Walker Museum, University of Chicago, number 10876
Coeymans limestone, Schoharie

2 Lateral view of another of Hall's types, showing the ornamentation of the cup very well and the proximal portion of the arms. Collection of Walker Museum, University of Chicago, number 10877
Coeymans limestone, Schoharie

3 The arms of a third type. Collection of American Museum Natural History, number 2304
Coeymans limestone, Schoharie

4 Portion of a dorsal cup showing the ornamentation well. Collection of State Museum
Coeymans limestone, Schoharie

Melocrinus paucidactylus (Hall)

Page 122

5 Lateral view of a very beautifully preserved specimen, showing the greater part of the crown and several centimeters of stem. Collection of Yale University; type of Talbot, 1905
Coeymans limestone, Jerusalem hill, Litchfield

G. S. Barkentin del.

PLATE 9

Genus MELOCRINUS Goldfuss

Melocrinus paucidactylus (Hall)

Page 122

Figures 1–10, and figure 5 on plate 8 constitute an ontogenetic series. Figures 1–8 occur on a slab of Coeymans limestone from Jerusalem hill, Litchfield, a photographic reproduction of which is shown on plate 10. Figures 9 and 10 are from the same locality. The slab on which figure 9 occurs is shown on plate 11 in photographic reproduction. As shown by the series, the chief differences between the young and adult forms are in the character of the arms, strength of the ornamentation and relative size of the basals. (*See* page 123.)

1 Posterior view of a very young specimen showing the simple arms and the short armlets given off by the secundaxils on the inner side. Basals comparatively large (x 3)
2 Lateral view of a specimen showing the same characteristics (x 3)
3 Lateral view of another, similar specimen in which the inner armlets are either not well preserved or not well developed (x 2)
4 Lateral view of a specimen showing four arms to the ray; the inner branched, the outer unbranched (x 3)
5 Posterolateral view of another specimen showing similar arm characters (x 2)
6 Lateral view of a specimen in which the two inner arms of each ray are united in their proximal parts in some of the rays
7, 8 Lateral views of two young specimens (x 2), showing the union of the two inner arms of each ray to form the typical, compound Melocrinus arm. The outer arms correspond to the auxiliary arms of the adult
9 Lateral view of an older specimen, showing the adult characters
10 Lateral view of the calyx of an adult specimen, of which another example is shown on plate 8, figure 5. Collection of Yale University Museum
Coeymans limestone, Jerusalem hill, Litchfield
11 Lateral view of Hall's type (After Hall 1859)
Coeymans limestone, Jerusalem hill, Litchfield

Originals, except as otherwise indicated, in the State Museum

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PLATE 10

Genus MELOCRINUS Goldfuss

Melocrinus paucidactylus (Hall)

Page 122

Photographic reproduction, natural size, of a slab of rock containing ontogenetic stages, enlargements of some of which are shown on plate 9, figures 1–8. Collection of State Museum

Coeymans limestone, Jerusalem hill, Litchfield

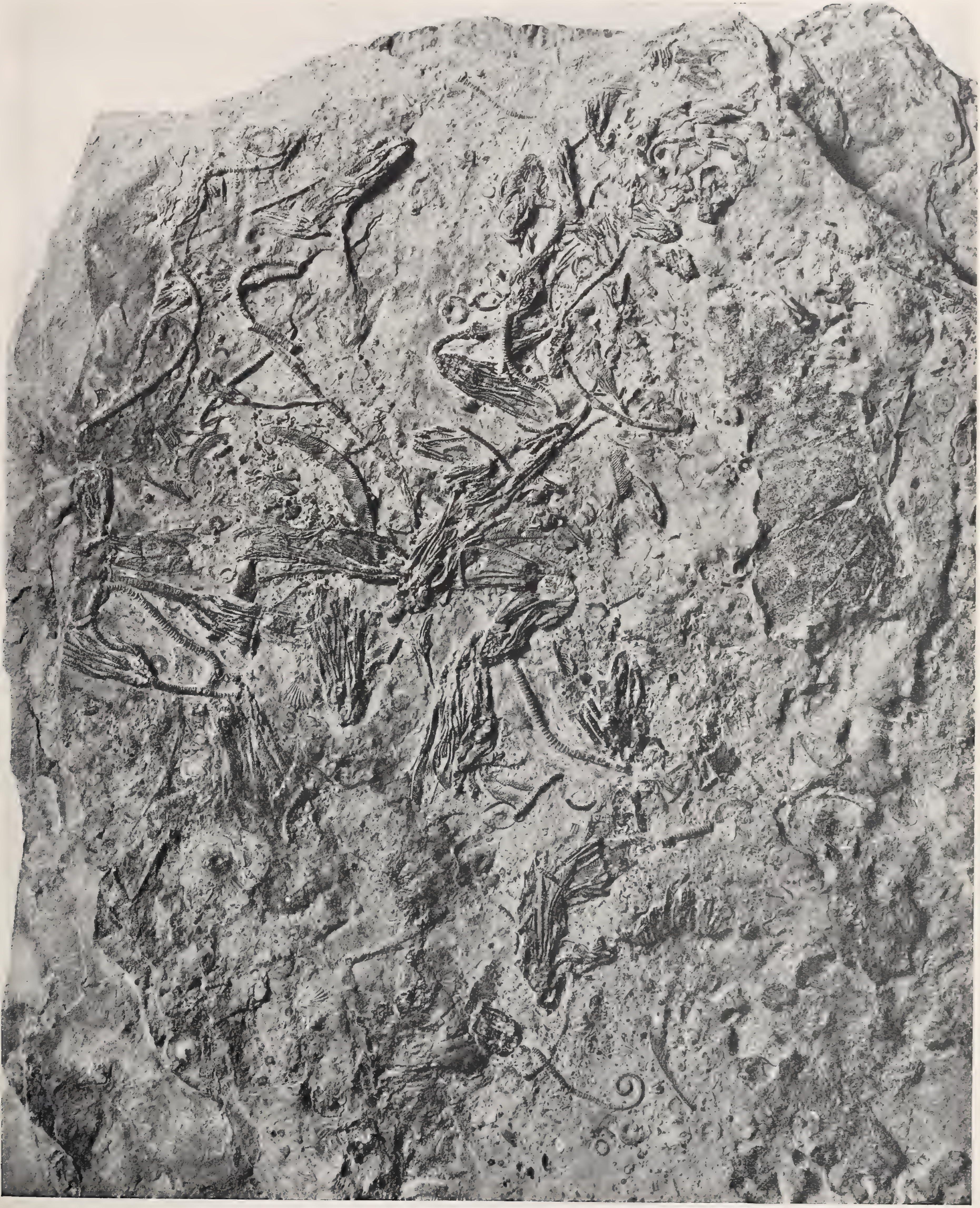

PLATE 11

507

Genus MELOCRINUS Goldfuss

Melocrinus paucidactylus (Hall)

Page 122

Photographic reproduction, natural size, of a slab containing a group of adult forms, one of which is figured in the ontogenetic series on plate 9, figure 9. The distal extremities of the columns are coiled, as is often seen in forms which have become detached during the life of the individual. Collection of State Museum

Coeymans limestone, Jerusalem hill, Litchfield

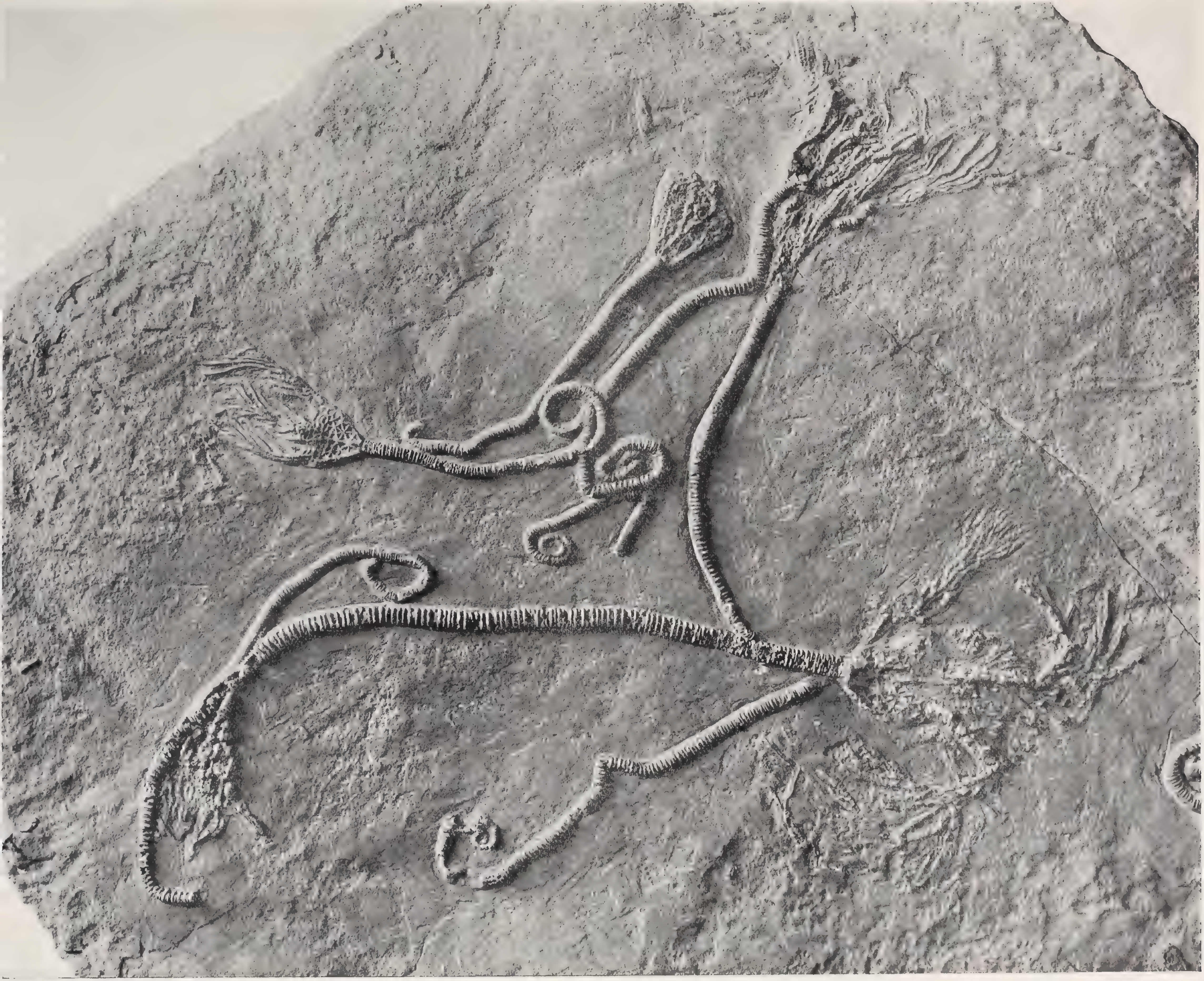

PLATE 12

Genus MELOCRINUS Goldfuss

Melocrinus (Ctenocrinus) typus (Bronn)

Page 116

1 Lateral view of the type specimen. Introduced here for comparison with the other species of Melocrinus with uniserial arms. Figured from a squeeze in the collection of Doctor Springer
Lower Devonian, Grauwacke, Siegan, Germany

Melocrinus nodosus (Hall)

Page 125

2 View of anterior side of calyx of type. Collection of American Museum Natural History, number $\frac{5579}{1}$
Hamilton beds, Milwaukee, Wis.
3 Posterior side of the same specimen
4 View of anterior side of a very young specimen. Collection of American Museum Natural History, number $\frac{5579}{1}$
Hamilton beds, Milwaukee, Wis.

Melocrinus bainbridgensis Hall & Whitfield

Page 130

5 Basal view of the calyx of the type. Collection of Ohio University, number 3965
Huron shale, Bainbridge, Ross county, Ohio
6 Left anterolateral view of the same specimen
7 Fragment of an arm trunk showing the uniserial arms. Type. Collection of Ohio State University, number 3963
Huron shale, Bainbridge, Ross county, Ohio
8 Proximal portions of columns. Type. Collection of Ohio State University, number 3964
Huron shale, Bainbridge, Ross county, Ohio
9 Distal portions of columns. Type. Collection of Ohio State University, number 3962
Huron shale, Bainbridge, Ross county, Ohio

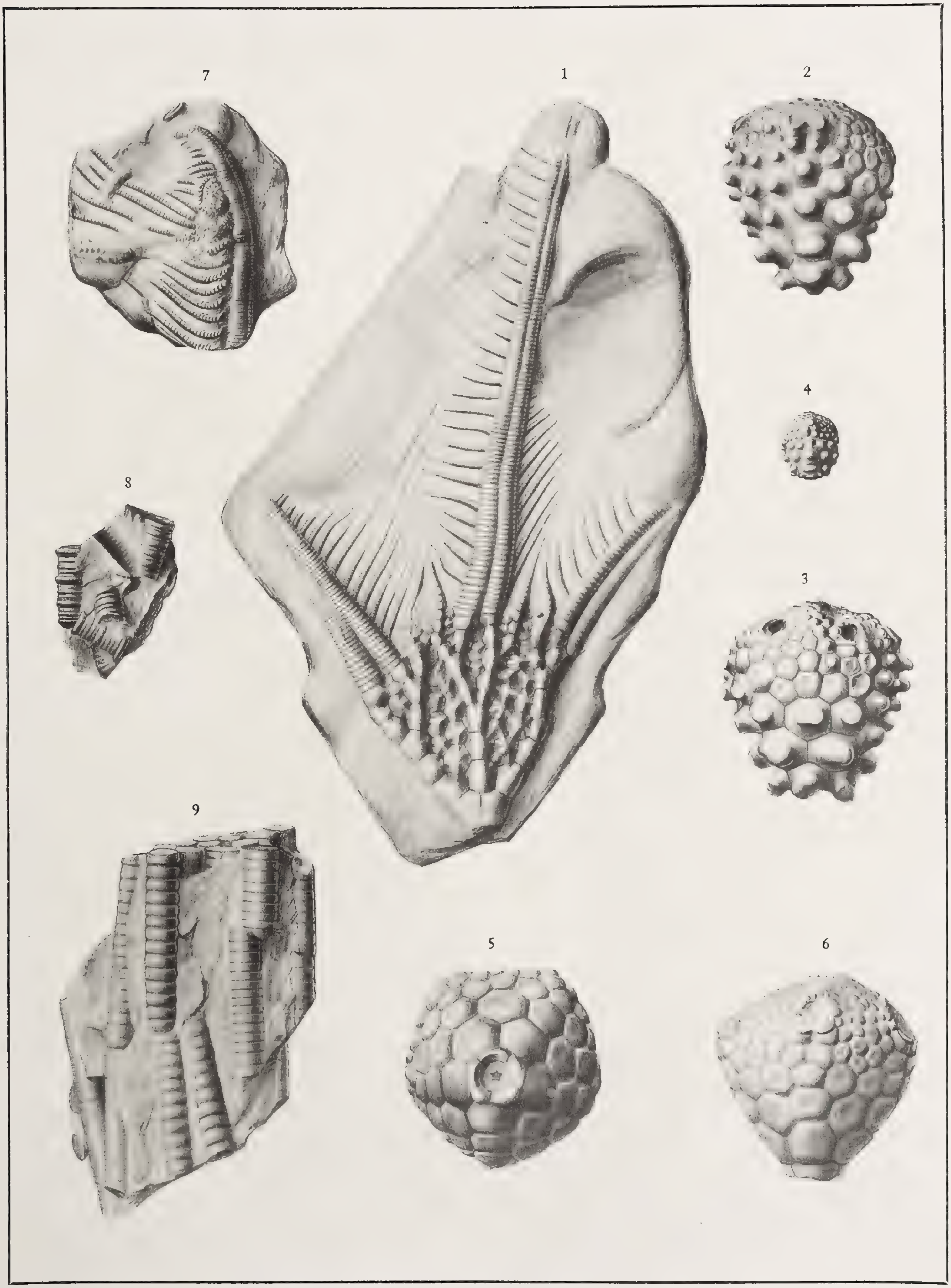

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PLATE 13

511

Genus MELOCRINUS Goldfuss

Melocrinus breviradiatus Hall

Page 127

1 Basal view of the type. Jewett Collection, Cornell University, number 7330
Hamilton (Moscow ?) shale, Eighteen Mile creek
2 Anterior view of the calyx of the same specimen

Melocrinus clarkei (Hall Ms) Williams

Page 132

3 Part of a crushed crown from the original slab, showing two rays. Type, number $\frac{4340}{1}$ (*see* plate 14)
Genesee (West River) shale, Bell's gully, Canandaigua lake
4 Basal view of another specimen from the same slab, showing parts of four arms. Type, number $\frac{4340}{1}$ (*see* plate 14)
5 Basolateral view of the dorsal cup of a specimen showing the delicate ornamentation. Drawn from a gutta-percha squeeze
Portage (Cashaqua shale) beds, Eighteen Mile creek, North Evans

Melocrinus gracilis Wachsmuth & Springer

Page 136

6 Lateral view of the type specimen, number $\frac{4341}{1}$, showing the highly arched tegmen
Hamilton (Moscow) shale, Canandaigua lake

Originals, except as otherwise indicated, in the State Museum

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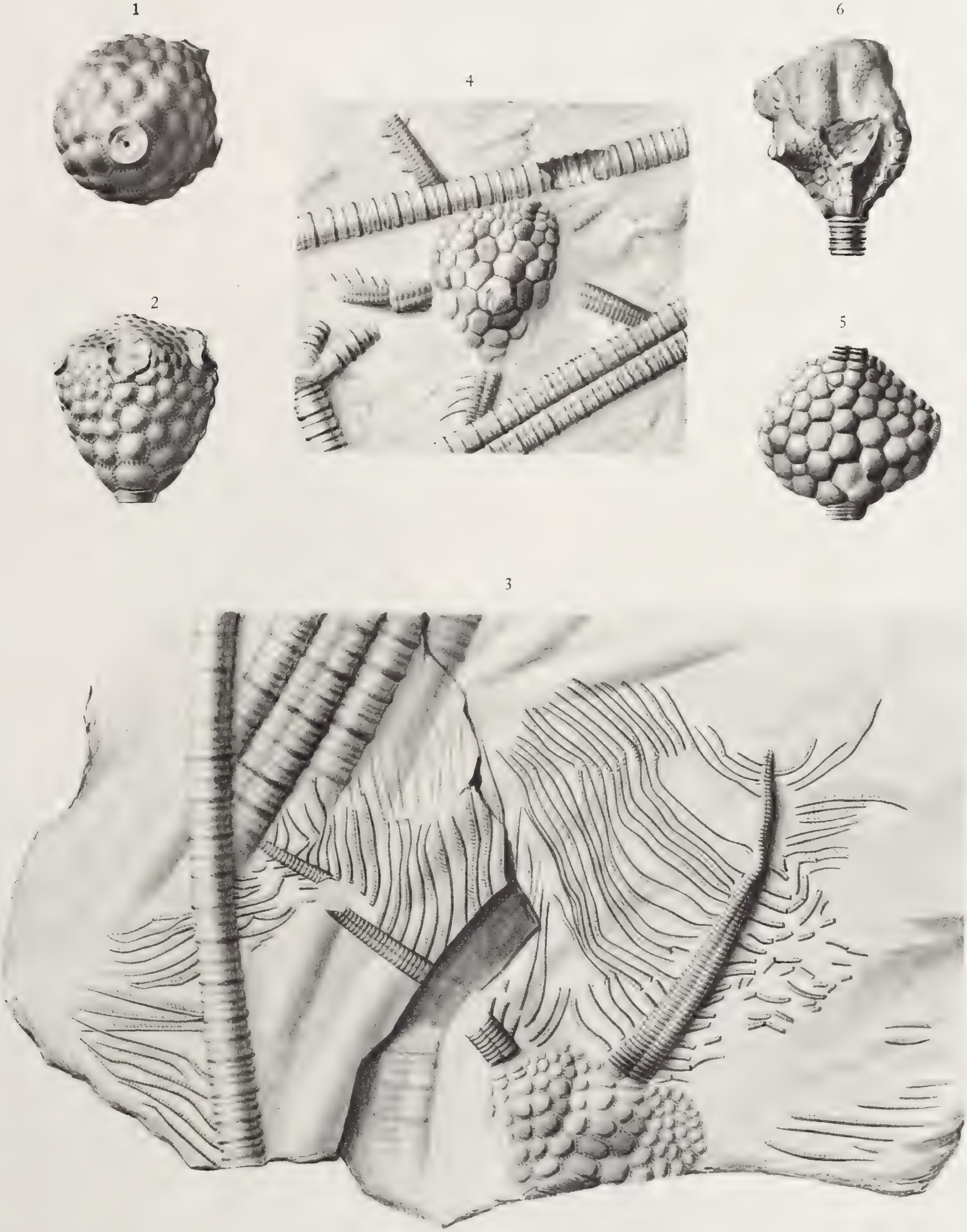

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PLATE 14

Genus MELOCRINUS Goldfuss

Melocrinus clarkei (Hall Ms) Williams

Page 132

Photographic reproduction, about one-half natural size, of the original slab from which the type material was described (*see* plate 13, figures 3, 4). Collection of State Museum

Genesee (West River) shale, Bell's gully, Canandaigua lake

PLATE 15

Genus MELOCRINUS Goldfuss

Melocrinus reticularis Olsson

Page 137

1 Lateral view of dorsal cup, exterior impression. After Olsson, 1912, plate 7, figure 1; original not located
Portage (Ithaca) beds, McGraw or University quarry, Ithaca

Melocrinus williamsi Olsson

Page 138

2 Lateral view of calyx showing a portion of the anal tube. After Olsson, 1912, plate 6, figure 3; original not located
Portage (Ithaca) beds, near Cortland

Melocrinus naplesensis sp. nov.

Page 140

3 Lateral view of calyx and column of an adult specimen
Portage (West Hill flags), Italy hollow, near Naples
4 Posterolateral view of a young specimen from the same locality.
5 A very young Melocrinus which may be the young of M. naplesensis (x 2)
Portage (West Hill flags), Italy hollow, near Naples

Melocrinus sp. (?)

Page 142

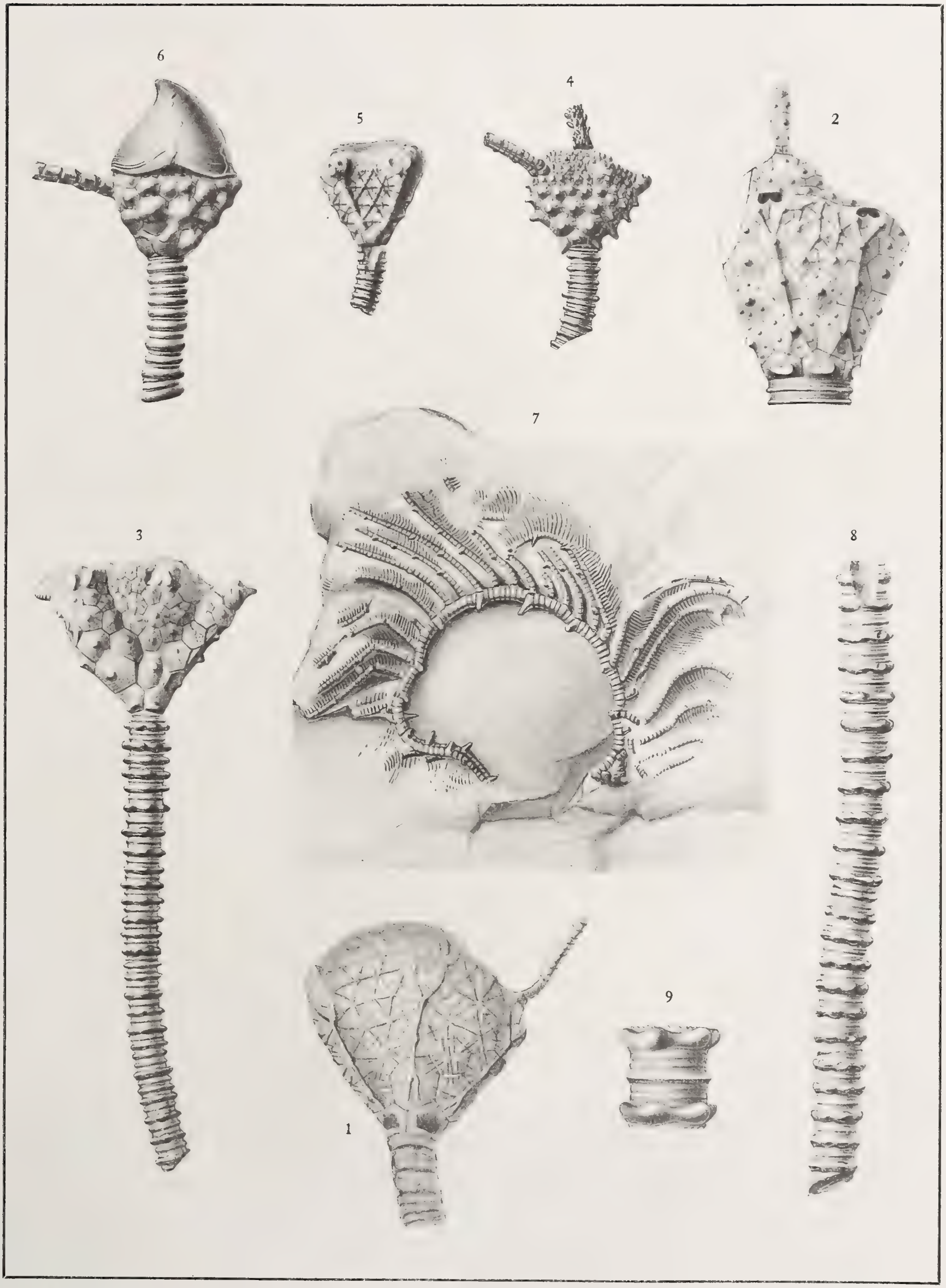
6 Another young specimen (x 3) on the same slab with figure 5. No possible relationships of this specimen have been determined. Note the parasitic gastropod

Melocrinus sp. nov.

Page 142

7 Dorsolateral view of an arm trunk, showing the spines on the main trunk and the uniserial arms
Hamilton (Moscow) shale, Cashong creek, near Bellona
8 Portion of a column from the same locality. This type of column is found associated with the arm figured and with other arm fragments of the same type, and probably belongs to this species
9 An enlargement (x 2) of a section of the same specimen, showing the crenulate edges of the columnals

Originals, except as otherwise indicated, in the State Museum



G. S. Barkentin del.

PLATE 16

Genus MELOCRINUS Goldfuss

Melocrinus splendens sp. nov.

Page 144

1 Lateral view of a specimen showing ornamentation and character of arms. Collection of University of Chicago, Walker Museum, number 12926
Chemung beds, Binghamton

Melocrinus willetensis sp. nov.

Page 146

2 Lateral view of the calyx
Lower Chemung beds, Willet

Melocrinus willetensis var. **perstriatus** nov.

Page 147

3 Lateral view of a crushed calyx showing the bases of the arms. Collection of University of Chicago, Walker Museum, number 14240
Lower Chemung beds, Willet
4 Fragment of posterior side, showing anal tube and bases of two arms
Lower Chemung beds, Willet
5 Fragment of a radius showing the ornamentation
Lower Chemung beds, Willet

Subgenus TRICHOTOCRINUS Olsson

Melocrinus (Trichotocrinus) harrisi Olsson

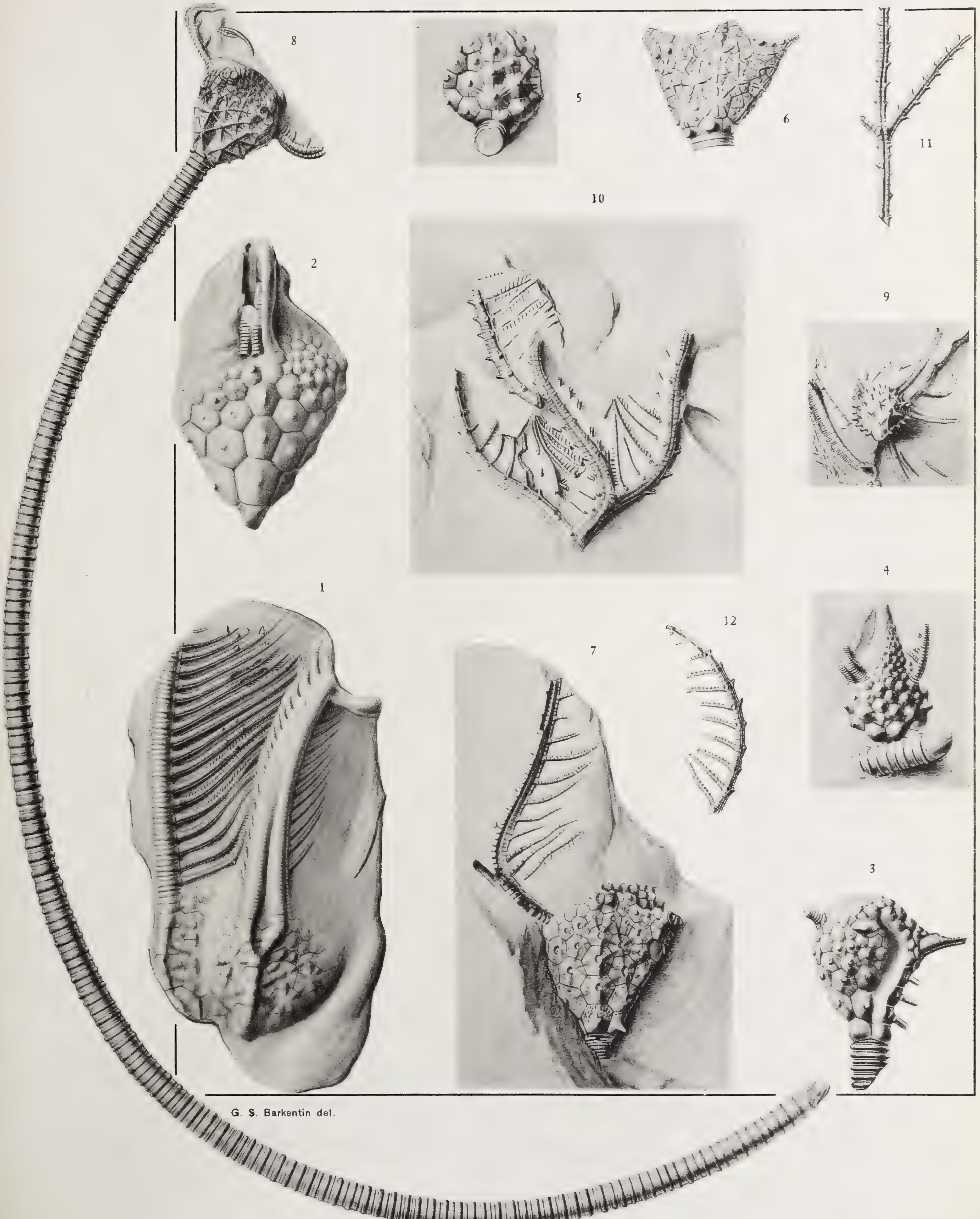
Page 148

6 Lateral view of the dorsal cup. After Olsson, 1912, plate 6, figure 1; original not located
Portage (Ithaca) beds, McGraw or University quarry, Ithaca

Melocrinus (Trichotocrinus) lutheri sp. nov.

Page 149

7 Lateral view of the calyx of an adult specimen
Portage (West Hill flags), Italy hollow, near Naples
8 Lateral view of calyx and column of a younger specimen
Portage (West Hill flags), Italy hollow, near Naples
9 Basolateral view of a very young specimen showing the posterior side. The main arms are unbranched so far as preserved
Portage (West Hill flags), Italy hollow, near Naples



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10 Dorsal side of an arm trunk showing irregular trichotomous branching, the spinose character and the uniserial arms

Portage (West Hill flags), Italy hollow, near Naples

11, 12 Portions of main arms showing the usual regular trichotomous branching, the dorsal spines and the uniserial arms

Portage (West Hill flags), Italy hollow, near Naples

Originals, except as otherwise indicated, in the State Museum

Figures 1–5, 8–10, were drawn from gutta-percha and plasticine squeezes

PLATE 17

Genus DOLATOCRINUS Lyon (W. & Sp.)

Dolatocrinus liratus (Hall)

Page 158

1 Basal view of an adult showing the beautiful ornamentation of numerous carinae. Basal area flattened; basals prominent and project in a well-defined rim

Hamilton (Moscow) shale, Leicester

2 Basal view of a smaller specimen, one of the types, number $\frac{4142A}{2}$, in which the ornamentation is particularly well shown. Basal ring less prominent

Hamilton (Moscow) shale, Cashong creek, near Bellona

3 Basal view of a specimen in which the carinae are noticeably regular and uninterrupted. Radial keels prominent and strongly nodose at the centers of the plates; basal ring likewise well developed

Hamilton (Moscow) shale, Bellona

4 View of the tegmen of another specimen showing the heavy nodose plates. Drawn from a wax impression taken from the mold

Hamilton (Moscow) shale, Canandaigua lake

5 Proximal portion of an anal tube

Hamilton (Moscow) shale, Bellona

6 Basal view of a very young specimen showing the deeply excavated basal region and the few heavy ridges and carinae

Hamilton (Moscow) shale, west shore of Canandaigua lake

7 Basal view of a somewhat older form which still shows the deeply excavated basal region

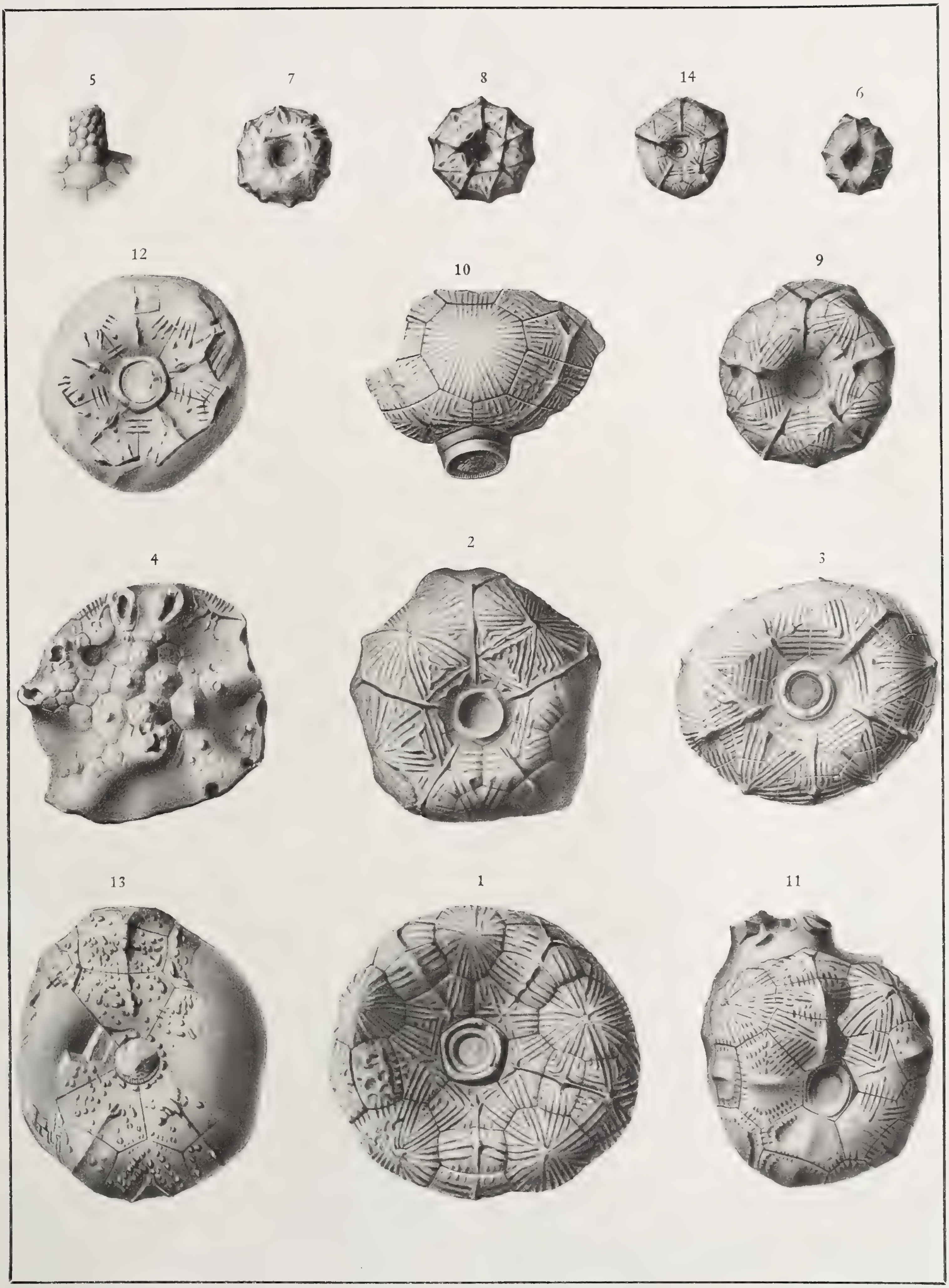
Hamilton (Moscow) shale, Bellona

8 Basal view of a specimen only a little older than the one shown in figure 7. Deeply excavated basal region well shown. The development up to this point has been in the strengthening of carinae already formed, the accentuation of the nodes on the plates of the radial series and the primary interbrachials. Somewhat irregular ridges have been added

Hamilton (Moscow) shale, west shore of Canandaigua lake

9 Basal view of a specimen considerably older, in which the resemblance to the adult is very strong. Basal pit marked, but very shallow. Carinae much less prominent, and with the widening of the interradii have greatly increased in number. Radial keels strong; the nodes here and at the centers of the primary interbrachials comparatively less conspicuous. The base has been slightly crushed in, making the basal pit appear deeper than it really is

Hamilton (Moscow) shale, Bellona



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10 Lateral view of Hall's type of D. liratus *var.* multilira, number $\frac{4142}{1}$. This is a very mature form of liratus. The radial keels have become an insignificant part of the ornamentation, and the ornamentation in the interradii has become highly complex. Carinae very numerous and fine, giving the delicate multilira type of ornamentation

Hamilton (Moscow) shale, Menteth's point, Canandaigua lake

11 Basal view of a specimen showing the breaking up of the carinae seen in older forms

Hamilton (Moscow) shale, Bellona

12 Basal view of a fragmentary specimen in which the breaking up of the carinae has progressed still farther. Basal ring thickened and prominent

Hamilton (Moscow) shale, Bellona

13 Basal view of a portion of a very large, old specimen showing a complete breaking up of the carinae, which are now represented by scattered tubercles with more or less linear arrangement. Even the projecting basal rim is marked by a ring of tubercles

Hamilton (Moscow) shale, Bellona

Dolatocrinus liratus var. **parvulus** nov.

Page 164

14 Basal view showing the complexity and delicacy of the ornamentation

Hamilton (Moscow) shale, Canandaigua lake

All the originals in the State Museum

PLATE 18

Genus DOLATOCRINUS Lyon (W. & Sp.)

Dolatocrinus liratus (Hall)

Page 158

1 Basal view of an abnormal form with four rays. Two primary interbrachials together with an extension of the basals in that area (at the right in the figure) occupy the space usually filled by two interradii and a radial series

Hamilton (Moscow) shale, Canandaigua lake

2 Lateral view of the same specimen showing the two interbrachials. The one at the left has a carina which sends a branch to the first secundibrach of the adjoining radial series

3 Lateral view of the same specimen showing a ray with one primibrach, the primaxil. The interradius with two primary interbrachials is at the right.

Dolatocrinus glyptus (Hall)

Page 155

4 Basal view of a young form. Here the ornamentation is somewhat of the type seen in liratus. Radial ridge represented by elongate nodes

Hamilton (Moscow) shale, York

5 Basal view of an adult specimen. Radial ridge practically continuous. Ornamentation tends to be made up of rather irregularly arranged elongate nodes and granules

Hamilton (Moscow) shale, York

6 Lateral view of an old specimen showing the breaking up of the elongate nodes. Type. Collection of American Museum Natural History, number $\frac{5031}{1}$.

Hamilton (Moscow) shale, Pavilion

7 Basal view of an old specimen showing this process continued still farther. Basals very short and represented by a thickened ring

Hamilton (Moscow) shale, Hopewell

Dolatocrinus glyptus var. **intermedius** (Hall)

Page 157

8 Lateral view of Hall's type, number $\frac{4141}{1}$

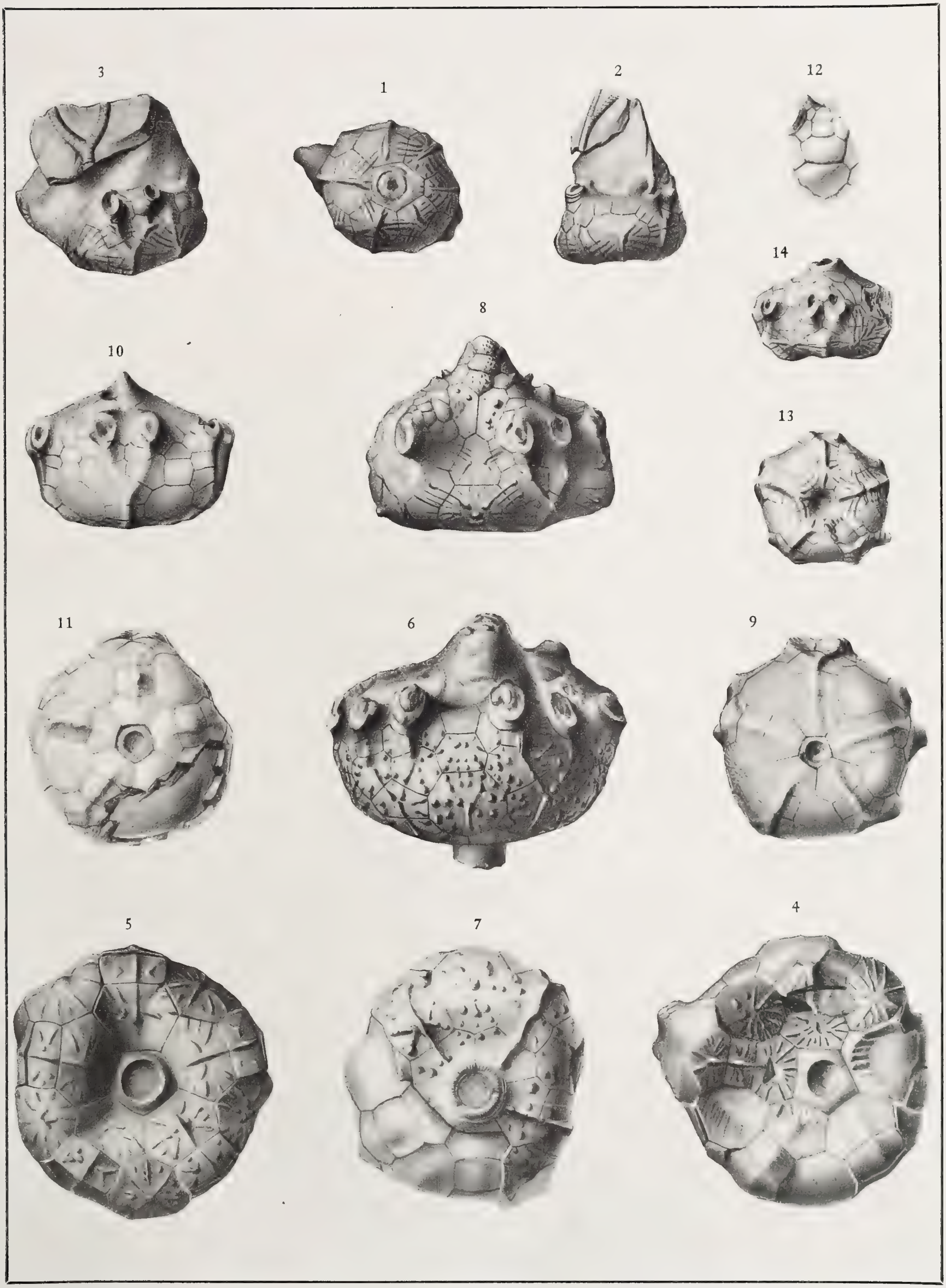
Hamilton (Moscow) shale, York

Dolatocrinus speciosus (Hall)

Page 168

9 Basal view of the type specimen, number $\frac{4143}{1}$

Onondaga limestone, Schoharie



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10 Lateral view of the same specimen
11 Basal view of an older specimen showing the shortening of the radials due to the enlargement of the stem
Onondaga limestone, Cherry Valley
12 Interbrachial plates of another specimen
Onondaga limestone, Schoharie county

Dolatocrinus ornatus Meek

Page 170

13 Basal view. The ornamentation is well shown at the right in the figure
Onondaga limestone, Cherry Valley
14 Lateral view of the same specimen

Originals, except as otherwise indicated, in the State Museum

PLATE 19

Genus DOLATOCRINUS Lyon (W. & Sp.)

Dolatocrinus lamellosus (Hall)

Page 164

1 Basal view of the type specimen showing the ornamentation. Collection of American Museum Natural History, number 4167
Onondaga limestone, Louisville, Ky.

2 Basolateral view of a smaller specimen showing the higher plates of the radial and interradial series. Surface ornamentation not preserved. Collection of American Museum Natural History, number 4167
Onondaga limestone, Louisville, Ky.

Dolatocrinus insignis sp. nov.

Page 174

3 Basal view of an adult specimen
Hamilton (Moscow) shale, Bellona

4 View of the tegmen of the same specimen showing the massive, granulose plates

5 Basal view of a younger specimen. Basal disk quite small. Radial ridge more prominent. Central, longitudinal depressions in the radials and primary interbrachials more noticeable
Hamilton (Moscow) shale, Bellona

6 Dorsal view of a fragment of the dorsal cup of a very large specimen. Ridges in the interradii form more or less complete patterns. Central longitudinal depressions, giving the curious pinched appearance to the plates, well shown. (*See* text figure 39, page 174)
Hamilton (Moscow) shale, Canandaigua lake

Originals, except as otherwise indicated, in the State Museum

G. S. Barkentin del.

PLATE 20

Genus DOLATOCRINUS Lyon (W. & Sp.)

Dolatocrinus marshi var. **glaber** nov.

Page 173

1 Dorsal view of the calyx
Onondaga limestone, Cherry Valley
2 Lateral view of the same specimen

Dolatocrinus lobatus sp. nov.

Page 176

3 Dorsal view of the calyx of an adult specimen
Onondaga limestone, Cherry Valley
4 Lateral view of the same specimen
5 Dorsal view of the calyx of a very young specimen
Onondaga limestone, Cherry Valley
6 Lateral view of the same specimen

Genus CRATEROCRINUS gen. nov.

Craterocrinus ruedemanni sp. nov.

Page 186

7 Dorsal view of the calyx showing the broad, low character of the dorsal cup
Onondaga limestone, Cherry Valley
8 View of the tegmen of the same specimen. A parasitic gastropod has been attached to this crinoid, and its position is well marked on the tegmen

Craterocrinus schoharie sp. nov.

Page 189

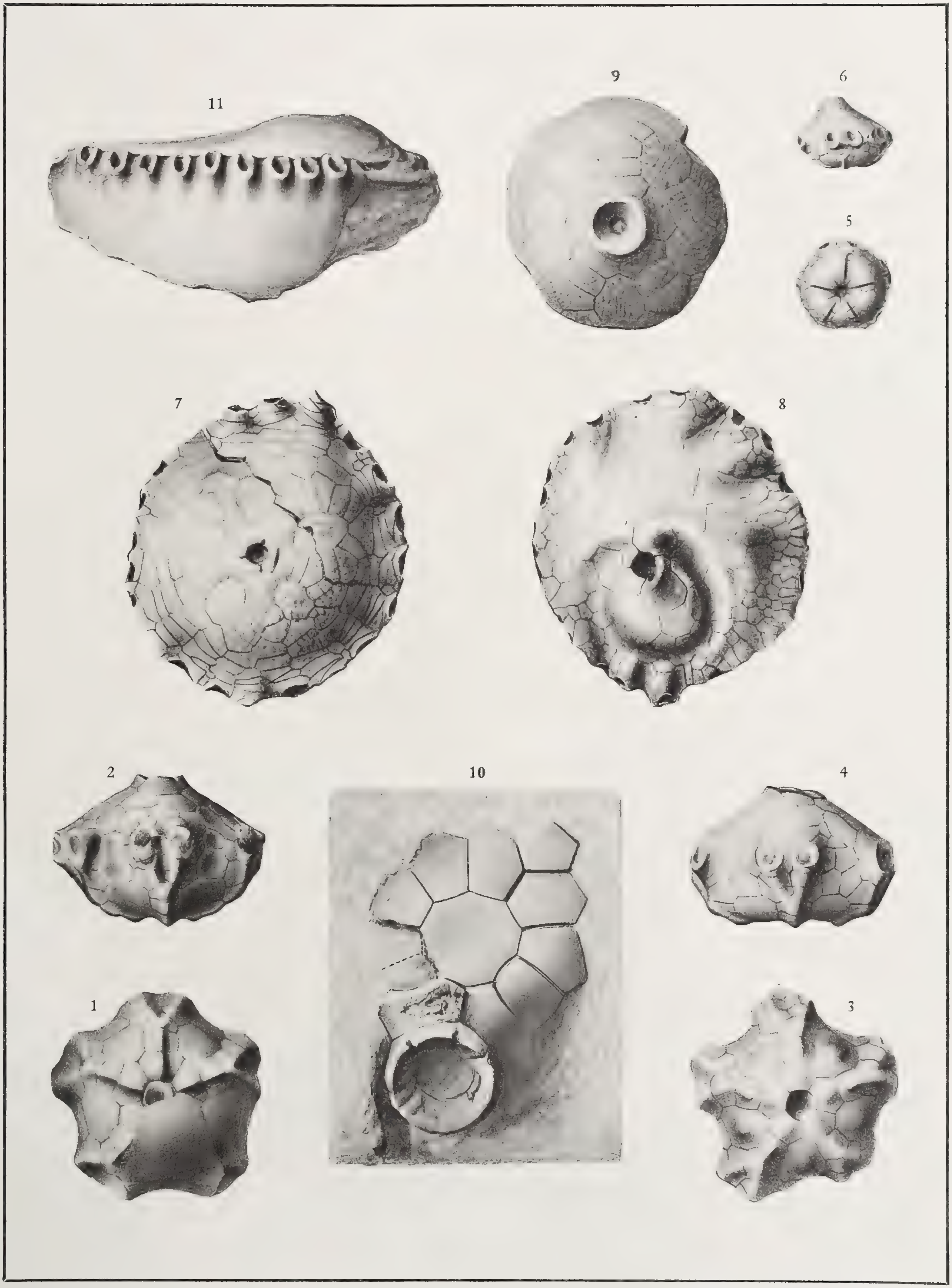
9 Basal view of a fragmentary dorsal cup
New Scotland limestone, Schoharie

Genus CLONOCRINUS Quenstedt

Clonocrinus (?) **macropetalus** (Hall) n. comb.

Page 153

10 Lateral view of a fragment of a dorsal cup showing parts of an interbrachial and two radial series. Type. Collection of American Museum Natural History, number $\frac{2299}{2}$
Becraft limestone, Helderberg Mountains



G. S. Barkentin del.

Genus HIMEROCRINUS Springer

Himerocrinus (?) **polydactylus** (Hall)

Page 199

11 Lateral view of a fragment of a calyx. The type specimen, number $\frac{4120}{1}$

New Scotland limestone, Schoharie

Originals, except as otherwise indicated, in the State Museum

PLATE 21

Genus CLARKEOCRINUS nov.

Clarkeocrinus troosti (Hall) n. comb.

Page 181

Lateral view of the crown and proximal part of the column of a very well-preserved specimen (*see* plate 25). Proximal circinate cirri well shown. Collection of State Museum

Hamilton (Moscow) shale, Vincent

G. S. Barkentin del.

PLATE 22

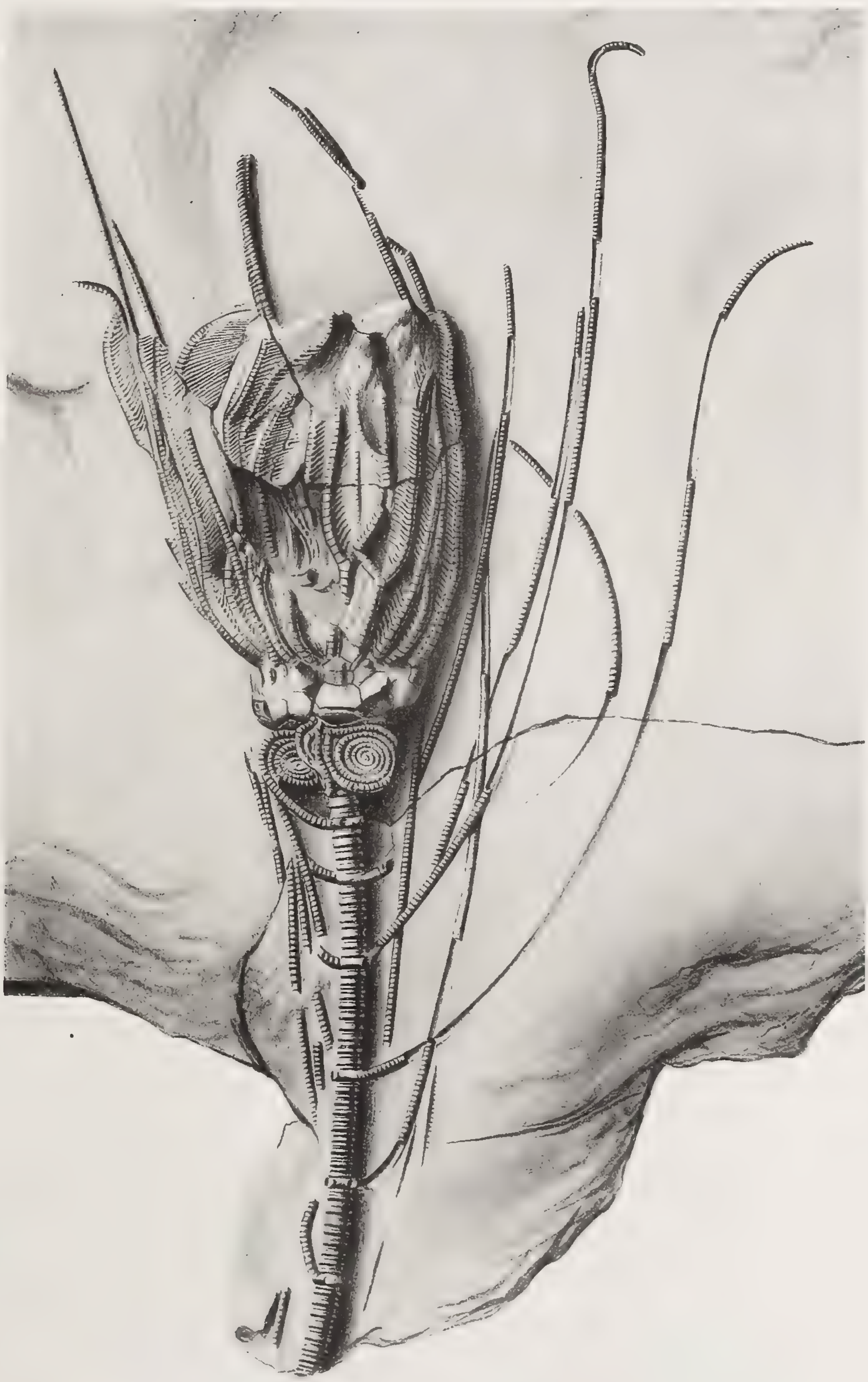
Genus CLARKEOCRINUS nov.

Clarkeocrinus troosti (Hall) n. comb.

Page 181

Lateral view of the crown and proximal part of the column of one of the types, number $\frac{4140}{11}$. The calyx is somewhat crushed, but the arms and cirri are well shown. Collection of State Museum

Hamilton (Moscow) shale, Vincent



G. S. Barkentin del.

PLATE 23

Genus CLARKEOCRINUS nov.

Clarkeocrinus troosti (Hall) n. comb.

Page 181

1 Lateral view of a large crown showing the proximal cirri. The interradius shown is abnormal (*see* plate 25)

2 Lateral view of a crown showing a well-preserved dorsal cup

3 Dorsal view of the crown of another specimen, one of the types, number $\frac{4140}{3}$

4 Lateral view of a crown, one of the types, number $\frac{4140}{6}$. The dorsal cup is somewhat crushed and broken

5 A proximal nodal with cirri

Specimens all from the Hamilton (Moscow) shales of Vincent, N. Y., and in the collection of the State Museum

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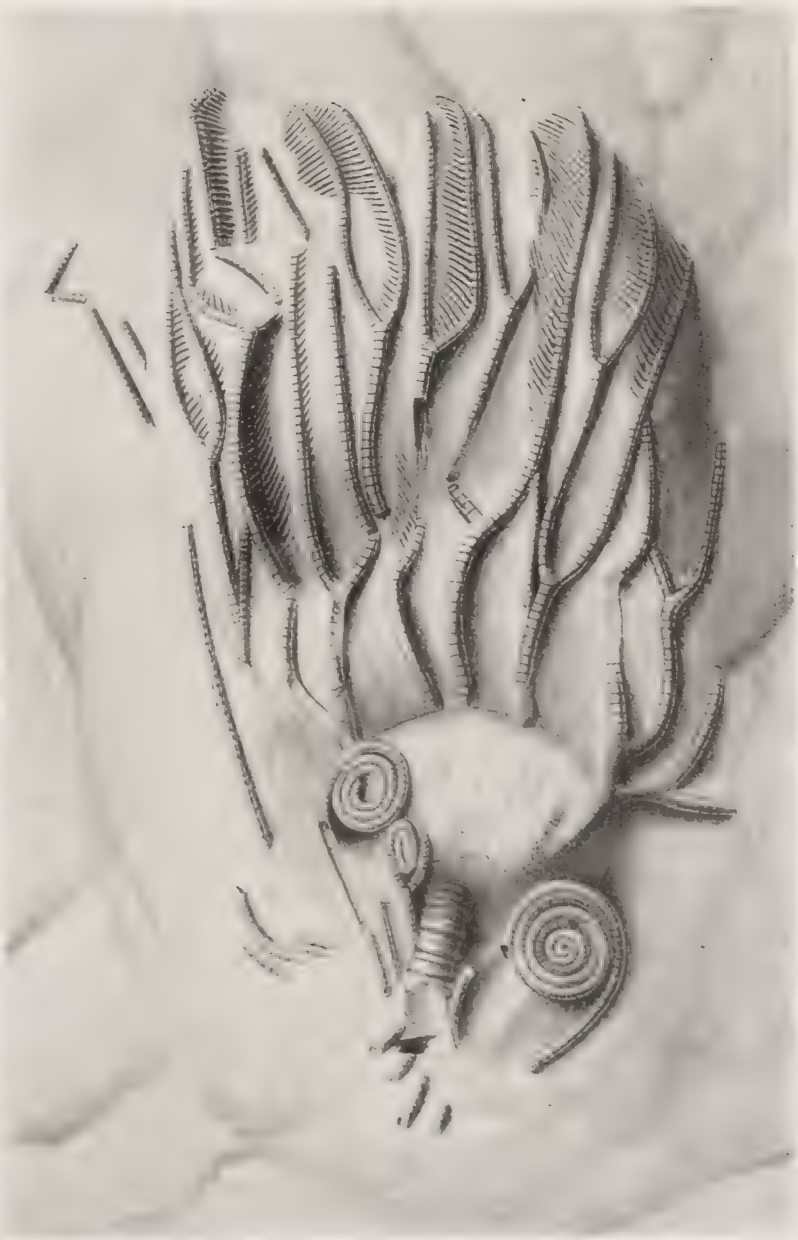

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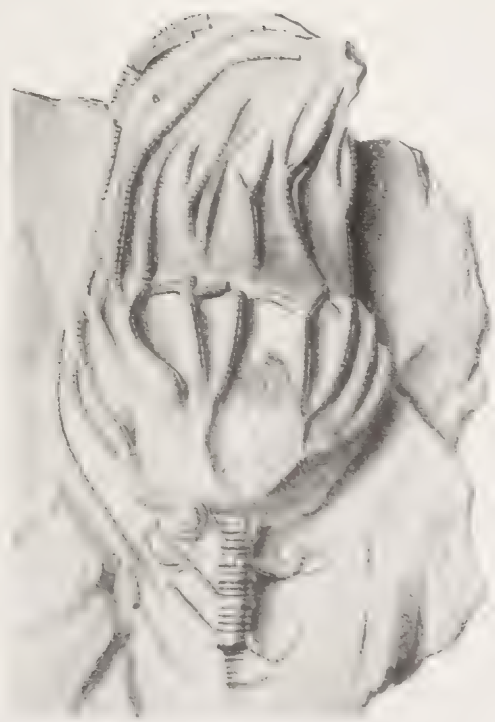


G. S. Barkentin del.

PLATE 24

Genus CLARKEOCRINUS nov.

Clarkeocrinus troosti (Hall) n. comb.

Page 181

1 Lateral view of a crown and the proximal part of the column. One of the types, number $\frac{4140}{2}$

Hamilton (Moscow) shale, Vincent

2 Lateral view of a crown showing the anal tube

Hamilton (Moscow) shale, Vincent

3 The anal tube of the same specimen, detached

4 Portion of an anal tube

Hamilton (Moscow) shale, Vincent

Genus COMANTHOCRINUS Springer

Comanthocrinus indianensis (Miller & Gurley)

Page 192

5 Dorsal view of a specimen showing the dorsal cup and the proximal portion of the arms. Collection of Doctor Springer

Hamilton (Moscow) shale, Canandaigua lake

6 Dorsal view of one of the type specimens. Collection of the University of Chicago, Walker Museum, number 6068

Hamilton beds, Charlestown, Ind.

7 Highly arched tegmen of another specimen seen from the anterior side. It shows the excentric anal tube, the raised, rounded ridges marking the course of the ambulacra and the pores at the level of the arms in the interradii and between the arm bases. Collection of Doctor Springer

Hamilton beds, Silver creek, Clark county, Ind.

8 Posterior view of the tegmen of the same specimen, showing the spinose anal ridge and the posterior inflation produced by the coil of the intestine

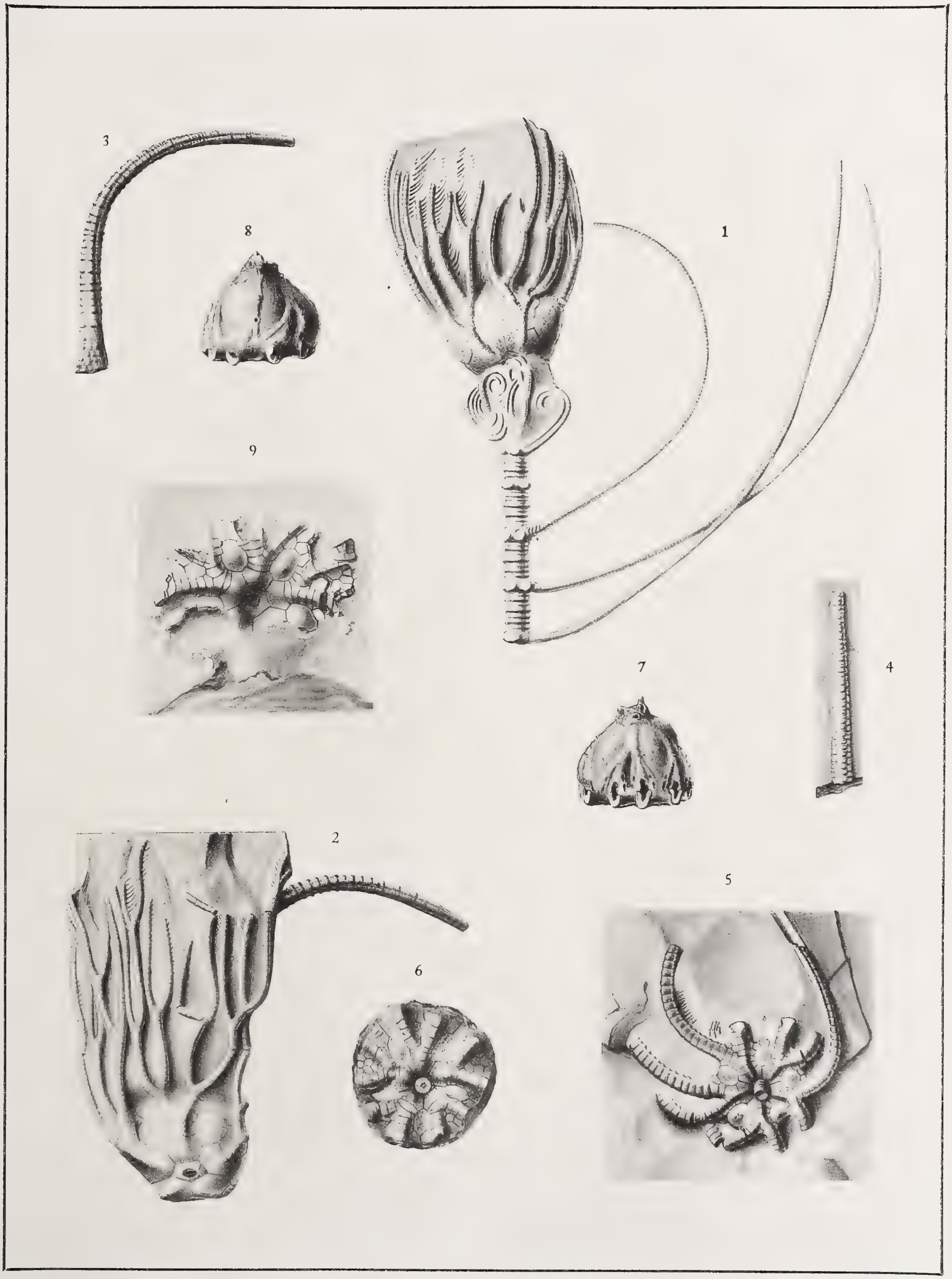
Comanthocrinus priscus Springer

Page 197

9 Basal view of a very fragmentary cup, which nevertheless shows well the large size of the specimen and the greater extent of incorporation of the brachials in this species. Enough of the specimen is preserved to show the general character of the cup. Collection of Doctor Springer

Onondaga limestone, Le Roy

Originals, except as otherwise indicated, in the State Museum



G. S. Barkentin del.

PLATE 25

Genus CLARKEOCRINUS nov.

Clarkeocrinus troosti (Hall) n. comb.

Page 181

Photographic reproduction, about one-half natural size, of a crinoid colony showing thirteen specimens of Clarkeocrinus troosti (*see* plate 21 and plate 23, figure 1). This is the largest and finest colony of Devonian crinoids known. In addition to the above species, there are shown Acanthocrinus spinosus (Hall), Gilbertsocrinus spinigerus (Hall) and Eleutherocrinus whitfieldi Hall. Collection of State Museum

Hamilton (Moscow) shale, Vincent

PLATE 26

Genus ACACOCRINUS Wachsmuth & Springer

Acacocrinus pentadactylus (Grabau) n. comb.

Page 200

1 Left posterior view of the crown of the type specimen (x 2). For the natural size view see text figure 45, page 200. Collection of Columbia University

Hamilton (Moscow) shale, Eighteen Mile creek

Genus COROCRINUS nov.

Corocrinus ornatus sp. nov.

Page 203

2, 3, 4 Posterior views of three dorsal cups, showing the very broad posterior interradius and the ridge marking the median line of anal plates

Hamilton (Ludlowville) shale, Fall brook, near Geneseo

Corocrinus (?) **calypso** (Hall) n. comb.

Page 205

5 Lateral view of a badly crushed calyx. Hall's type of "Actinocrinus" calypso. Collection of American Museum Natural History, number $\frac{5025}{1}$

Hamilton (Moscow) shale, Jaycox's run, Genesee Valley

Genus SACCOCRINUS Hall

Saccocrinus (?) **hamiltonensis** sp. nov.

Page 207

6 Right anterolateral view of the dorsal cup. Collection of Doctor Springer

Hamilton (Upper Moscow) shale, Bellona

7 Posterior view of the same specimen

Genus THAMNOCRINUS nov.

Thamnocrinus springeri sp. nov.

Page 243

8 Lateral (left anterolateral) view of a specimen showing the dorsal cup, proximal portion of the arms and three of the tegminal spines

Hamilton (Moscow) shale, Cashong creek, near Bellona

DEVONIAN CRINOIDS

G. S. Barkentin del.

9 Basal view of a crown showing the flexible integument joining the main arm trunks

Hamilton (Moscow) shale, Cashong creek, near Bellona

10 Anterior view of the same specimen showing the strong tegminal spines

Originals, except as otherwise indicated, in the State Museum

PLATE 27

Genus GENNAEOCRINUS Wachsmuth & Springer

Gennaeocrinus eucharis (Hall)

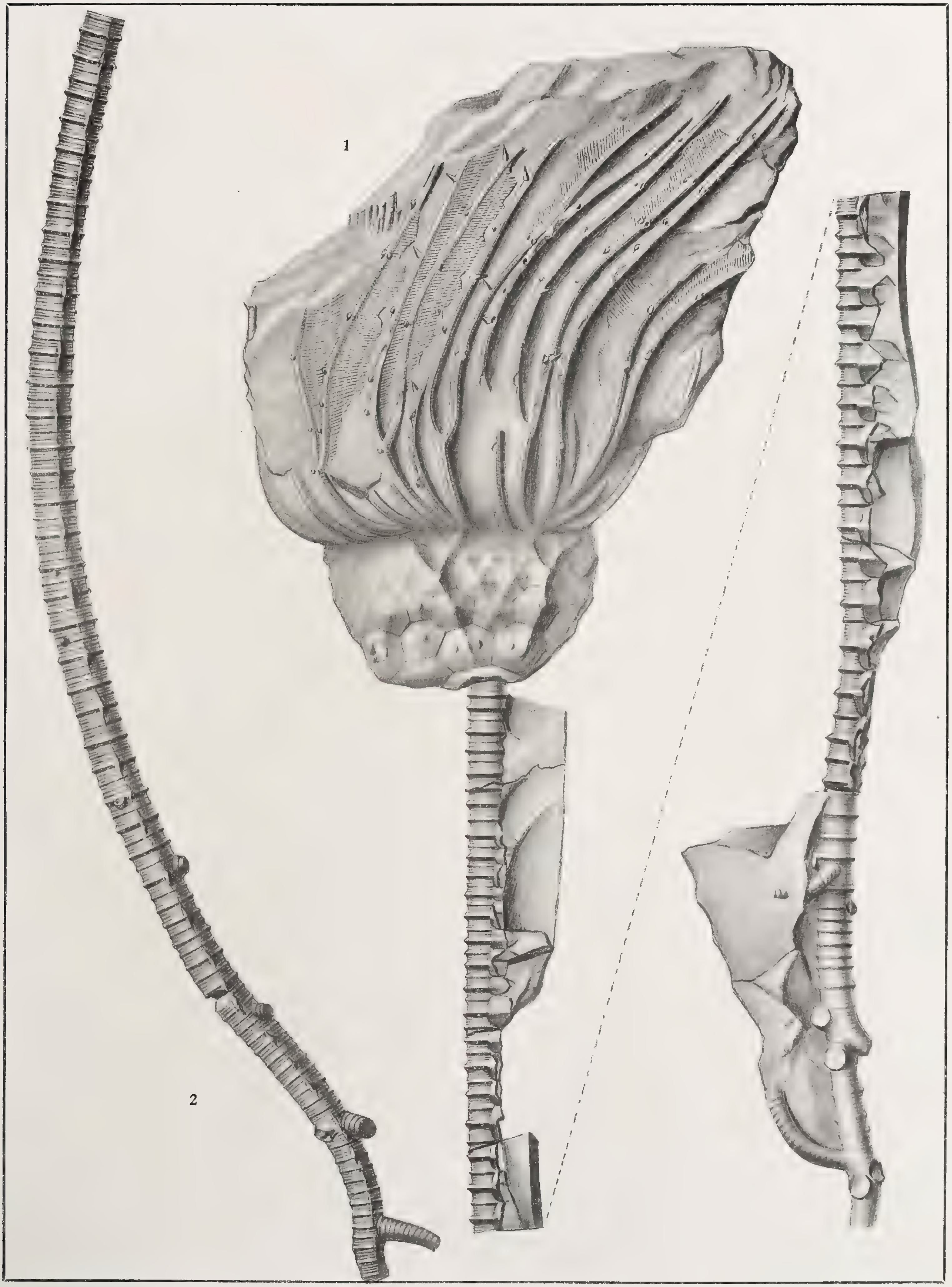
Page 212

1 Lateral view of a specimen showing the crown and almost the full length of the column. This specimen shows the spines on the arms and the peculiar appendages of the column. One of the types, number $\frac{4220}{3}$ in the State Museum

Hamilton (Moscow) shale, Vincent

2 Column of another specimen (*see* plate 29) showing the attachment of the column appendages, which here have been broken away. One of the types, number $\frac{4220}{4}$ in the State Museum

Hamilton (Moscow) shale, Vincent



G. S. Barkentin del.

PLATE 28

Genus GENNAEOCRINUS Wachsmuth & Springer

Gennaeocrinus eucharis (Hall)

Page 212

1 Lateral view of the dorsal cup, showing the numerous, faint striae which have been developed between the radiating ridges. One of the types, number $\frac{4220}{1}$ in the State Museum

Hamilton (Moscow) shale, Cashong creek, Bellona

2 Lateral view of a fragmentary specimen showing well the ornamentation of radiating ridges

Hamilton (Moscow) shale, Cashong creek, Bellona

3 Lateral view of a more mature specimen showing the spines on the arms and two of the vertical rows of appendages on the column. Radial ridges less prominent, and radiating ridges on the plates fainter, in places represented by scattered tubercles

Hamilton (Moscow) shale, Vincent

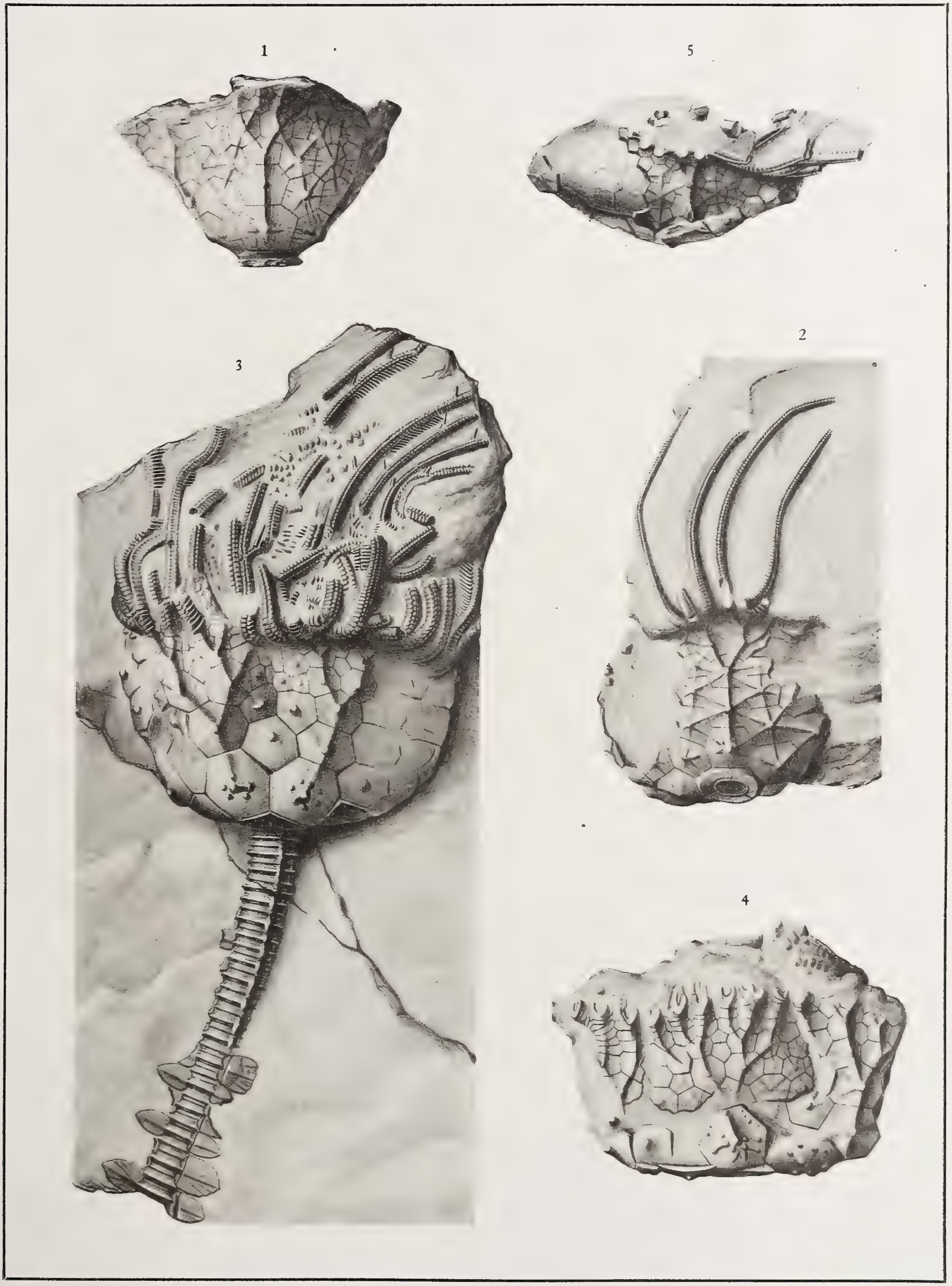
4 Lateral view of a rather crushed dorsal cup, showing as the preceding, the breaking up of the ornamentation. Arm bases well shown

Hamilton (Moscow) shale, Fall Brook, near Geneseo

5 A very fragmentary, crushed specimen, the only specimen showing the strong tegminal spines

Hamilton (Moscow) shale, Cashong creek, Bellona

All of the originals in the State Museum



G. S. Barkentin del.

PLATE 29

Genus GENNAEOCRINUS Wachsmuth & Springer

Gennaeocrinus eucharis (Hall)

Page 212

Photographic reproduction, about four-fifths natural size, of a large specimen with practically the full length of the column preserved (*see* plate 27, figure 2). Two small crowns and fragments of another, as well as the distal portion of another column, are associated with it. The vertical rows of appendages of the column are broken off. One of the types, number $\frac{4220}{4}$ in the State Museum

Hamilton (Moscow) shale, Vincent

PLATE 30

Genus GENNAEOCRINUS Wachsmuth & Springer

Gennaeocrinus eucharis (Hall)

Page 212

Photographic reproduction, natural size, of a large specimen showing almost the full length of the column. Some of the plates of the dorsal cup have been broken away. One of the types, number $\frac{4220}{5}$ in the State Museum

Hamilton (Moscow) shale, Vincent

PLATE 31

Genus GENNAEOCRINUS Wachsmuth & Springer

Gennaeocrinus nyssa (Hall)

Page 216

1 Right anterolateral view of an incomplete crown showing the ornamentation of the dorsal cup and parts of some of the arms. One of the types, number $\frac{4221}{1}$ in the State Museum
Hamilton (Moscow) shale, Vincent
2 Basal view of the dorsal cup of a more mature specimen showing the fainter radiating ridges and the prominent nodes at the centers of the plates. One of the types, number $\frac{4221}{3}$ in the State Museum
Hamilton (Moscow) shale, Fall brook, near Geneseo
3 Anterior side of the same specimen
4 Right anterolateral view of a dorsal cup showing the ornamentation well, the arm bases and the proximal portion of some of the arms
Hamilton (Moscow) shale, Fall brook, near Geneseo
5 Lateral view of a young specimen showing the character of the arm branching
Hamilton (Moscow) shale, North Bristol

Gennaeocrinus kentuckiensis (Shumard)

Page 208

6 Posterior view of the dorsal cup of a large specimen
Hamilton (Moscow) shale, Canandaigua lake
7 Posterior view of the dorsal cup of another specimen. Type. Collection of Doctor Springer
Hamilton beds, Falls of the Ohio, Louisville, Ky.
8 Fragment of an older form showing the more elaborate ornamentation due to increase in number and fineness of the carinae. Collection of American Museum Natural History, number 4162
Hamilton beds, Bear Grass creek, near Louisville, Ky.

Gennaeocrinus decorus sp. nov.

Page 223

9 Fragment of a specimen showing the character of the ornamentation of the cup plates, the arm bases with the proximal part of two arms, and a few millimeters of column. Drawn from gutta-percha and plasticine squeezes.
Hamilton beds, Worcester

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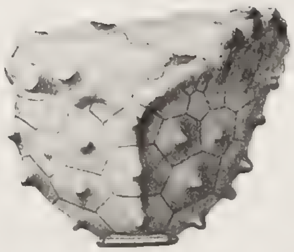

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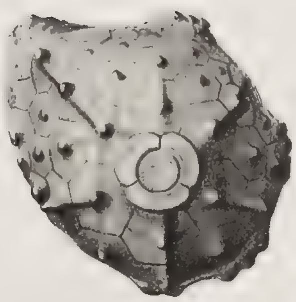

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G. S. Barkentin del.

Gennaeocrinus peculiaris sp. nov.

Page 225

10 Anterolateral view of the dorsal cup. The anterior ray is at the left
Hamilton (Moscow) shale, Moscow

Originals, except as otherwise indicated, in the State Museum

PLATE 32

Genus GENNAEOCRINUS Wachsmuth & Springer

Gennaeocrinus carinatus Wood

Page 219

1 Posterior side of the calyx of the type specimen (x 3/2). This and the two following figures are reproduced from the original figures by Miss Wood. Collection of Boston Society of Natural History
Hamilton beds, Charlestown, Ind.
2 Basal view of the same specimen (x 3/2)
3 Tegmen of the same specimen (x 3/2)
4 Basal view of part of a dorsal cup of a more mature individual. Collection of Doctor Springer
Hamilton beds, Falls of the Ohio, Louisville, Ky.
5 Basal view of the calyx of a small (probably young) specimen
Hamilton (Ludlowville) shale, Athol Springs
6 Basolateral view of part of a dorsal cup showing the posterior interradius at the left. Drawn from gutta-percha squeezes
Hamilton (Moscow) shale, Canandaigua lake
7 Fragment of an older form showing the increase in minor carinae. The crescentic ridges on the radials are here crushed down and broken
Hamilton (Moscow) shale, Canandaigua lake

Gennaeocrinus carinatus var. **crassicostatus** nov.

Page 222

8 Lateral view of a dorsal cup showing the globose form and coarse carinae. Parts of long, stout tegminal spines also shown
Hamilton (Moscow) shale, Cashong creek, Bellona

Originals, except as otherwise indicated, in the State Museum

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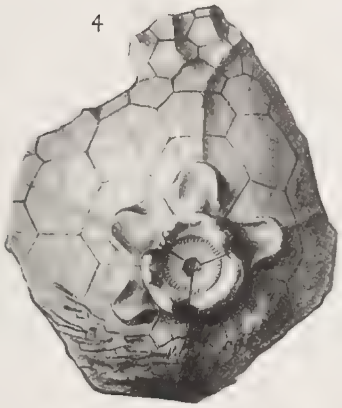

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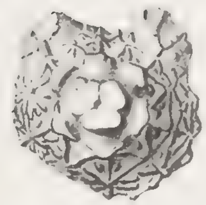

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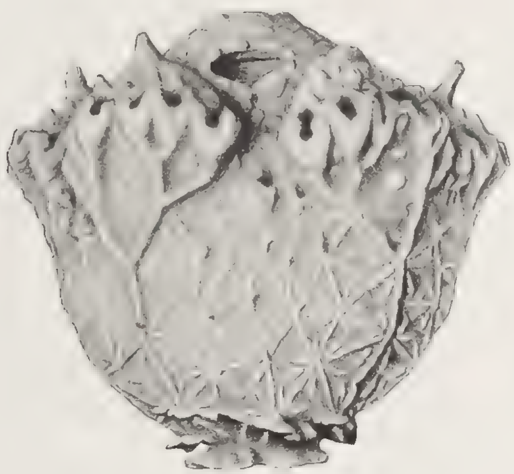

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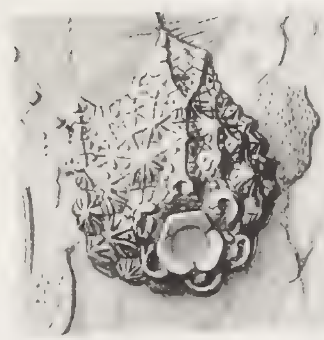

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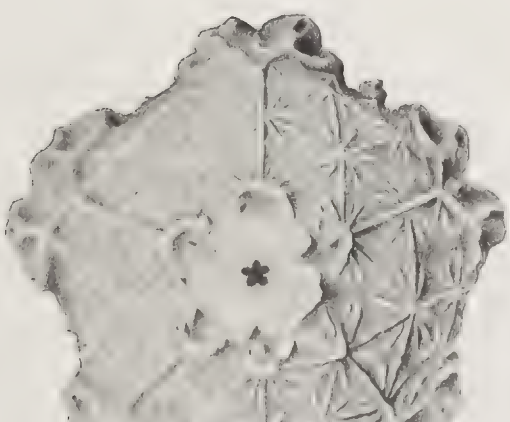

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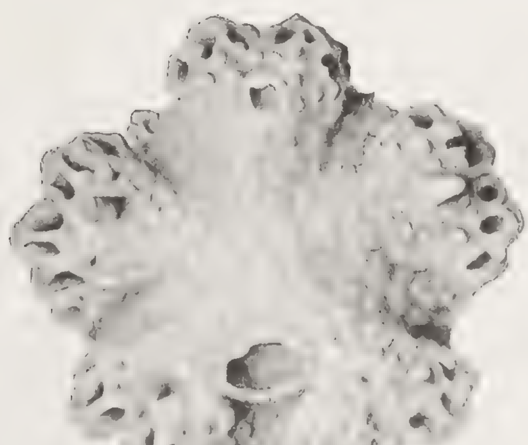


G. S. Barkentin and E. Wood del.

PLATE 33

Genus MEGISTOCRINUS Owen & Shumard (W. & Sp.)

Megistocrinus depressus Hall

Page 226

1 Basal view of a dorsal cup showing the centers raised in a sort of tablet roughly conforming in shape to the outline of the plate and separated from the edges of the plate by a narrow beveled area. One of the types, number $\frac{4320}{1}$ in the State Museum

Hamilton (Moscow) shale, Menteth's point, Canandaigua lake

2 Tegmen of a smaller specimen oriented incorrectly in drawing

Hamilton (Moscow) shale, Bellona

3 Dorsal view of the calyx of a young specimen (x 2)

Hamilton (Moscow) shale, Vincent

4 The same specimen seen from the anterior side (x 2)

5 Tegmen of the same specimen (x 2)

6 Posterior view (x 2) of a young specimen referred to this species. One of the types of Hall's "Actinocrinus" cauliculus, number $\frac{4020}{2}$ in the State Museum

Hamilton (Moscow) shale, Vincent

7 Lateral view of a young specimen showing the tegmen and some of the arms

Hamilton (Moscow) shale, Vincent

8 Left posterior view of a young specimen showing the arm branching. One of the types of Hall's "Actinocrinus pocillum," number $\frac{4021}{2}$ in the State Museum

Hamilton (Moscow) shale, Vincent

9 Left anterolateral view of another young specimen showing the character of the arms. One of the types of Hall's "Actinocrinus pocillum," number $\frac{4021}{1}$ in the State Museum

Hamilton (Moscow) shale, Cashong creek, near Bellona

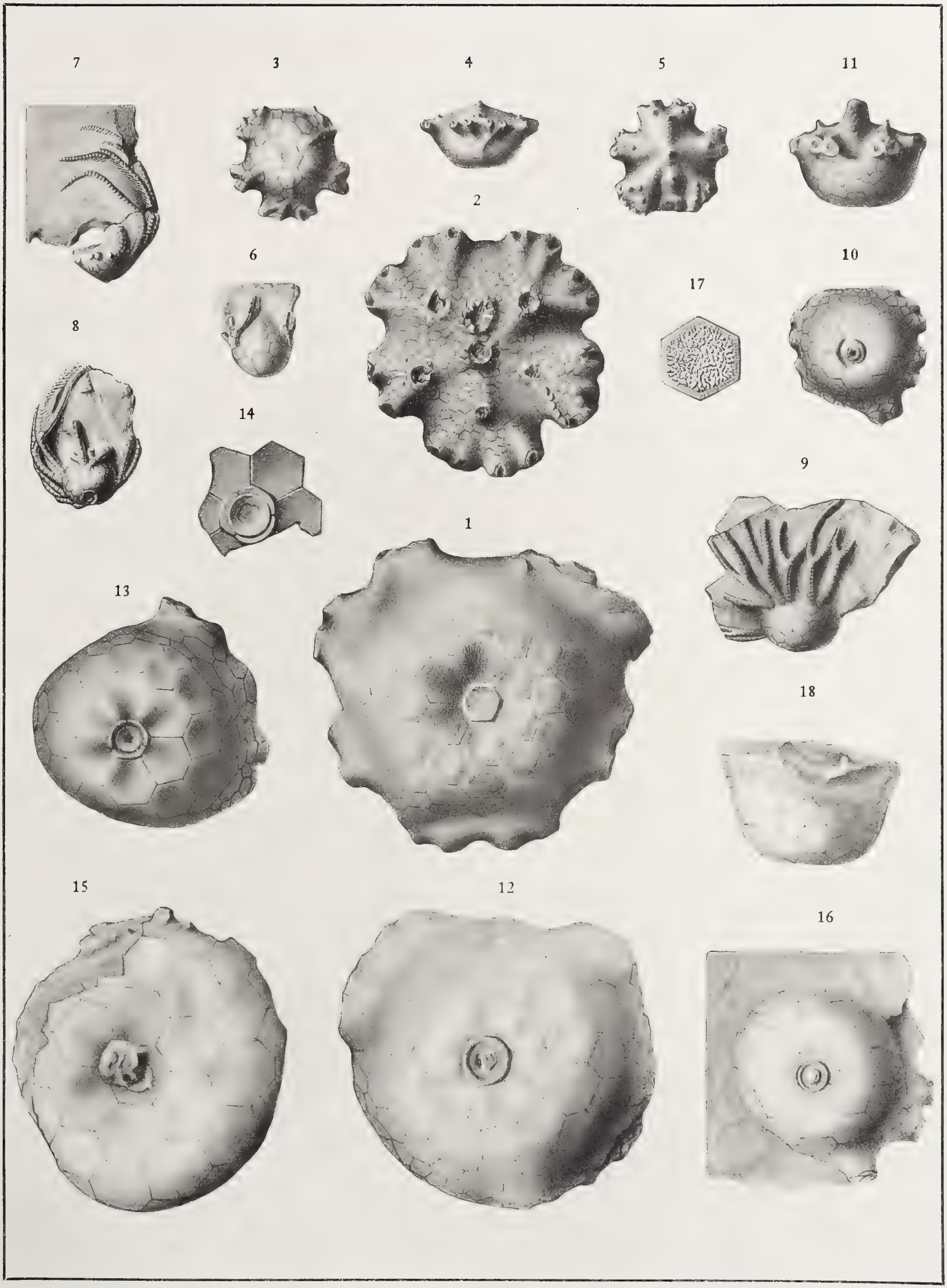
10 Dorsal view of the calyx of a specimen showing a very delicate and elaborate type of ornamentation. A young specimen, but considerably older than the one shown in figure 9

Hamilton (Moscow) shale, Vincent

11 The same specimen seen from the posterior side

12, 13 Basal views of the dorsal cups of two specimens showing the rounding ridges at the sutures between the radials, characteristic of very mature or old specimens

Hamilton (Moscow) shale, Cashong creek, Bellona



G. S. Barkentin and E. Wood del.

14 Fragment of a specimen showing the basals produced into a trilobate rim
Hamilton (Moscow) shale, Cashong creek, Bellona

15 Basal view of a dorsal cup showing the depressed basal area
Hamilton (Moscow) shale, Cashong creek, Bellona

16 Basal view of a specimen showing a dorsal cup of a deeper, narrower type
Hamilton (Ludlowville) shale, Alden

17 Enlargement (x 2) of a primary interbrachial of the same showing the character of the ornamentation

18 Posterior side of a dorsal cup of a shape similar to that shown in figure 16
Hamilton (Moscow) shale, Bellona

All the originals in the State Museum

PLATE 34

Genus MEGISTOCRINUS Owen & Shumard (W. & Sp.)

Megistocrinus ontario Hall

Page 234

1 Right anterolateral view of a specimen showing the arms. One of the types, number $\frac{4321}{2}$ in the State Museum
Hamilton (Moscow) shale, Canandaigua lake

2 Enlargement (x 3) of the middle plate of a second row of interbrachials in the above specimen

3 Basal view of a broken calyx. The left anterolateral radius is directed upward. One of the types, number $\frac{4321}{1}$ in the State Museum
Hamilton (Moscow) shale, Dresden

4 Enlargement (x 2) of the primary interbrachial in the left posterior interradius of the same specimen

5 Tegmen of the same specimen

6 Basal view of a fragmentary dorsal cup showing the excavated character of the plates. Listed as type of Megistocrinus depressus, number $\frac{5029}{1}$ in the American Museum Natural History
Hamilton (Moscow) shale, Seneca lake

7 Enlargement (x 2) of second anal plate of the above specimen

8 Lateral (anterior) view of a young specimen showing some of the arms, a few millimeters of column and the ornamentation of the plates of the dorsal cup
Hamilton (Moscow) shale, Bristol

9 Dorsal cup of a young specimen showing the character of the column
Hamilton (Moscow) shale, North Bristol

10 Basal view of the calyx of a young specimen showing three arms in the left anterolateral ray
Hamilton (Moscow) shale, North Bristol

Originals, except as otherwise indicated, in the State Museum

G. S. Barkentin and E. Wood del.

PLATE 35

Genus AOROCRINUS Wachsmuth & Springer

Aorocrinus cauliculus (Hall)

Page 249

1 Lateral view of a mature specimen showing dorsal cup and arms. One of the types, number $\frac{4020}{1}$ in the State Museum
Hamilton (Moscow) shale, Vincent

2 Lateral view of a young specimen (x 2), showing the dorsal cup and arms. One of the types, number $\frac{4020}{3}$ in the State Museum
Hamilton (Moscow) shale, Vincent

3 Lateral (anterior) view of a very mature or old specimen showing the spines on the arms
Hamilton (Moscow) shale, Canandaigua lake

Aorocrinus praecursor (Hall)

Page 253

4 Basal view of the type specimen, number $\frac{4023}{1}$ in the State Museum
Hamilton (Moscow) shale, Canandaigua lake shore

Aorocrinus formosus sp. nov.

Page 259

5 Left anterolateral view of a calyx
Hamilton (Moscow) shale, Cashong creek, Bellona

6 Basal view of the calyx of the same specimen

7 Posterior side of the same calyx

8 Basal view of the dorsal cup and arms of a younger specimen
Hamilton (Moscow) shale, Cashong creek, Bellona

9 Lateral (left posterior) view of the same specimen

Aorocrinus longidactylus sp. nov.

Page 262

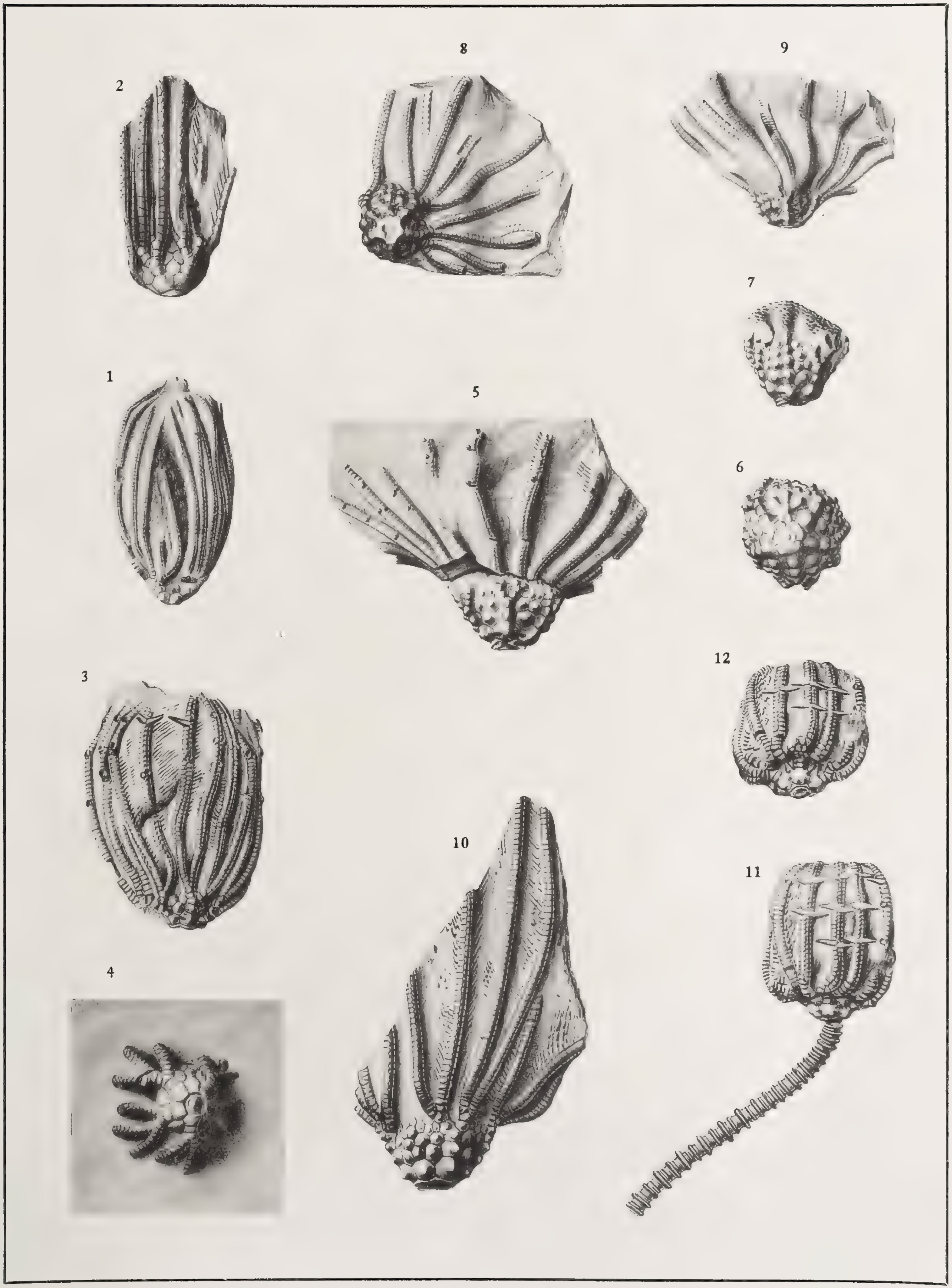
10 Posterolateral view of the dorsal cup and arms. Collection of Doctor Springer
Hamilton (upper Moscow limestone) beds, Cascade Mills, three miles west of Dundee

Aorocrinus armatus sp. nov.

Page 255

11 Lateral view of the crown and stem; left anterolateral ray directly in front. As here figured the stem is in its normal position, the crown

DEVONIAN CRINOIDS



G. S. Barkentin del.

has been freed from the matrix and turned over. Collection of Doctor Springer

Hamilton (lower Moscow limestone) beds, Cashong creek, Bellona

12 A slightly more basal view of the crown of the same specimen. In figuring, one of a pair of spines has been omitted from the arm at the right

Originals, except as otherwise indicated, in the State Museum

PLATE 36

Genus CYTTAROCRINUS nov.

Cyttarocrinus eriensis (Hall) n. comb.

Page 268

1 Left posterior view of dorsal cup and arms (x 3). Type. Collection of American Museum Natural History, number $\frac{5023}{1}$
Hamilton (Moscow) shale, Hamburg
2 Enlargement (x 15) of a few brachials of the same specimen

Cyttarocrinus (?) **jewetti** sp. nov.

Page 271

3 Anterior view of a dorsal cup. Jewett Collection, Cornell University, number 7329. Figured, in error, as type of "Platycrinus" eboraceus
Hamilton shale, Bloomfield
4 Posterior view of the same specimen
5 Basal view of the same specimen

Genus CORDYLOCRINUS Angelin

Cordylocrinus plumosus (Hall)

Page 273

6 Lateral view of the crown of a large specimen with a few millimeters of column attached. Posterior interray at the right
Coeymans limestone, Jerusalem hill, Litchfield
7 Lateral view of a very well-preserved specimen (x 2), figured by Miss Talbot (1905). The distal portion of the arms show syzygies. Collection of Yale University Museum
Coeymans limestone, Days Corners, near Litchfield
8 Specimen seen from the posterior side, showing the first two plates of the anal tube. One of the types. Collection of American Museum Natural History, number 2293
Coeymans limestone, Jerusalem hill, Litchfield
9 Fragmentary specimen showing the proboscis-like anal tube or sac. On the rock with the type shown in figure 8. Collection of American Museum Natural History, number 2293
10 View of a small specimen (x 2) showing the arms well
Coeymans limestone, Jerusalem hill, Litchfield
11 Lateral view of another specimen showing the posterior side (at right)
Coeymans limestone, Schoharie

DEVONIAN CRINOIDS

G. S. Barkentin del.

12, 13 Two small specimens showing the crowns and some distance of the columns with their whorls of long cirri. Figured here as younger forms of this species. Types of Hall's C. parvus in the collection of American Museum Natural History, number 2292
Coeymans limestone, Jerusalem hill, Litchfield

Cordylocrinus (?) **ramulosus** (Hall)

Page 276

14 Specimen showing the arms above the second bifurcation. Type. After Hall, 1859, plate 4, figure 10; original not located
Coeymans limestone, Jerusalem hill, Litchfield

15 Specimen showing two anal plates. The arm in the right posterior ray shows an irregularity in bifurcation. Type. After Hall, 1859, plate 4, figure 11; original not located
Coeymans limestone, Jerusalem hill, Litchfield

16 Several brachials with pinnules attached, enlarged. After Hall, 1859, plate 4, figure 12

17 Enlargement showing structure of arms as far as shown in figure 14. After Hall, 1859, plate 4, figure 13

Genus MARSIPOCRINUS Bather

(nom. nov. pro Marsupiocrinus Phillips)

Marsipocrinus tentaculatus (Hall)

Page 277

18 Anterolateral view of the dorsal cup and arms. Anterior ray at the left. Type. Collection of American Museum Natural History, number 2303
New Scotland limestone, Schoharie

Originals, except as otherwise indicated, in the State Museum

PLATE 37

Genus ARTHRACANTHA Williams

(*see* plate 60, figures 1–3)

Arthracantha eboracea (Hall) n. comb.

Page 279

1 Set of basal plates constituting one of Hall's types, number $\frac{4460}{2}$ in the State Museum
Hamilton (Moscow) shale, York

2 An isolated radial, part of Hall's type material, number $\frac{4460}{1}$ in the State Museum
Hamilton (Moscow) shale, York

3 A crushed, but fairly good, dorsal cup
Hamilton (Moscow) shale, Moscow

4 An internal cast, referred to this species, which shows, in addition to the dorsal cup, portions of the tegmen. Collection of American Museum Natural History, number $\frac{5022}{2}$
Hamilton (Moscow) shale, Hamilton

Arthracantha punctobrachiata (Hall)

Page 285

5 Lateral view of the type specimen. Posterior interradius at the left. Jewett Collection, Cornell University, number 2214
Hamilton, western New York

Arthracantha ithacensis Williams

Page 292

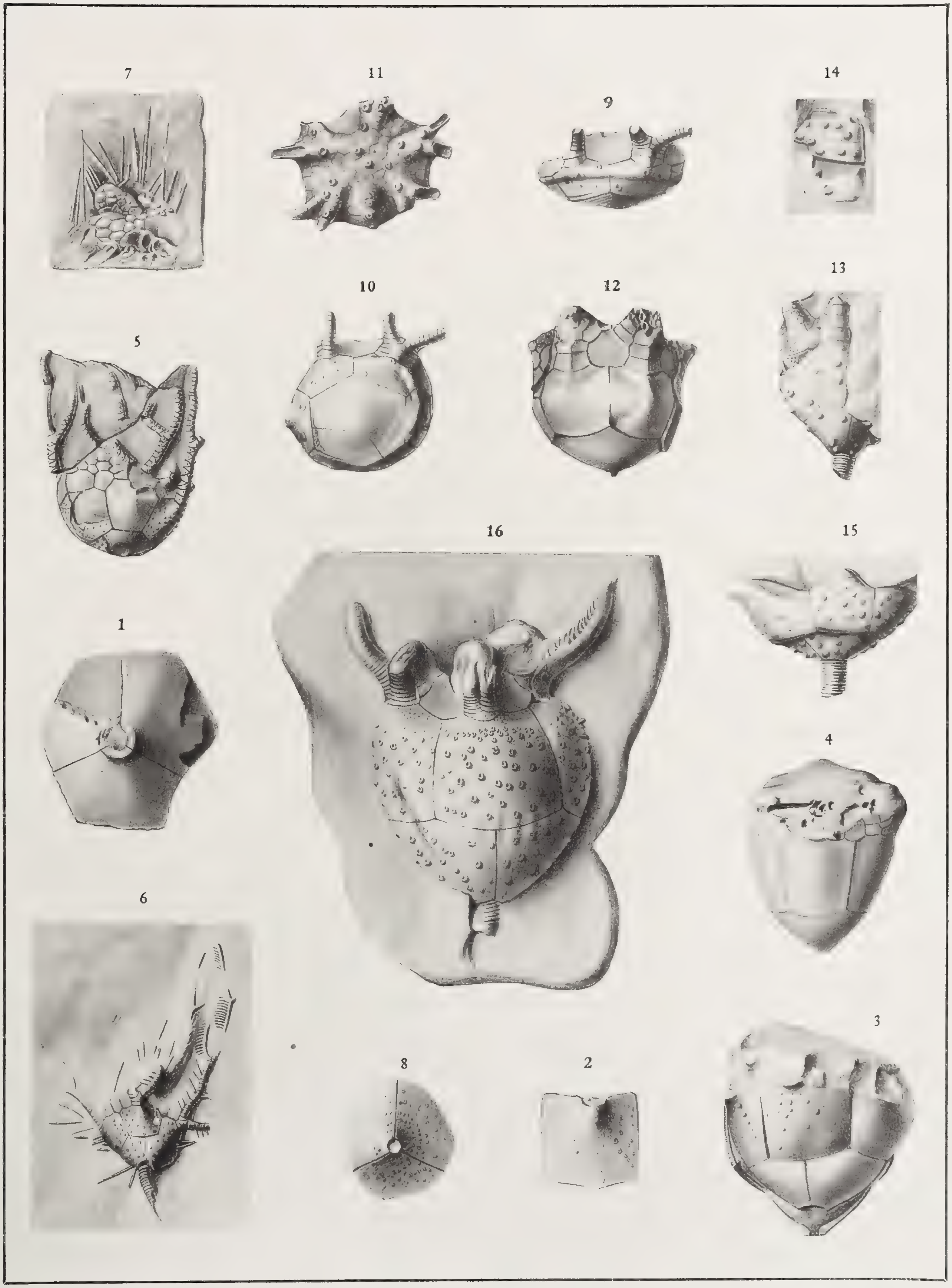
6 Lateral view of one of the types
7 Portion of the tegmen showing the ventral tube and long spines
8 A large basal disk, referred with a query to this species
All the above specimens are from Portage (Ithaca) beds, Ithaca

(The types of A. ithacensis are in the collection of the late Professor H. S. Williams; plastotypes are in the collection of Doctor Springer. Figures 6 and 8 are taken from the plastotypes; figure 7 is after Wachsmuth and Springer 1897, plate 76, figure 1*b*)

Arthracantha depressa W. & Sp.

Page 295

9 Lateral view of the type, showing the crumpling of the plates. Collection of Doctor Springer
Lower Chemung (Prattsburg) sandstone, Steuben county



G. S. Barkentin del.

10 Basal view of the same specimen
11 Tegmen of the same specimen

Arthracantha granosa sp. nov.

Page 298

12 Internal cast of a somewhat crushed calyx
Portage beds (Grimes sandstone), Deyo basin, near Naples
13 Gutta-percha squeeze taken from portion of the external mold of the above specimen
14 An isolated, fragmentary radial showing the tubercles for the reception of the spines
Portage beds (Grimes sandstone), Deyo basin, near Naples
15 A specimen doubtfully referred to this species. The number, size and distribution of the tubercles are well shown
Lower Chemung beds, Avoca

Arthracantha splendens sp. nov.

Page 302

16 Lateral view of a specimen showing the dorsal cup and parts of the tegmen and arms
Lower Chemung beds, four miles north of Bath

Figures 6, 8, 9–11, 13, 15, 16 were made from gutta-percha and plasticine squeezes

Originals, except as otherwise indicated, in the State Museum

PLATE 38

Genus CLIDOCHIRUS Angelin

Clidochirus schucherti (Talbot)

Page 305

1 Right anterolateral view of the type specimen, showing the crown and proximal part of the column. Right posterior ray at the left. Collection of Yale University Museum

New Scotland limestone, Clarksville

2 Posterior view of the crown of another specimen showing the anal side. Type of Springer 1920, reproduced from the original drawing. Collection of Doctor Springer

New Scotland limestone, Schoharie

Genus SYNAPTOCRINUS Springer

Synaptocrinus nuntius (Hall)

Page 307

3 View of the type specimen from the left posterior interradius. Collection of American Museum Natural History, number $\frac{5033}{1}$

Hamilton (Moscow) shale, Hamburg, on Lake Erie

4 Basal view of the same specimen

5 Right anterior interradial view of the crown and part of the column of a large specimen. Type of Springer 1920. Collection of Doctor Springer

Hamilton (Moscow) shale, Bellona

6 Posterior view of the same specimen

7 Fragment of a specimen showing the posterior side (x 2). Type of Grabau 1899, Springer 1920. Collection of Columbia University

Hamilton (Ludlowville) shale, Eighteen Mile creek

Figures 3–7 have been reproduced from the original drawings prepared by Doctor Springer

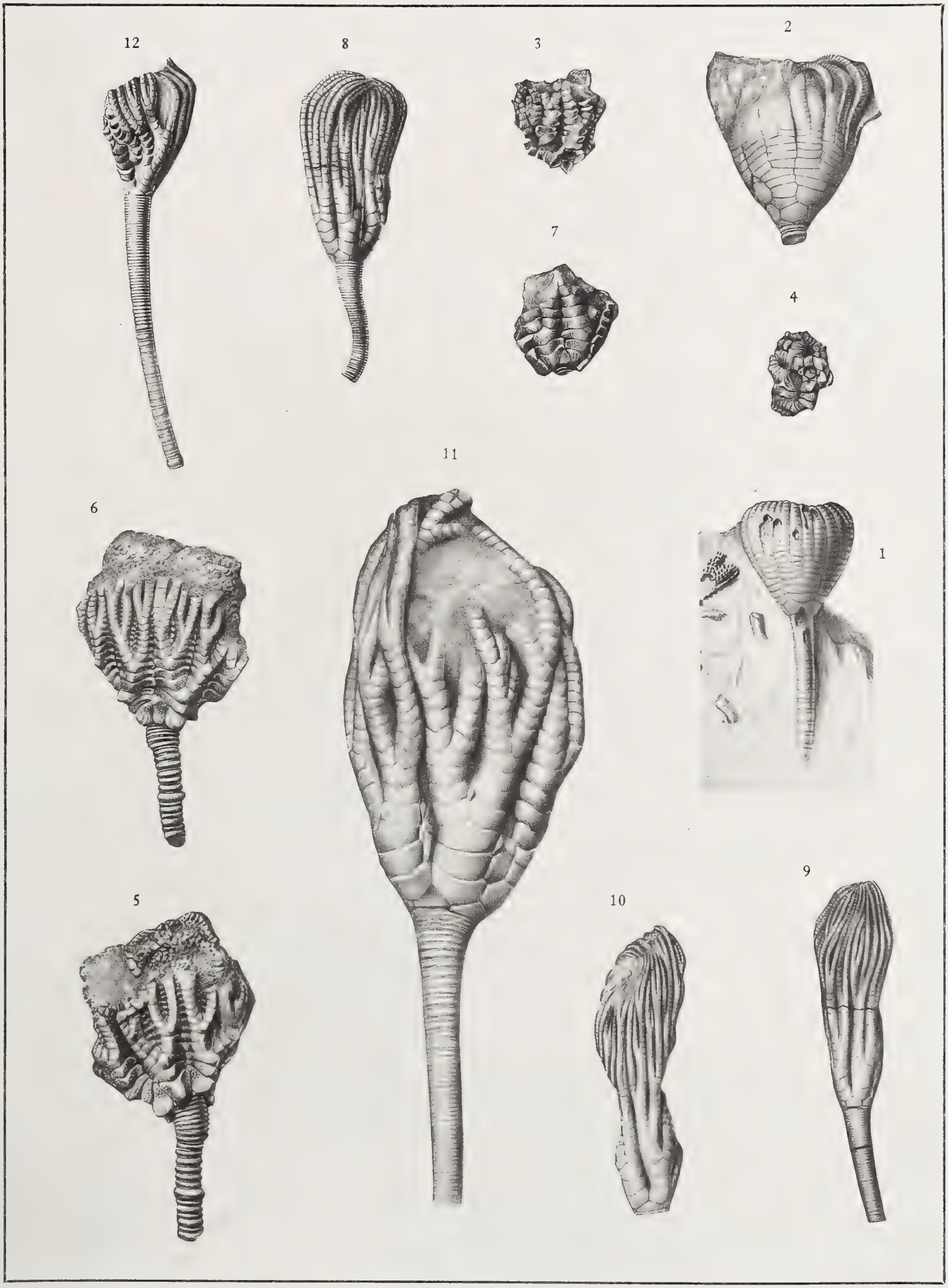
Genus EUTAXOCRINUS Springer

Eutaxocrinus pulcher Springer

Page 314

8 Lateral view of the type specimen, showing the crown and proximal portion of the column

9 Right anterolateral view of another specimen showing the crown and proximal part of the column. Reproduced from the original drawing prepared by Doctor Springer



G. S. Barkentin and K. M. Chapman del.

10 Left anterolateral view of a third specimen, showing part of the crown. Reproduced from the original drawing prepared by Doctor Springer

Figures 8, 9, 10 from lower Chemung beds, Gorton's quarry, Belmont

Eutaxocrinus amplus Springer

Page 316

11 Lateral view of the type specimen, showing the crown and proximal part of the column. Cast from natural mold; plastotype in collection of University of Chicago, Walker Museum, Hall Collection

Upper Chemung beds, Binghamton

Eutaxocrinus dumosus sp. nov.

Page 317

12 Lateral view of a specimen showing the crown and about 50 mm of column. Drawn from plastotype in State Museum; impression of same specimen in collection of Doctor Springer

Portage (Ithaca) beds, De Ruyter

Originals, except as otherwise indicated, in the State Museum

PLATE 39

585

Genus EUTAXOCRINUS Springer

Eutaxocrinus ithacensis (Williams)

Page 309

1 Lateral view of the type specimen, a substantially complete individual. Type in collection of Cornell University Museum; plastotype in collection of Doctor Springer

Portage (Ithaca), Sherburne sandstone, Ithaca

2 Lateral view of a young specimen, one of the types, showing the crown and a few millimeters of the proximal part of the column. Collection of Cornell University Museum; plastotype in collection of Doctor Springer

Portage (Ithaca), Sherburne sandstone, Ithaca

3 A young specimen showing the large, rounded columnal below the most proximal thin ones. This feature is found in the young of this and other species

Portage (Ithaca) beds, ravine east of South Otselic

4 A specimen referred to this species, showing the posterior side of the crown

Portage (Ithaca) beds, Montour Falls

Eutaxocrinus alpha (Williams)

Page 311

5, 6 Lateral views of two of the type specimens. The anal side is slightly shown in figure 6. Collection of Cornell University Museum; plastotypes in collection of Doctor Springer

Lower Chemung beds, Ithaca

Figures 7–13 are views of young specimens from lower Chemung beds, Cotton Hill, Avoca

7 View, natural size, of a young specimen showing several centimeters of column

8, 9 Views (x 3) of opposite sides of another specimen. The enlargement shows the character of the column very well

10, 11 Views of two specimens which show what appears to be a subradial plate in the ray at the left in each case (*see* p. 312)

12 Lateral view (x 2) of another specimen

13 Lateral view (x 2) of a larger specimen showing two bifurcations of the arms

G. S. Barkentin and K. M. Chapman del.

Eutaxocrinus curtus (Williams)

Page 313

14 Lateral (left posterior) view of the type specimen, a young form. Collection of Cornell University Museum; plastotype in collection of Doctor Springer

Lower Chemung beds, Ithaca

15 Lateral view of another young specimen, showing better the short, stout character of the crown. Type of Springer 1920, collection of Doctor Springer

? Lower Chemung beds (*see Horizon and locality* under description), Ithaca

16 An adult specimen showing well the short, stout, rotund character of the crown and several centimeters of column

Lower Chemung beds, Cotton hill, Avoca

17 Posterior view of another specimen from the same horizon and locality

Genus TAXOCRINUS Phillips

Taxocrinus lobatus (Hall)

Page 319

18 Right anterolateral view of the type specimen. The column has become detached, but is here shown attached as originally described and figured. Collection of American Museum Natural History, number $\frac{5043}{1}$

Hamilton (Moscow) shale, Bristol

19 Posterior view of a large, well-preserved crown, showing all the characters of the species

Hamilton (Moscow) shale, Canandaigua lake

20 A beautifully preserved column, shown from the most proximal part for a distance of about 17 cm

Hamilton (Moscow) shale, Menteth's point, Canandaigua lake

Figures 1, 2, 5, 6, 7, 14, 15, 19 have been reproduced from the original drawings prepared by Doctor Springer

Figures 2, 3, 5, 6, 7–17 were made from gutta-percha and plasticine squeezes

Originals, except as otherwise indicated, in the State Museum

PLATE 40

Genus HYPSOCRINUS Springer & Slocom

Hypsocrinus fieldi Springer & Slocom

Page 322

1 Lateral view of calyx from right posterior ray
Hamilton (Moscow) shale, East Bethany
2 Same, from right anterolateral ray
3 Same, from anterior ray
4 Same, from left anterolateral ray
5 Same, from left posterior ray

All the above figures (x 5/2) are taken from the original drawings of the type in the collection of Field Columbian Museum, Chicago

Genus ANAMESOCRINUS nov.

Anamesocrinus lutheri sp. nov.

Page 324

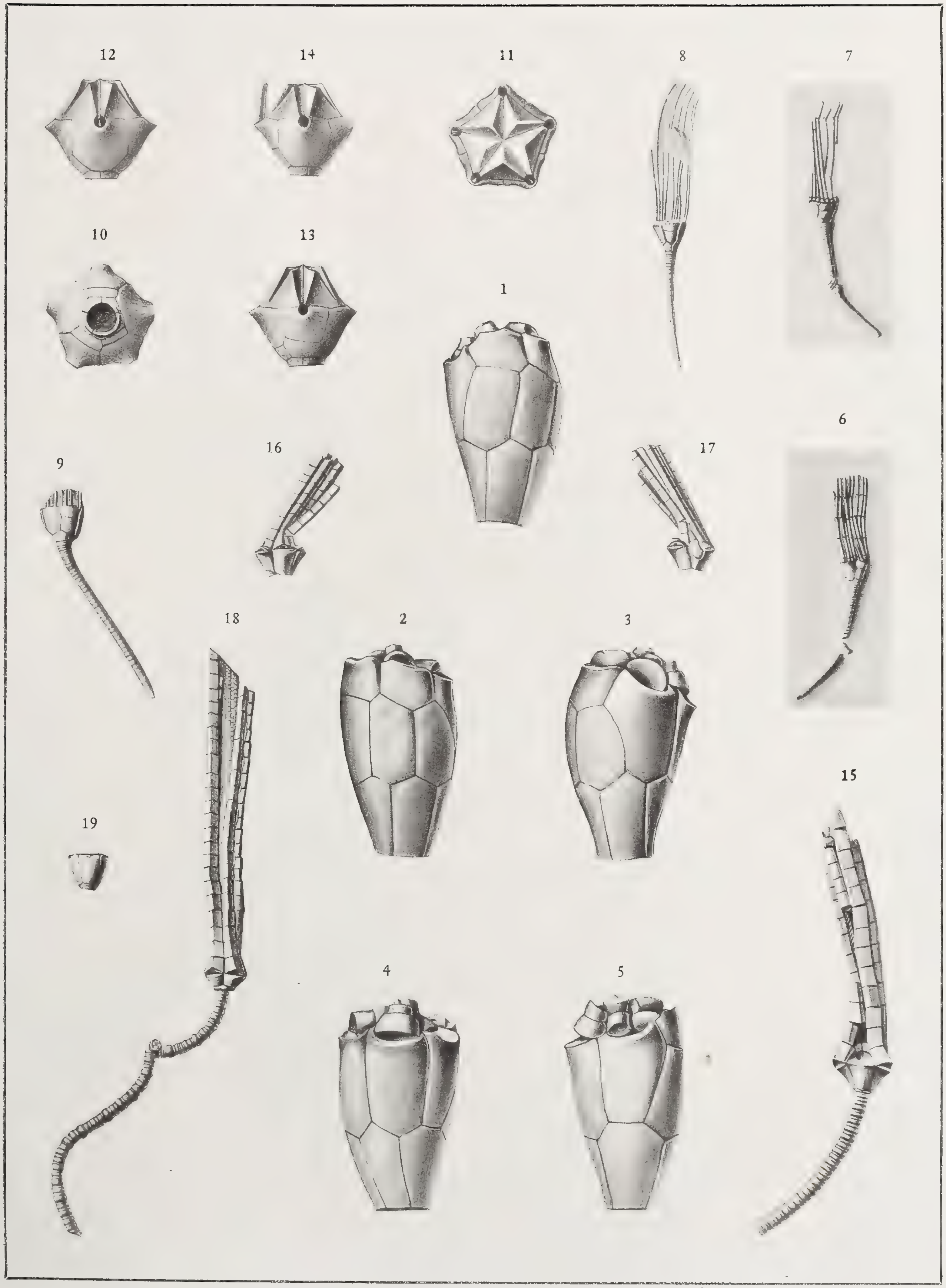
6 Anterolateral view (x 2); anterior ray at the left
Lower Chemung beds, Scott's ravine, Fillmore
7 Posterior view (x 2) of the same specimen
8 Lateral view of another specimen from the left anterolateral ray (x 2). Drawn from a gutta-percha squeeze
Lower Chemung beds, along road from Watkins to Elmira
9 Lateral view of a larger specimen from the left anterolateral ray. Drawn from a gutta-percha squeeze
Lower Chemung beds, along road from Watkins to Elmira

Genus HAPLOCRINUS Steininger

Haplocrinus clio Hall

Page 326

10 Basal view of calyx (x 6). Specimen oriented incorrectly in drawing. Anterior ray at the upper left side. One of the cotypes. Collection of American Museum Natural History, number $\frac{4371}{1}$
Cherry Valley limestone, Marcellus
11 Tegmen of the same specimen
12 The same specimen seen from the anterior side
13 Lateral view of the same specimen, right anterolateral ray
14 Lateral view of another specimen from the left posterior ray, showing the first brachial. Cotype. Collection of American Museum Natural History, number $\frac{4371}{1}$
Cherry Valley limestone, Marcellus



G. S. Barkentin del.

Genus SYMBATHOCRINUS Phillips

Symbathocrinus sulcatus sp. nov.

Page 329

15 Specimen viewed from the anterior side (x 2)
Onondaga limestone, near Le Roy

Symbathocrinus subtrigonalis sp. nov.

Page 328

16 Specimen viewed from the anterior side. Collection of Doctor Springer
Hamilton (Moscow) shale, Cashong creek, Bellona

17 Posterior view of the same specimen

Symbathocrinus matutinus Hall

Pages 329, 330

18 Lateral view of the crown and column. Collection of University of Chicago, Walker Museum, number 11370
Hamilton beds, New Buffalo, Iowa

Genus STYLOCRINUS Sandberger

Stylocrinus (?) **canandaigua** sp. nov.

Page 331

19 Lateral view of the dorsal cup from the left posterior ray
Hamilton (Moscow) shale, west shore of Canandaigua lake

Originals, except as otherwise indicated, in the State Museum

PLATE 41

Genus BRACHIOCRINUS Hall

Brachiocrinus nodosarius Hall

Page 332

1, 2 Portions of columns with cirri. Types, number $\frac{4080}{1}$ (figure 2), number $\frac{4080}{2}$ (figure 1)

New Scotland limestone, Schoharie

3, 4 Distal portions of the columns of two other specimens, showing the cirri and the bulblike process at the end of the column

New Scotland limestone, east of Clarksville

Genus DELTACRINUS Ulrich

Deltacrinus clarus (Hall)

Page 334

5 Left anterolateral view of the type specimen. Collection of American Museum Natural History, number $\frac{5028}{1}$

Hamilton (Moscow) shale, Canandaigua lake

Genus HALYSIOCRINUS Ulrich

Halysiocrinus secundus (Hall) n. comb.

Page 337

6 Lateral (left posterior) view of one of the type specimens. Collection of Cornell University Museum, number 7327

Onondaga limestone, near Lima

7 Enlargement (x 2) of the basal area of the same (*see* text figure 56, page 338)

8 Lateral (left anterior) view of another type specimen, showing the hinge area. Collection of Cornell University Museum, number 7327

Onondaga limestone, near Lima

9 Enlargement (x 3) of the hinge area of the same (*see* text figure 57, page 338)

Genus BOTRYOCRINUS Angelin (em. Bather)

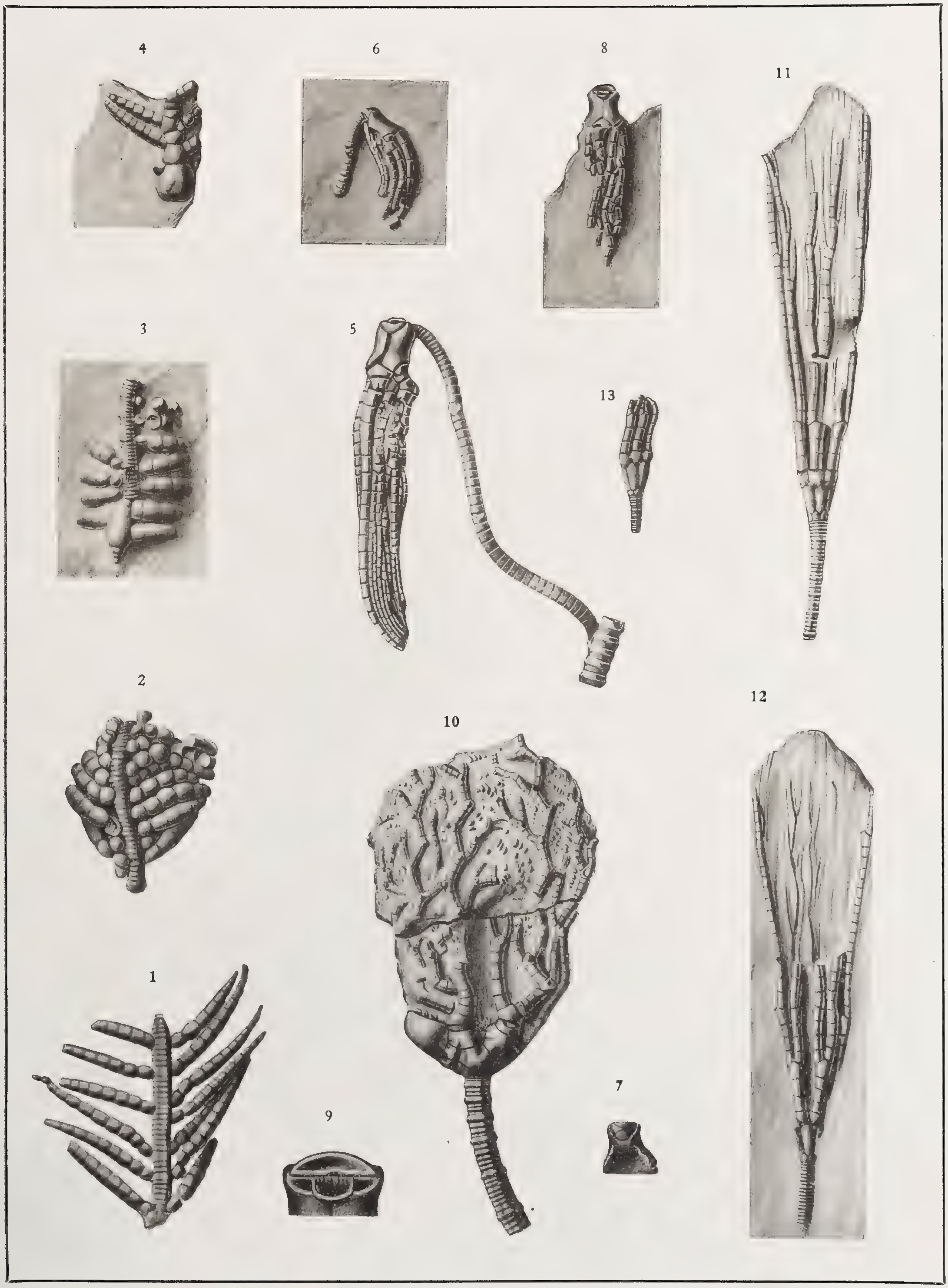
Botryocrinus sentosus sp. nov.

Page 372

10 Lateral view (right posterior) of a crown with a few millimeters of column

Hamilton (Moscow) shale, Cashong creek

DEVONIAN CRINOIDS



G. S. Barkentin del.

Genus CRADEOCRINUS nov.

Cradeocrinus elongatus sp. nov.

Page 348

11 Lateral (left anterolateral) view (x 2). Drawn from a gutta-percha squeeze

Lower Chemung beds, Cotton hill, Avoca

12 Right posterior view of the same specimen (x 2). Drawing made from a gutta-percha squeeze

13 Lateral view (x 2) of another specimen

Lower Chemung beds, Cotton hill, near Avoca

Originals, except as otherwise indicated, in the State Museum

PLATE 42

Genus CRADEOCRINUS nov.

Cradeocrinus pergracilis sp. nov.

Page 350

1 Lateral (right posterolateral) view of the crown and proximal portion of the column (x 2)
Portage (Ithaca) beds, ravine east of South Otselic

Genus ITEACRINUS nov.

Iteacrinus flagellum sp. nov.

Page 345

2 Posterior view of the crown and proximal part of the column
Lower Chemung beds, Cotton hill, near Avoca

Iteacrinus robustus sp. nov.

Page 347

3 Lateral (anterior ?) view of a fragmentary crown
Lower Chemung beds, Cotton hill, near Avoca

Genus LASIOCRINUS Kirk

Lasiocrinus scoparius (Hall)

Page 340

4 Anterolateral view (x 2) of the crown showing the anal tube. One of the cotypes. Collection of American Museum Natural History, number $\frac{2294}{1}$

5 Enlargement (x 5) of the upper portion of an arm of the same

6 Anterolateral view (x 2) of another specimen. One of the cotypes. Collection of American Museum Natural History, number $\frac{2294}{1}$

7 Posterior view (x 2) of a calyx with proximal portions of two of the arms, anal tube and column

8 Right posterolateral view (x 2) of a crown and proximal part of the column. One of the types. Collection of American Museum Natural History, number $\frac{2294}{1}$

9 Right posterolateral view (x 2) of a small specimen

10 Left posterolateral view (x 3) of a small specimen

All the above specimens from Coeymans limestone, Jerusalem hill, Litchfield

Originals, except as otherwise indicated, in the State Museum

G. S. Barkentin del.

PLATE 43

Genus LASIOCRINUS Kirk

Lasiocrinus scoparius (Hall)

Page 340

1 Anterolateral view (x 2) of a well-preserved crown
2 Posterior view (x 2) of a specimen showing a well-preserved anal tube. One of the types. Collection of American Museum Natural History, number $\frac{2294}{1}$
3 Posterior view (x 2) of the calyx, proximal part of anal tube and column of a large specimen
4 Left posterolateral view (x 2) of a specimen showing the cirri on the distal part of the column. Collection of American Museum Natural History
5 Lateral view (x 1) of a large specimen. Collection of American Museum Natural History

All the above specimens from Coeymans limestone, Jerusalem hill, Litchfield

6 Right posterolateral view (x 2) of a crown and proximal part of the column

Manlius limestone, Schoharie county

7 Right posterolateral view (x 2) of another specimen

Manlius limestone, Schoharie

Lasiocrinus tenuis (Bather)

Pages 341, 342

8 Posterior view (x 3) of the proximal portion of the crown, showing the character of the arm branching. Placed here for comparison with the figures of the Devonian representative of the genus. (After Bather 1893, plate 4, figure 144)

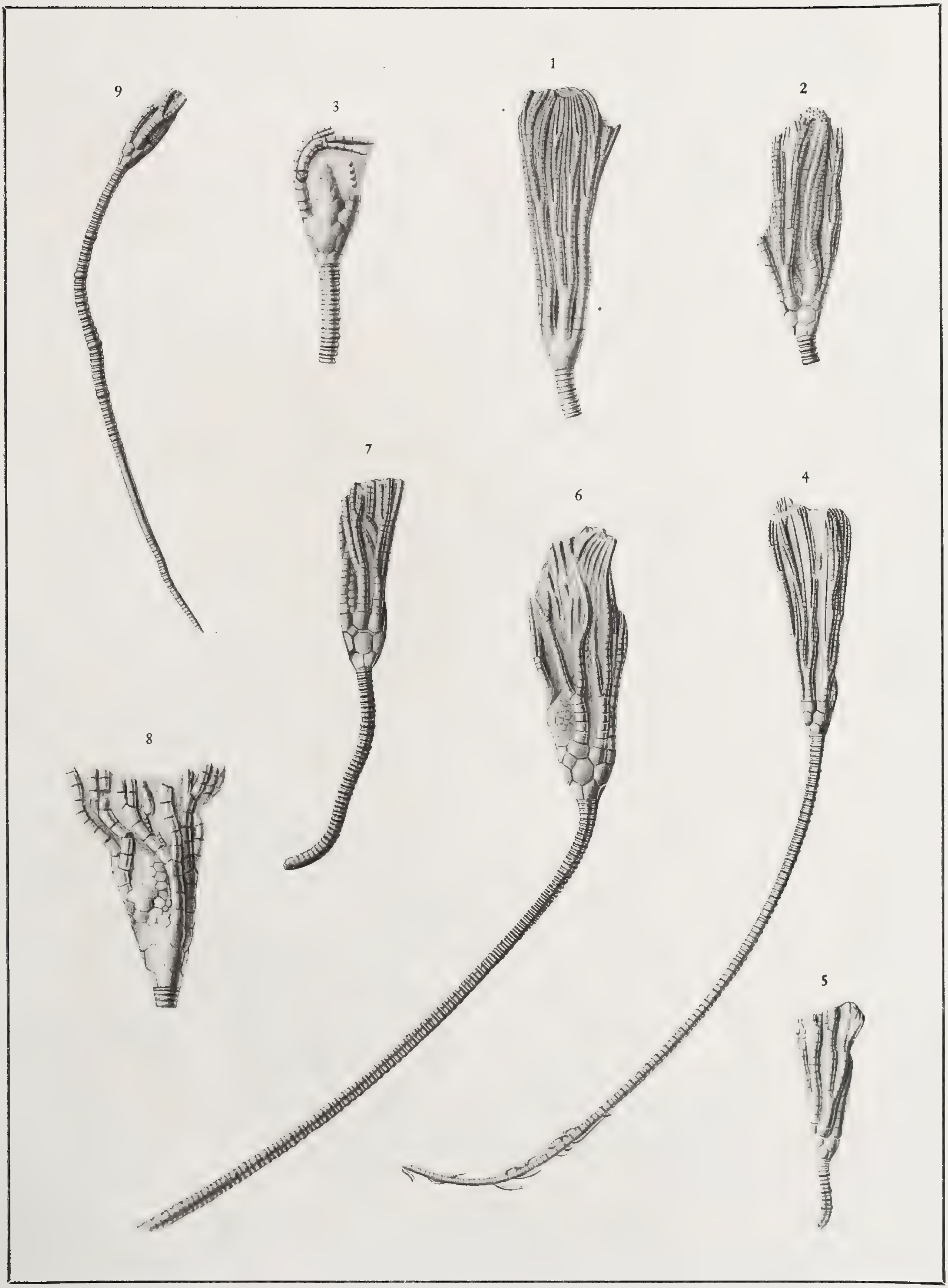
Silurian, Bursvik, Gotland

Lasiocrinus (?) **schohariensis** sp. nov.

Page 343

9 Lateral view of the calyx, proximal part of two arms and several centimeters of column

Schoharie grit, Pine hill, Highland Mills



G. S. Barkentin del.

PLATE 44

Genus SCHULTZICRINUS Springer

Schultzicrinus typus Springer

Page 351

1 Lateral view of a specimen showing part of the arms and several centimeters of column. Collection of State Museum

Onondaga limestone, Limerock

Figures 2–6 after Springer 1911; specimens in collection of Doctor Springer

Onondaga limestone, near Le Roy

2 Posterior view of calyx and base of arms, showing anal opening through the dorsal cup, with the radials meeting above it

3 Basal view of calyx of another specimen showing the undivided infrabasal disk and the quadripartite axial canal. Edge of anal opening also visible

4 Lateral view of a specimen with parts of the arms and column, showing the greatly projecting nodals and thin internodals

5, 6 An internodal (figure 5) and nodal (figure 6) columnal detached from the same specimen showing the central and four peripheral canals

7 Lateral (left anterolateral) view of a very much crushed specimen. Figured as C y a t h o c r i n u s sp. (?) by Hall, 1872. Collection of Cornell University Museum

Onondaga limestone, Lima

Schultzicrinus (?) **elongatus** Springer

Page 352

8 Specimen with part of column and arms, the latter much shattered and displaced, but showing that they were long and perhaps simple. The broad ventral furrow and deep transverse section of brachials, perforated by dorsal canal, appear at several places. After Springer 1911. Collection of Doctor Springer

9 Cross section of the column of the same showing tripartite axial canal. After Springer 1911

10 Dorsal view (x 2) of a higher brachial in the same specimen, studded with fine, sharp tubercles. After Springer 1911

Onondaga limestone, Le Roy

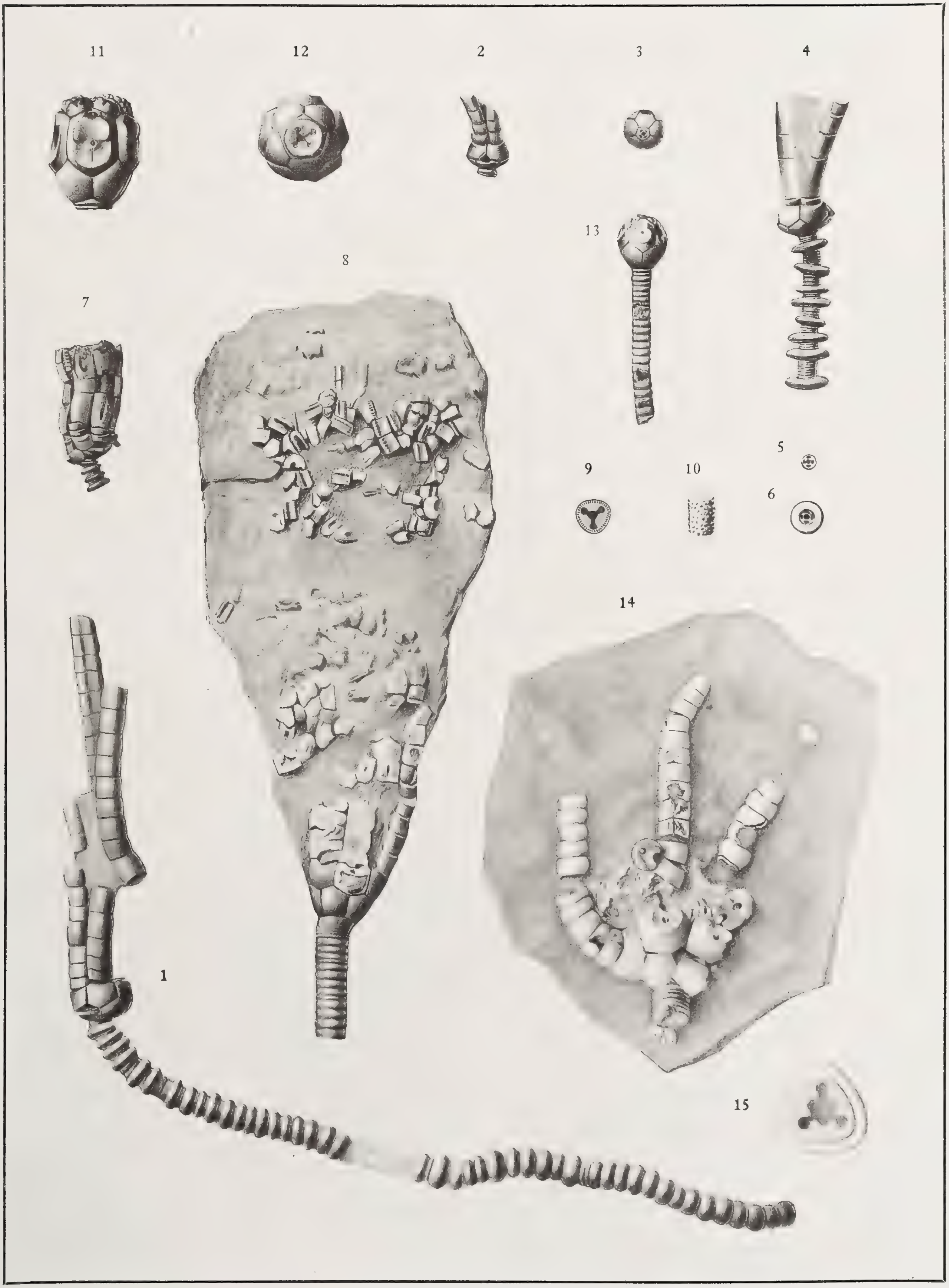
Genus MYRTILLOCRINUS Sandberger

Myrtillocrinus americanus Hall

Page 358

11 Lateral view of the type specimen, showing the deep radial facets, with dorsal canal. Collection of American Museum Natural History, number 2976

Onondaga limestone, Caledonia



G. S. Barkentin and E. Wood del.

12 Basal view of the same specimen, showing the quadripartite axial canal

13 Lateral view of a smaller specimen showing the character of the column. After Springer 1911. Collection of Doctor Springer

Onondaga limestone, Livingston county

Myrtillocrinus (?) **levis** (Wood)

Page 360

14 Lateral view (x 3/2) of the type specimen, showing the tripartite axial canal. Reproduced from the original drawing; type in collection of United States National Museum, number 35146

Onondaga limestone, Le Roy

15 Top view of a columnal (x $4\frac{1}{2}$). Reproduced from the original drawing

PLATE 45

605

Genus ARACHNOCRINUS Meek & Worthen

Arachnocrinus bulbosus (Hall)

Page 353

1 Dorsal and ventral views of two specimens. Specimen at the right is one of Hall's types, number $\frac{4040}{1}$

Onondaga limestone, near Le Roy

2 Dorsal view of another specimen showing the character of the arms well. One of the types. Collection of University of Chicago, Walker Museum, number 13134

Onondaga limestone, Livingston county

3 Ventral view (x 2) of a specimen showing the ventral furrow and some covering plates in place. Lower left ray probably the anterior. After Springer 1911. Collection of Doctor Springer

Onondaga limestone, near Le Roy

4 An axillary brachial further enlarged (x 4) showing the sockets for the covering plates, 8 or 9 at each side. After Springer 1911

5 Anterolateral view of a very fine specimen showing the character of the arms. Type of Springer 1911. Collection of State Museum

6 Lateral view of a specimen with a well-preserved calyx

7 Basal view of the same specimen, showing what appears to be an anal plate between the radials

8 Lateral view of another specimen

9 Opposite side of the calyx of the same specimen

10 Basal view of the same specimen

11 Basal view of an imperfectly preserved specimen referred to this species

Figures 5–11 are from the Onondaga limestone, Le Roy

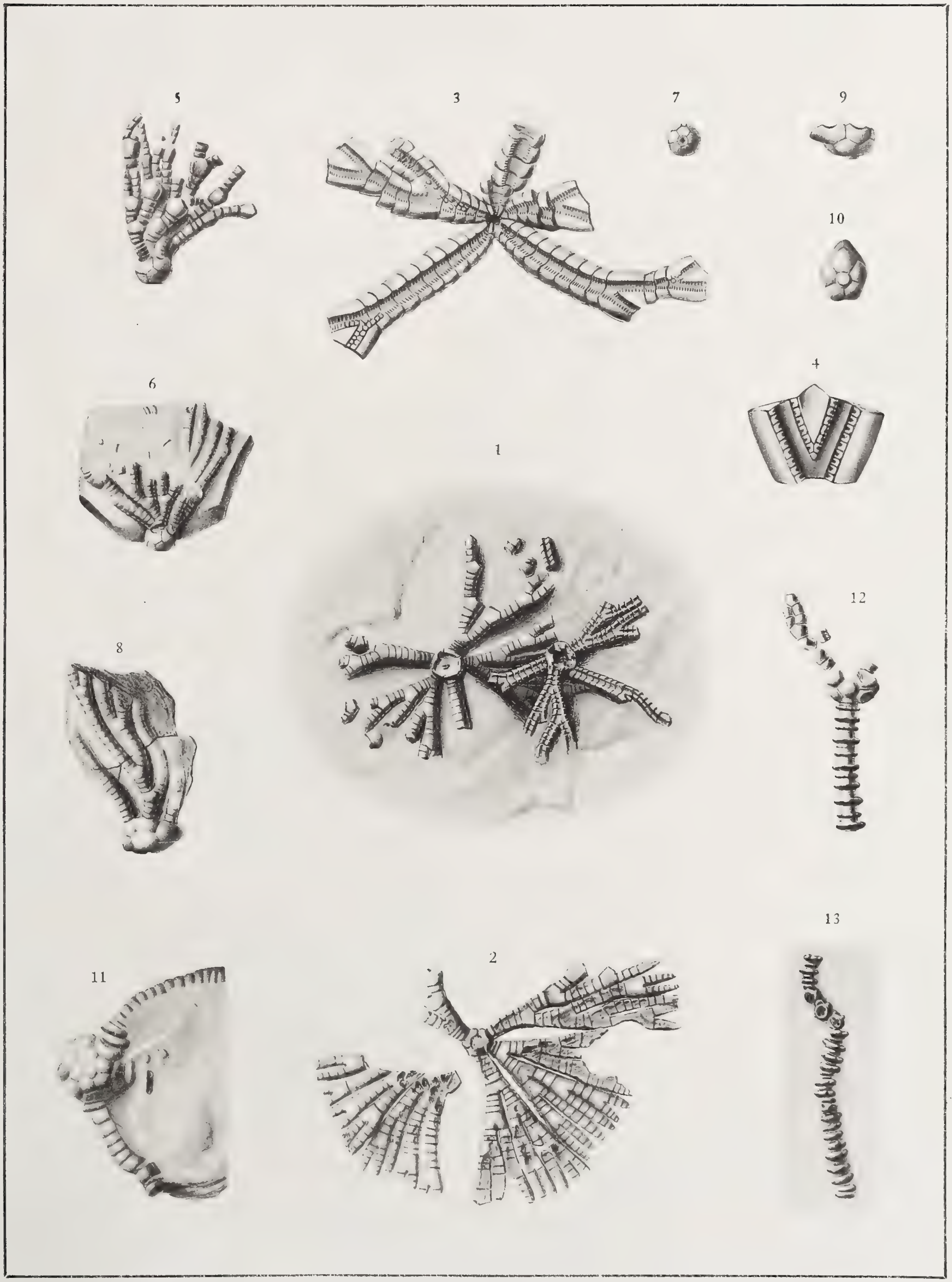
12 Lateral view of a specimen showing the large nodals and thin internodals of the column

Onondaga limestone, Ontario, Canada

13 Portion of a column of another specimen showing the character of the nodals and the quadripartite axial canal

Onondaga limestone, Limerock

Originals, except as otherwise indicated, in the State Museum



G. S. Barkentin del.

PLATE 46

Genus ARACHNOCRINUS Meek & Worthen

Arachnocrinus bulbosus (Hall)

Page 353

1 Dorsal view of large specimen showing well the ponderous character of the arms. Collection of Doctor Springer
Onondaga limestone, Le Roy

Arachnocrinus ignotus Stauffer

Page 357

2 Dorsal view of a specimen preserving the dorsal cup
3, 4 Dorsal views of two fragmentary specimens showing the character of the arms
Figures 2, 3, 4, are from the Onondaga limestone, Limerock
5 Dorsal view of another specimen
Onondaga limestone, Le Roy

Arachnocrinus extensus W. & Sp.

Page 355

6 Dorsal view of a small, imperfectly preserved specimen, showing the character of the arms (*see* plate 47, figure 1)
Onondaga limestone, Limerock

Originals, except as otherwise indicated, in the State Museum

G. S. Barkentin del.

PLATE 47

Genus ARACHNOCRINUS Meek & Worthen

Arachnocrinus extensus W. & Sp.

Page 355

1 Dorsal view of a specimen with base broken off, showing branching of the anterior and two lateral rays. One of Springer's types, introduced to give a better idea of the size and character of the arms of the species. (*See* plate 46, figure 6). After Springer 1911. Collection of Doctor Springer

Onondaga limestone, Falls of the Ohio, Louisville, Ky.

2 Portion of an arm provisionally referred to this species

Onondaga limestone, Le Roy

Genus BOTRYOCRINUS Angelin (em. Bather)

Botryocrinus nycteus (Hall) n. comb.

Page 363

3 Left posterior view of the type specimen, number $\frac{4474}{1}$ in the State Museum

Hamilton (Moscow) shale, Vincent

4 Right anterolateral view of the same specimen

5 Anterior view of a larger specimen showing the ventral tube, proximal part of the arms and a considerable length of column

Hamilton (Moscow) shale, Cashong creek, Bellona

6 Posterior view of the calyx of the same specimen

Botryocrinus crassus (Whiteaves)

Page 365

7 Right anterolateral view of the calyx. Type. Collection of Geological Survey of Canada Museum

Hamilton shale, Thedford, Ontario

8 Posterior view of the same specimen

Botryocrinus americanus Rowley

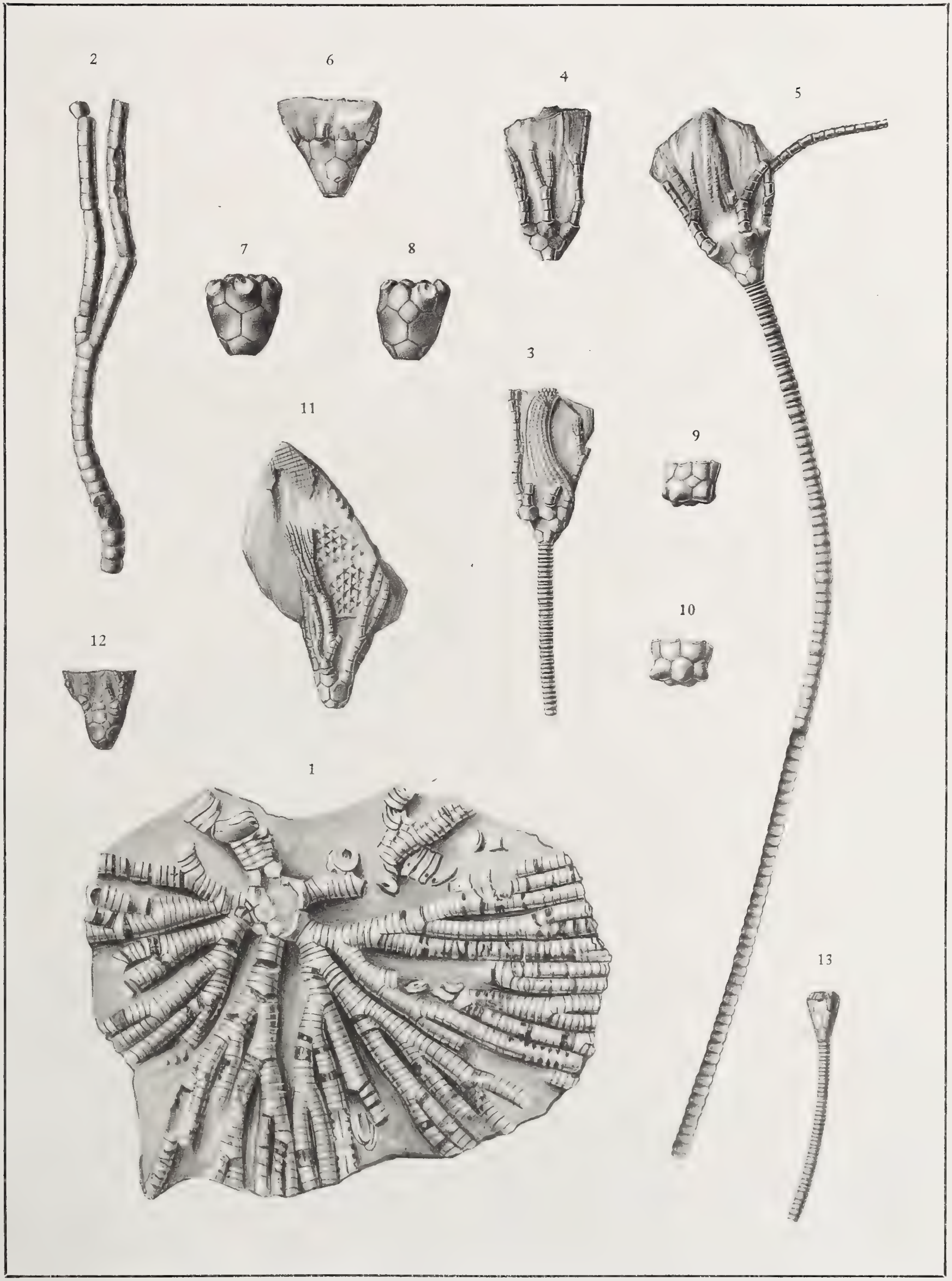
Page 367

9 Posterior view of the calyx. After Rowley 1904

Hamilton beds, Charlestown, Ind.

10 Anterior view of the same specimen. After Rowley 1904

DEVONIAN CRINOIDS



G. S. Barkentin del.

Botryocrinus concinnus sp. nov.

Page 369

11 Anterior view of an imperfect crown
Hamilton (Skaneateles) shale, east side of Owasco lake, Cayuga county

12 Posterior view of the calyx, proximal parts of the arms and ventral tube of the same specimen

Botryocrinus obconicus sp. nov.

Page 371

13 Left posterior view of the calyx and proximal portion of the column
Hamilton (Moscow) shale, Canadaigua lake

Originals, except as otherwise indicated, in the State Museum

PLATE 48

Genus MARAGNICRINUS Whitfield

Maragnicrinus portlandicus Whitfield

Page 384

Posterolateral view of one of the type specimens. Collection of American Museum Natural History, number $\frac{5849}{1}$

Portage limestone, shore of Lake Erie, Portland

G. S. Barkentin del.

PLATE 49

Genus MARAGNICRINUS Whitfield

Maragnicrinus portlandicus Whitfield

Page 384

1 Posterior view of a second type specimen. Collection of American Museum Natural History, number $\frac{5849}{1}$

Portage limestone, shore of Lake Erie, Portland

2 Enlargement (x 4) of a few brachials of the same, with pinnules

3 Lateral view of a third type specimen. Type in Williams College; plastotype in State Museum. Drawn from plastotype

Portage limestone, shore of Lake Erie, Portland

Genus HALLOCRINUS nov.

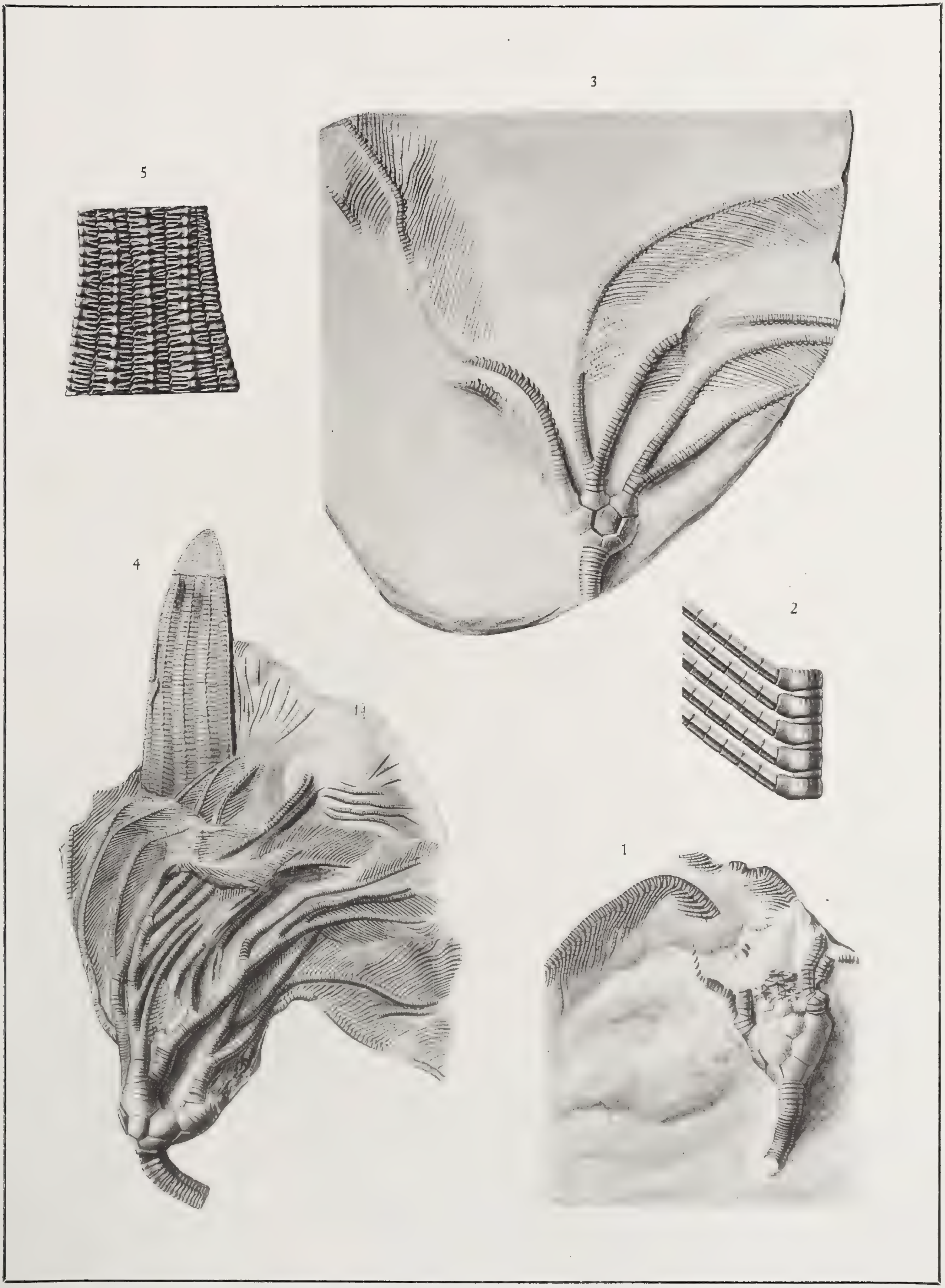
Hallocrinus ornatissimus (Hall) n. comb.

Page 374

4 Lateral view of a specimen showing the ventral sac. Type of Whitfield, 1905. Collection of American Museum Natural History, number $\frac{5850}{1}$

Portage limestone, shore of Lake Erie, Portland

5 Enlargement (x 2) of a portion of the ventral sac of the same



G. S. Barkentin del.

PLATE 50

617

Genus HALLOCRINUS nov.

Hallocrinus ornatissimus (Hall) n. comb.

Page 374

1 Posterolateral view of the original of Hall's type. Type of Whitfield 1905
2 Posterior view of a young specimen
3 Lateral view of a still younger specimen (x 2)
4 Enlargement (x 2) of a few columnals
Portage limestone, shore of Lake Erie, Portland

All specimens in the collection of the American Museum of Natural History, number $\frac{5850}{1}$ (figures 1–3) and $\frac{5849}{1}$ (figure 4)

DEVONIAN CRINOIDS

2

3

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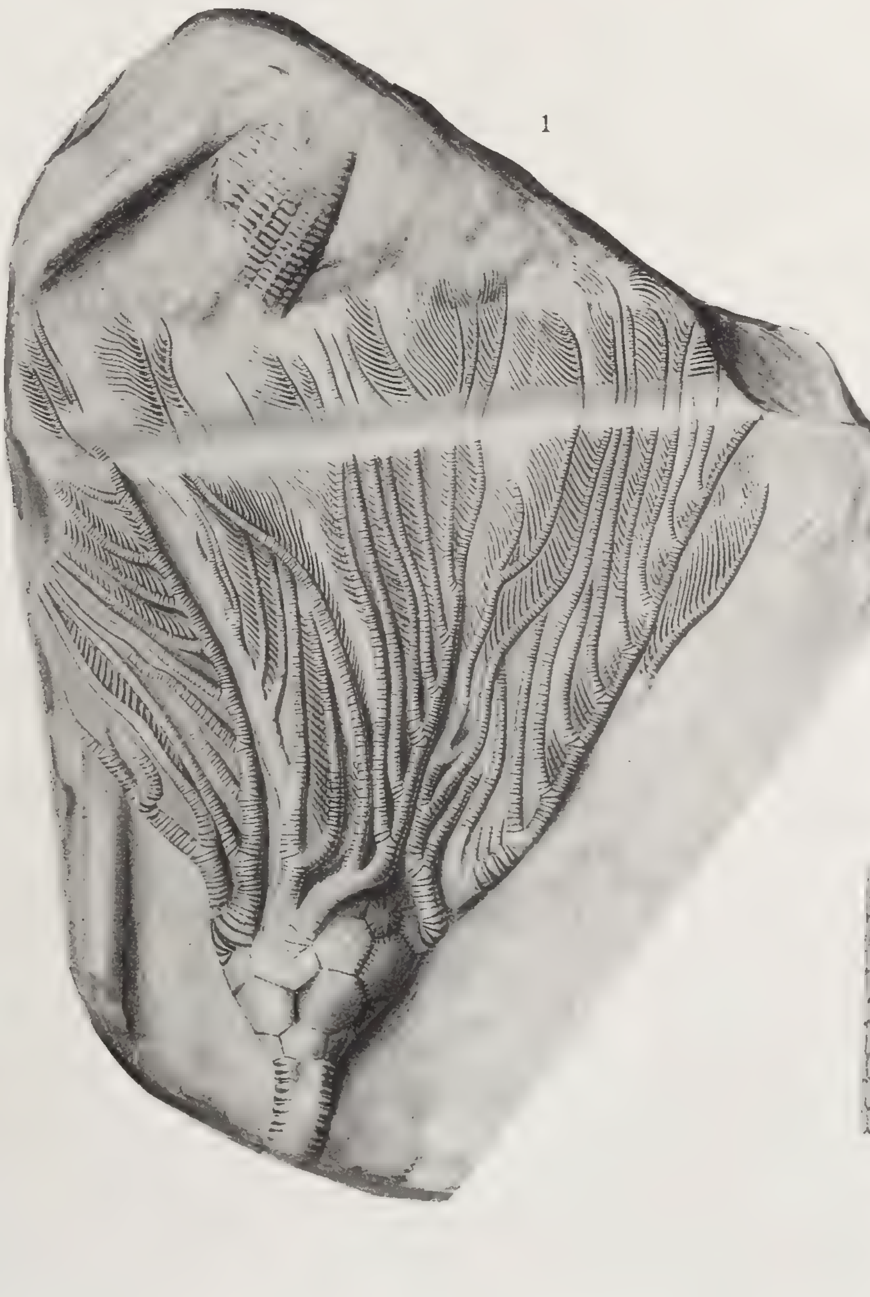

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PLATE 51

Genus HALLOCRINUS nov.

Hallocrinus ornatissimus (Hall) n. comb.

Page 374

Posterior view of another specimen. Collection of American Museum Natural History, number $\frac{5850}{1}$

Portage limestone, shore of Lake Erie, Portland

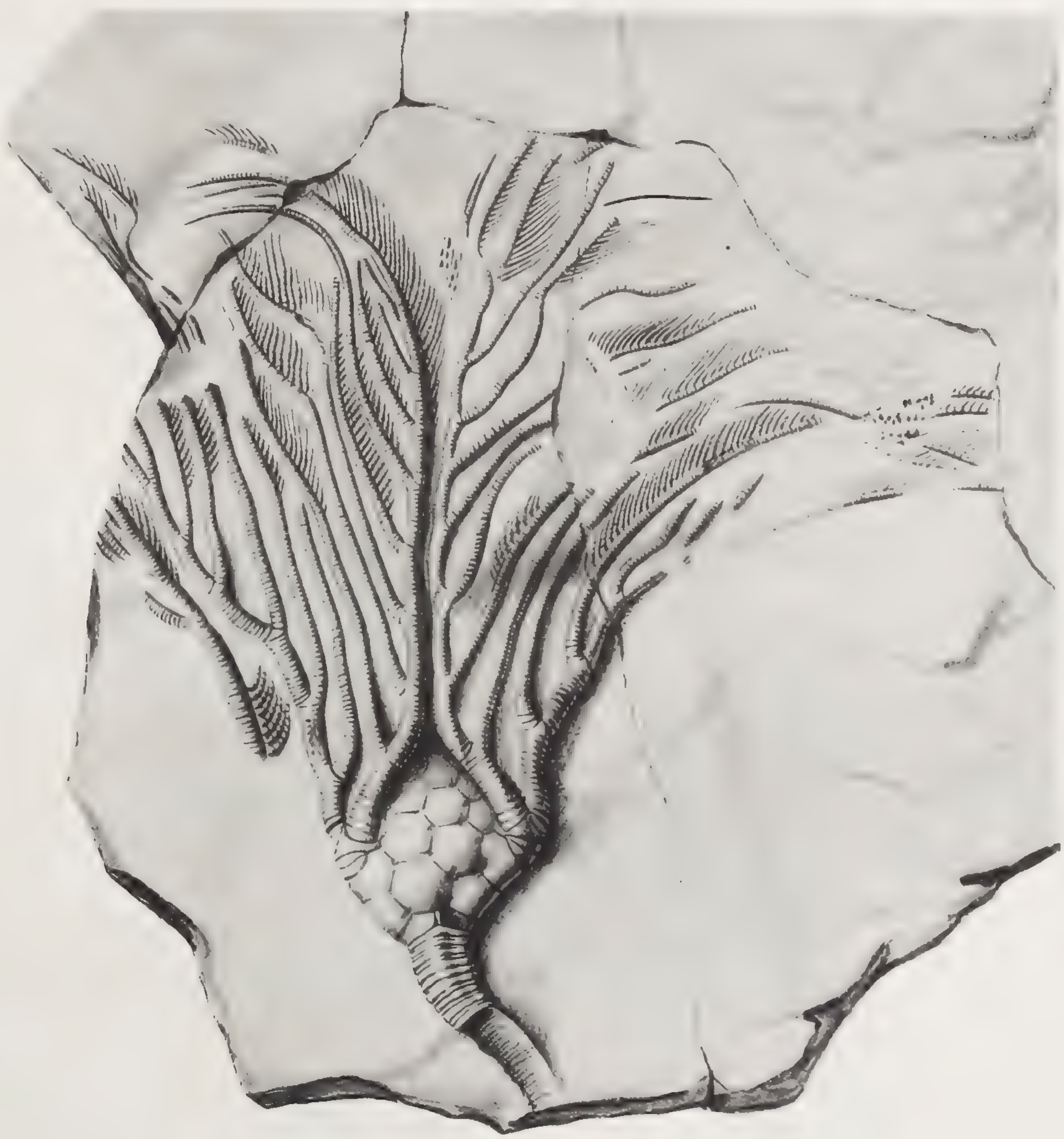

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PLATE 52

Genus GLOSSOCRINUS nov.

Glossocrinus naplesensis sp. nov.

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1 Lateral view (x 2) of a specimen showing the calyx, proximal parts of the arms and ventral tube, and several centimeters of column
Portage beds (West Hill flags), Italy hollow, near Naples

2 Posterior view of another specimen showing well the dorsal, median, armlike series of plates of the ventral tube and the long cirri
Portage beds (West Hill flags), Italy hollow, near Naples

3 Lateral view of a specimen showing the character of the arms and column.
Portage beds (Grimes sandstone), Deyo basin, near Naples

4 Lateral (anterior ?) view of the crown of a larger specimen showing the median line of small interlocking plates extending along the anterior side of the ventral tube
Lower Chemung beds, Chemung Narrows

5 View, from the posterior side, of a calyx with proximal parts of the arms and ventral tube. Specimen abnormal in the left posterior interradius, having two small plates instead of the one large basal
Portage beds (West Hill flags), Italy hollow, near Naples

Glossocrinus cornellianus (Williams) n. comb.

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6 View of the posterior side of one of the types. Type in collection of the late Professor H. S. Williams, Cornell University; plastotype, from which drawing was made, in collection of Doctor Springer
Lower Chemung beds, Ithaca

7 Lateral view (x 3/2) of calyx and proximal part of the arms of another type. After Williams 1882
Lower Chemung beds, Ithaca

Genus LIPAROCRINUS nov.

Liparocrinus batheri sp. nov.

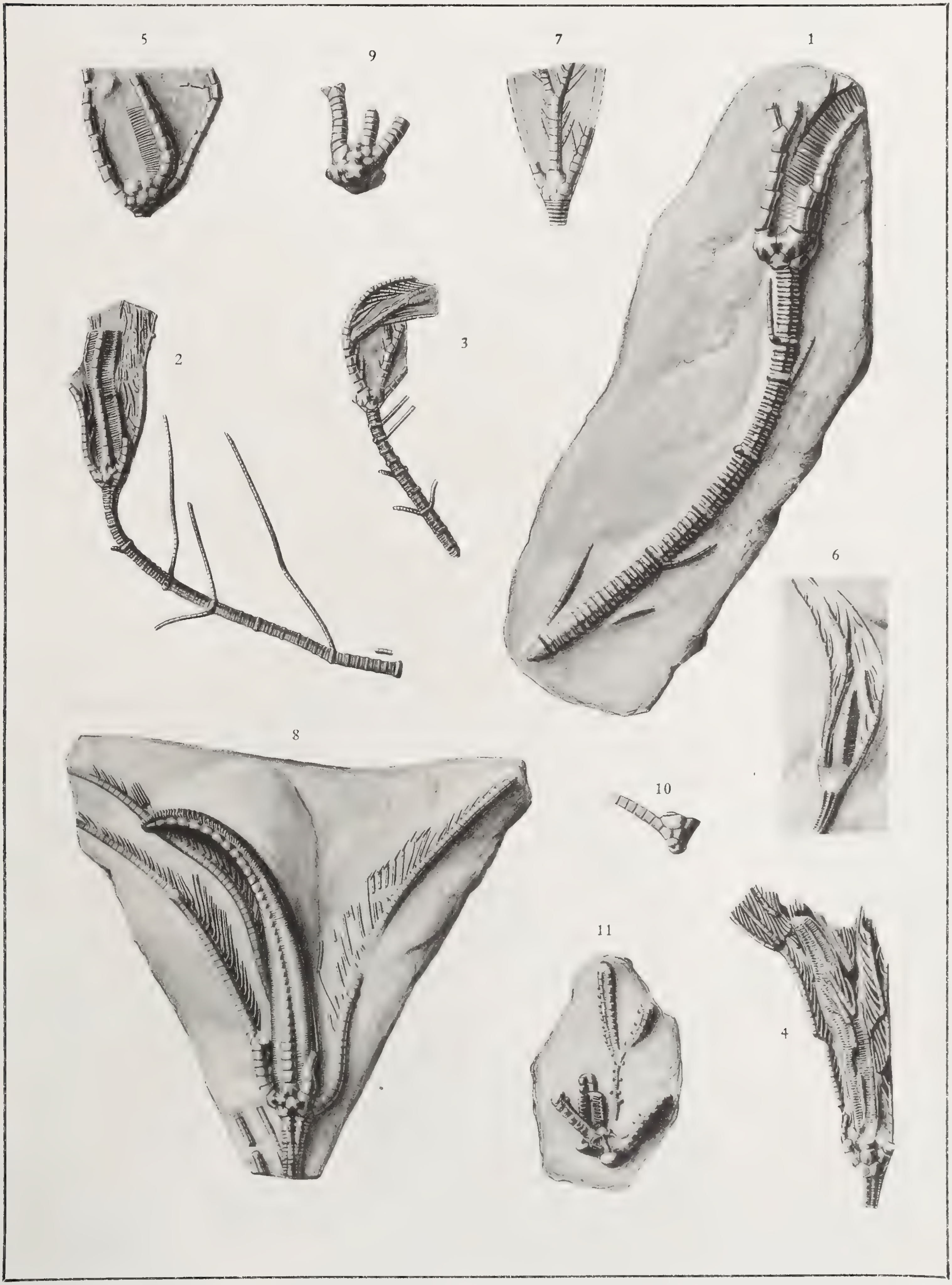
Page 397

8 View of the crown from the posterior side
Lower Chemung beds, Brown hill, Cohocton

Liparocrinus halli sp. nov.

Page 400

9 Basal view of a calyx with the proximal portions of two arms. Median dorsal line of tube plates shown
Chemung beds, Tracy Creek, Broome county



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10 Right anterolateral view of the same specimen

11 Another specimen showing the tegmen and the ventral side of the arms and ventral tube. Ambulacral plates well shown

Chemung beds, Tracy Creek, Broome county

Figures 1–4, 6, 8–11, were made from gutta-percha and plasticine squeezes

Originals, except as otherwise indicated, in the State Museum

PLATE 53

Genus CHARIENTOCRINUS nov.

Charientocrinus ithacensis sp. nov.

Page 402

1 Lateral view of imperfectly preserved crown with the proximal part of the column
2 Right anterolateral view of the calyx and parts of two arms of another specimen
3 Distal part of the arm of a third specimen showing the branching and the pinnules
4 Portion of the distal part of a column showing the rounded character and the cirri

All specimens from Portage (Ithaca) beds, Ithaca

Genus CATACTOCRINUS nov.

Catactocrinus leptodactylus sp. nov.

Page 405

5 Lateral view (x 2) of a fairly well-preserved crown, showing the ventral tube from the anterior side and several inches of column
6 Lateral view (x 2) of another specimen showing the anterior side of the ventral tube
7 Lateral view (x 2) of a third specimen. The ventral tube shows the median, ventral line of small plates
8, 9 Posterior (figure 8) and right posterior (figure 9) views of two rather fragmentary crowns. The dorsal, median, armlike series of plates of the ventral tube are shown in both

All specimens from lower Chemung beds, Cotton hill, Avoca

Figures 5–9 were made from gutta-percha and plasticine squeezes

All the originals in the State Museum

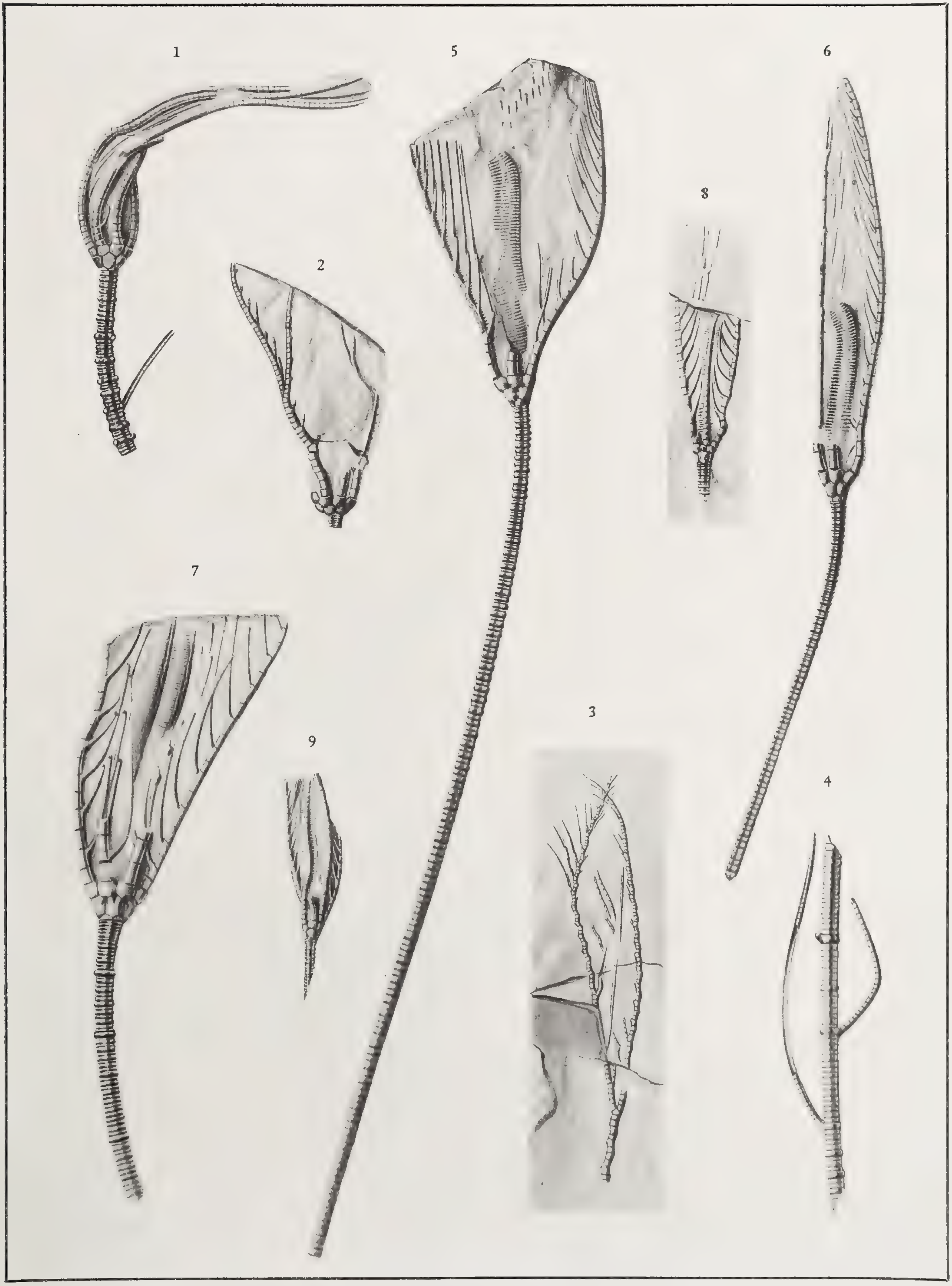

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PLATE 54

Genus POTERIOCRINUS Miller (em. W. & Sp.)

Poteriocrinus (?) **diffusus** Hall

Page 408

1 View of one of Hall's types from the right posterior side, number $\frac{4472}{1}$ in the State Museum
Hamilton (Moscow) shale, Vincent

Poteriocrinus nassa Hall

Page 410

2 Left anterolateral view of the dorsal cup. Anterior radius at the left. Type. Collection of American Museum Natural History, number $\frac{5035}{1}$
Hamilton (Moscow) shale, Canandaigua lake

3 Posterior view of the same specimen

Poteriocrinus clarkei Williams

Page 412

4, 5 Lateral views (x 2) of two of the cotypes. Figure 4 = number $\frac{4471}{1}$; figure 5 = number $\frac{4471}{2}$ in the State Museum
Chemung beds, Haskinsville

Poteriocrinus clarkei var. **alpha** Williams

Page 414

6 The few plates constituting the type of the variety, showing the size and the pronounced ridges and depressions. Type in the collection of the late Professor H. S. Williams, Cornell University; plastotype, from which the figure was made, in the collection of Doctor Springer
Lower Chemung beds, Ithaca

7 Posterior view of a fragmentary and poorly preserved specimen referred to this variety
Upper Chemung beds, Erie, Pa.

Poteriocrinus zethus Williams

Page 414

8 Lateral view (x 2) of the type specimen. Type. Collection of the late Professor H. S. Williams, Cornell University; plastotype, from which drawing was made, collection of Doctor Springer
Portage (Ithaca) beds, Ithaca

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Poteriocrinus (?) **dignatus** sp. nov.

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9 Right anterolateral view (x 2) of the calyx with anal tube and the proximal part of one arm
Hamilton (Skaneateles) shale, east side of Owasco lake, Cayuga county
10 Posterior view (x 2) of the same specimen

Genus DECADOCRINUS Wachsmuth & Springer

Decadocrinus nereus (Hall) n. comb.

Page 419

11 Lateral view (x 2) of the type specimen, number $\frac{4473}{1}$ in the State Museum
Hamilton (Moscow) shale, Vincent
12 Lateral view of another specimen figured by Hall as one of the types of *Poteriocrinus diffusus*, number $\frac{4472}{2}$ in the State Museum
Hamilton (Moscow) shale, Vincent
13 Basal view (x 2) of an older specimen showing the calyx, parts of the arms and the proximal portion of the anal tube
Hamilton (Moscow) shale, North Bristol
14 Left anterolateral view (x 2) of the calyx of the same specimen
15 Posterior view (x 2) of the same

Decadocrinus gregarius Williams

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16, 17 Lateral views (x 3/2) of two of the type specimens. After Williams 1882
Lower Chemung beds, Ithaca

Decadocrinus killawogensis sp. nov.

Page 428

18 Right posterior view (x 2) of an incomplete crown
Portage (Ithaca) beds, Killawog creek, west of Killawog
19 A fragmentary specimen, referred to this species, which shows the character of the arms and column
Portage beds (Grimes sandstone), Parrish gully, Naples

Figures 4, 5, 6, 7, 8, 18, 19 were made from gutta-percha and plasticine squeezes

Originals, except as otherwise indicated, in the State Museum

PLATE 55

Genus DECADOCRINUS Wachsmuth & Springer

Decadocrinus rugistriatus sp. nov.

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1 Lateral view (x 2) of the crown and proximal part of the column
2, 3 Views (x 2) of two specimens from the posterior side, showing the proximal part of the anal tube
4 Basolateral view (x 2) of a specimen showing well the ornamentation of the arms
All the above specimens from Portage beds (West Hill flags), Italy hollow, near Naples
5 Lateral view (x 2) of two smaller specimens preserving the column for a considerable distance
Portage (Ithaca) beds, near Ithaca

Decadocrinus decemnodosus sp. nov.

Page 424

6 Lateral view of an imperfectly preserved crown with a few millimeters of column attached
Portage (Ithaca) beds, near Morris, Otsego county

Decadocrinus multinodosus sp. nov.

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7 Lateral view (x 2) of the calyx and proximal parts of the arms
Hamilton (Moscow) shale, Cashong creek, Bellona
8 Anterior view (x 2) of the calyx of another specimen
9 Posterior view (x 2) of the same
10 Lateral view of a specimen showing the calyx and parts of the arms
11 Fragmentary specimen showing a portion of the arms and anal tube
All the specimens from Hamilton (Moscow) shale, Cashong creek, Bellona

Figures 1, 7, 8, 9, 11 were made from gutta-percha and plasticine squeezes

All the originals in the State Museum

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PLATE 56

Genus DECADOCRINUS Wachsmuth & Springer

Decadocrinus multinodus var. **serratobrachiatus** nov.

Page 431

1 Basolateral view of a specimen showing the calyx and parts of the arms
Hamilton (Moscow) shale, Cashong creek, Bellona
2 Enlargement (x 5) of a few brachials of the above

Decadocrinus insolens sp. nov.

Page 426

3 Posterior view (x 2) of a much crushed crown and the proximal part of the column
4 Posterior view (x 2) of a calyx and the proximal parts of the arms
5 Lateral view (x 2) of the calyx of another specimen, showing the proximal part of the column
Genesee (West River) shale, Blacksmith gully, Bristol

Genus COREMATOCRINUS nov.

Corematocrinus plumosus sp. nov.

Page 435

6 View of a crown from the right posterior side
7 Posterior view of another specimen
8 Anterior view of the same
All the above specimens from lower Chemung beds, Chemung Narrows
9 Posterior view of a crown showing well the character of the upper part of the arms
Portage (Gardeau) beds, Deyo basin, Naples

Figures 3, 6, 7, 8, 9 were made from gutta-percha and plasticine squeezes

All the originals in the State Museum

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PLATE 57

Genus LOGOCRINUS nov.

Logocrinus geniculatus sp. nov.

Page 438

1 Right posterior view (x 2) of the calyx showing part of one arm and the proximal part of the column
2, 3 Posterior views (x 2) of two other calyces.
4 Lateral view of another specimen, showing parts of the arms
5 Anterolateral view of a specimen showing well the character of the arms
6 Enlargements (x 5) of a few brachials of the same
All the specimens from Hamilton (Moscow) shale, Cashong creek, Bellona

Logocrinus infundibuliformis sp. nov.

Page 440

7 Lateral view (x 2) of a specimen showing the calyx, proximal parts of the arms and column
8 Lateral view of another specimen showing the character of the arms
9 Right posterior view (x 2) of a third specimen showing part of the anal tube
10, 11 Posterior views of two specimens showing the character of the anal tube
All the specimens from lower Chemung beds, Chemung Narrows
Figures 7–11 were made from gutta-percha squeezes

All the originals in the State Musenm

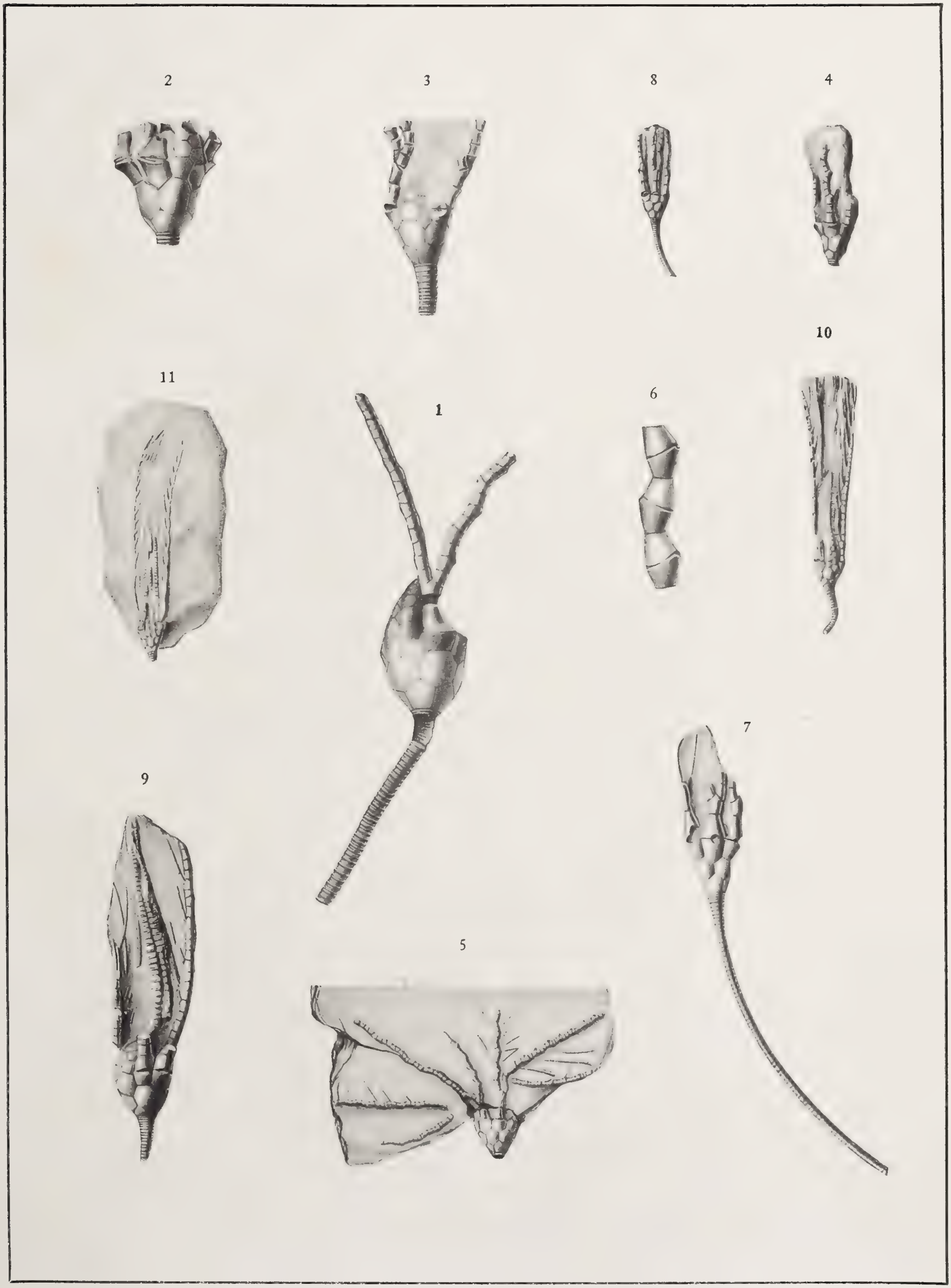

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PLATE 58

Genus EDRIOCRINUS Hall

Edriocrinus sacculus Hall

Page 448

1 An almost entire, adult individual, with the base broken off, preserving the radial plates and with the arms more or less entire. After Hall, 1859

2 Adult, free individual, crawling over the surface of a gastropod shell. Type of Kirk, 1911. Collection of United States National Museum, number 57504

Figures 1, 2 from Oriskany limestone, Cumberland, Md.

3 A fragmentary base (x 2) seen from above, showing the interior and the character of the wall. The double wall is given a cellular appearance by the occurrence of a median wall and transverse partitions

4 Similar view of another base, showing the thick wall and the markings of the inner surface

5 Lateral view of a third base

6, 7 Lateral views of two young, attached specimens showing the irregular, linear base

Figures 3–7 from Oriskany (Glenerie) limestone, Glenerie

8 Lateral view of a group of young, attached individuals. Type of Kirk, 1911. Collection of United States National Museum, number 57504

Oriskany limestone, Cumberland, Md.

Edriocrinus pocilliformis Hall

Page 447

9 Anterior view (x 2) of a dorsal cup. Type of Talbot, 1905. Collection of Yale University Museum

10 Posterior view (x 2) of the same

11 Anterolateral view (x 2) of another dorsal cup. Anterior radius at the left. Type of Talbot, 1905. Collection of Yale University Museum

12 Posterior view (x 2) of the same

Figures 9–12 from New Scotland limestone, Helderberg mountains

13, 14 Lateral views of two rather elongated bases. Figure 13 shows parts of two radials

15 Lateral view of the base of another specimen

Figures 13–15 from New Scotland limestone, Schoharie

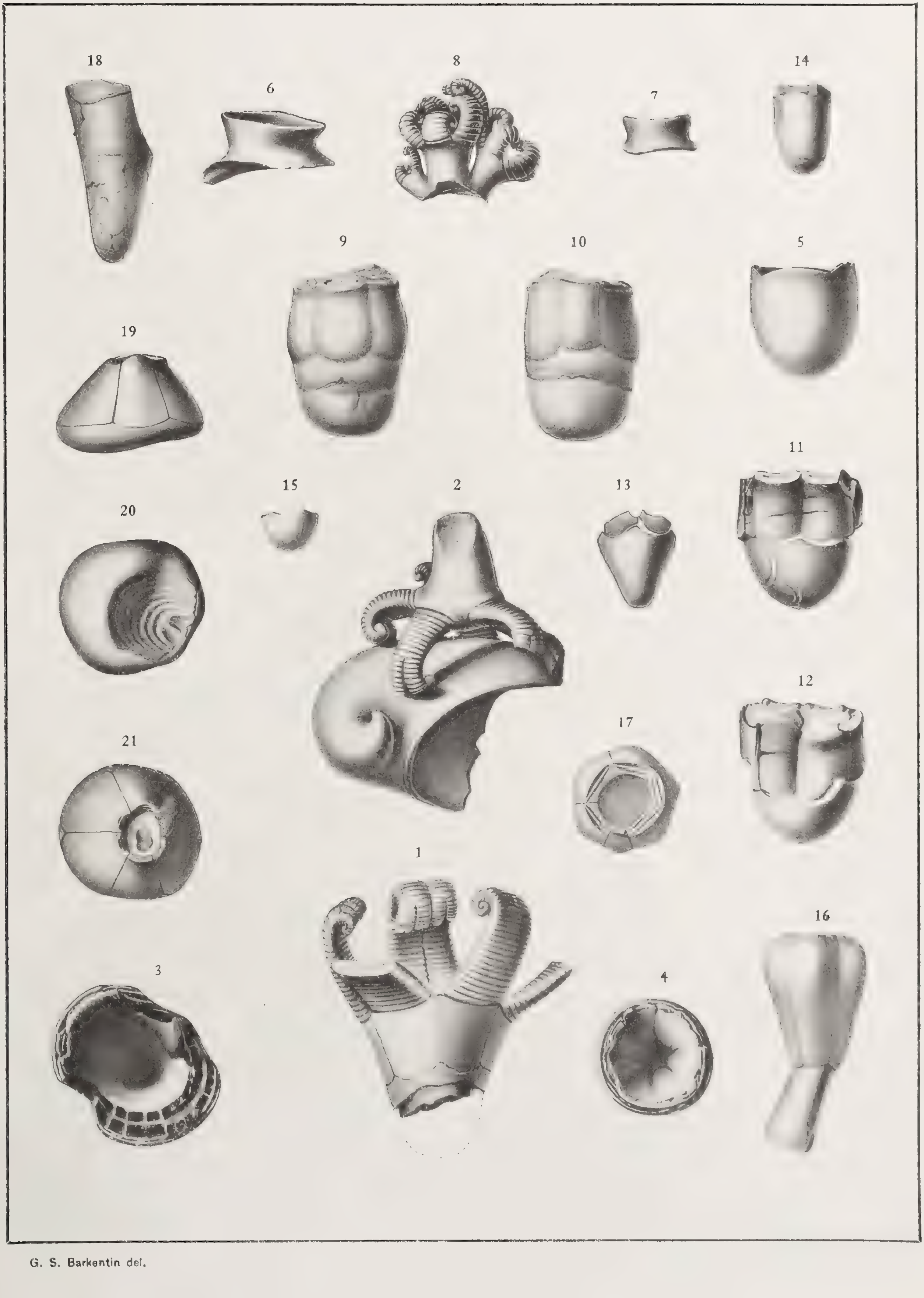
Edriocrinus pyriformis Hall

Page 451

16 Lateral view of the type specimen. Collection of American Museum Natural History, number $\frac{2980}{1}$

Coeymans limestone, Eastman's quarry, southeast of Utica

17 View of the same specimen from above



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Edriocrinus becraftensis Clarke

Page 453

18 Lateral view of the type specimen, number $\frac{4160}{1}$ in the State Museum

Oriskany limestone, Becraft mountain, Hudson

Edriocrinus dispansus Kirk

Page 453

19 Posterior view of the type specimen. Collection of United States National Museum, number 27757

Lower Helderberg (Linden formation), Bid Sandy river, Benton county, Tenn.

20 Basal view of the same specimen

21 View of the same specimen from above

Originals, except as otherwise indicated, in the State Museum

PLATE 59

Genus MARIACRINUS Hall

Mariacrinus stoloniferus Hall

Page 113

1, 2, 3 Large columns referred to this genus. Types: figures 1, 2 = $\frac{2298}{1}$, figure 3 = $\frac{2298}{2}$. Collection of American Museum Natural History
New Scotland limestone, Schoharie

4 Smaller column belonging to the same species. Type. Collection of American Museum Natural History, number $\frac{2298}{3}$
New Scotland limestone, Albany county, near Albany

5 A second small column. Type. Collection of American Museum Natural History, number $\frac{2298}{1}$
New Scotland limestone, near Schoharie

Genus ASPIDOCRINUS Hall

Aspidocrinus scutelliformis Hall

Page 442

6 A well-preserved specimen viewed from above
Becraft limestone, Becraft mountain, Hudson

7 Lateral view of the same specimen

Aspidocrinus digitatus Hall

Page 443

8 View from above of the type specimen, number $\frac{4060}{1}$ in the State Museum
New Scotland limestone, Schoharie

9 Lateral view of the same

Aspidocrinus callosus Hall

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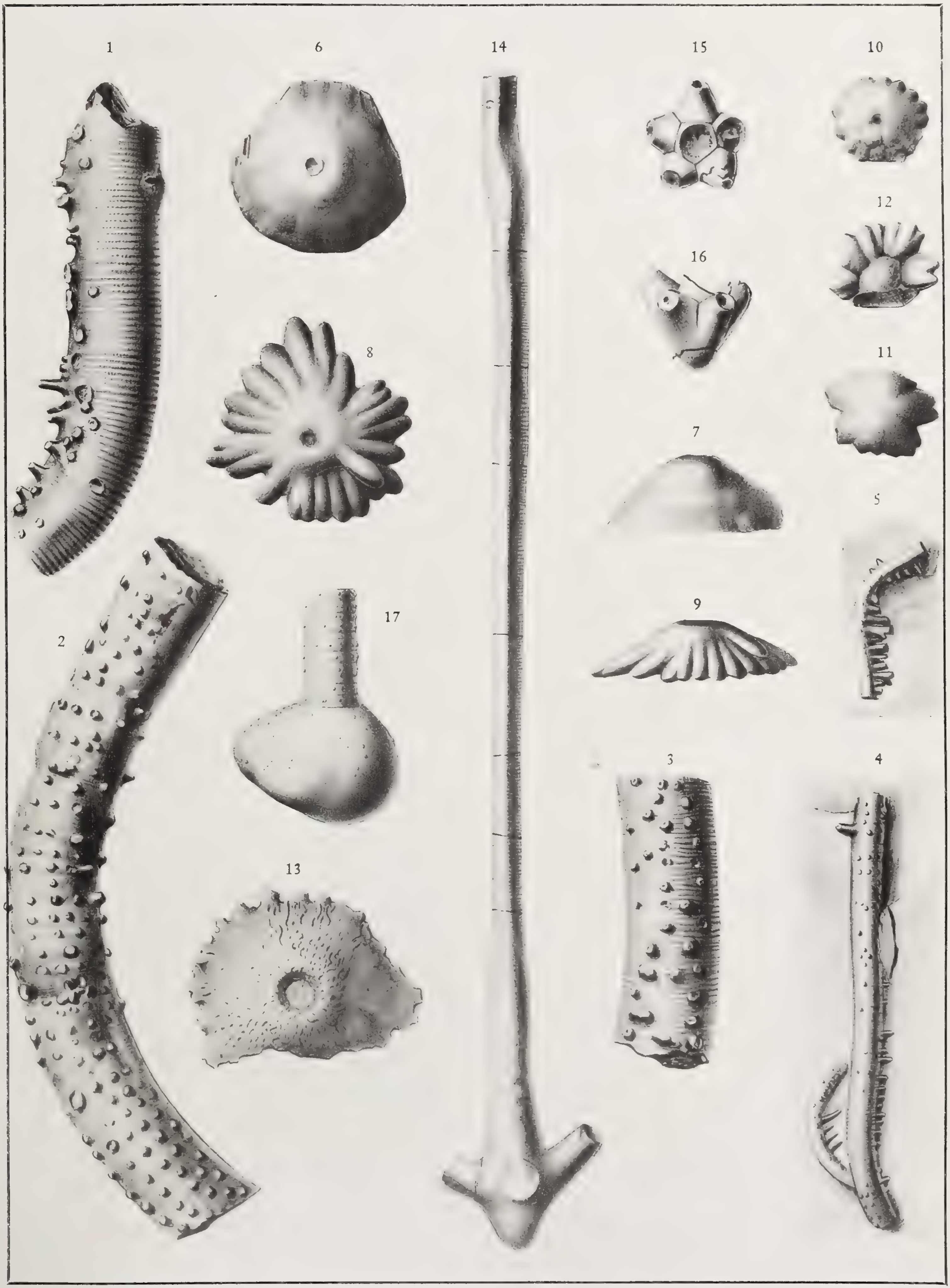
10 Specimen viewed from above

11 View from above of another specimen

12 Same specimen seen from below
Figures 10–12 from New Scotland limestone, Schoharie



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Aspidocrinus onondagensis sp. nov.

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13 View of a specimen seen from above
Onondaga limestone, Limerock

Genus ANCYROCRINUS Hall

Ancyrocrinus bulbosus Hall

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14 Lateral view of the type, number $\frac{4016}{1}$ in the State Museum
Hamilton (Moscow) shale, Lake Erie

Ancyrocrinus quinquepartitus sp. nov.

Page 458

15 A specimen with column missing, seen from above
Oriskany (Glenerie) limestone, Glenerie
16 Lateral view of the same specimen

Crinoid root

Page 35

17 Lateral view of the bulbous root of a crinoid
Hamilton (Moscow) shale, Canandaigua lake

Originals, except as otherwise indicated, in the State Museum

PLATE 60

Genus ARTHRACANTHA Williams

Arthracantha carpenteri (Hinde)

Page 288

1 Dorsal view (x 3/2) of a specimen in which the arms are particul rly well preserved. Type of Wood, 1904, reproduced from original drawing. Collection of United States National Museum, number 26380
Hamilton shale, Thedford, Ontario, Canada

2 Calyx of a crushed specimen seen from the left anterolateral side, showing the primibrachs, lowest secundibrachs and the first row of tegminal plates. A parasitic gastropod (Platyceras) is attached to the tegmen. Collection of Redpath Museum, Montreal
Hamilton shale, Bosanquet, Ontario, Canada

3 A slightly compressed specimen showing the posterior side, at the right. A parasitic gastropod is attached to the tegmen. After Hinde 1885
Hamilton shale, Arcona, Ontario, Canada

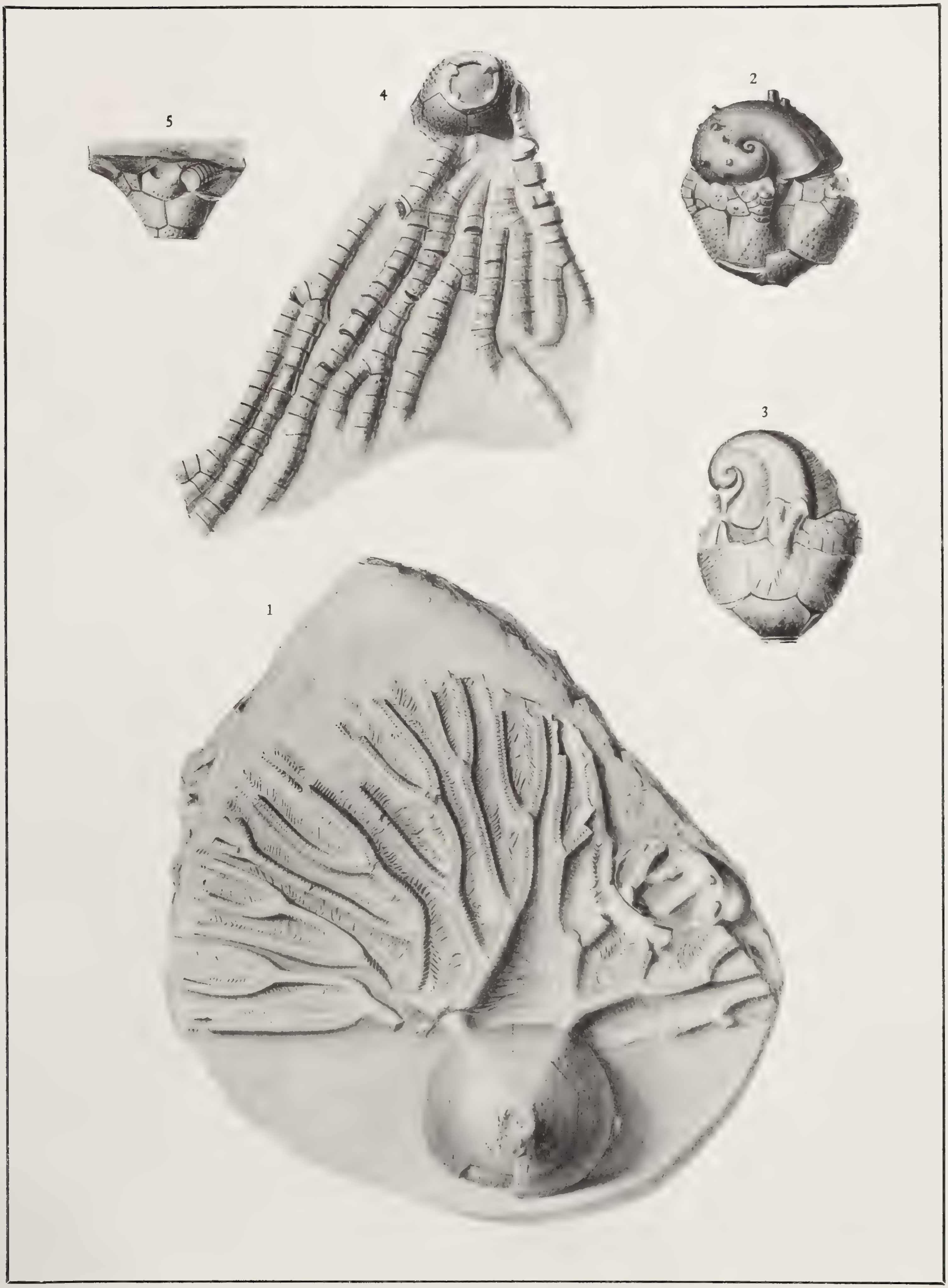
Genus MICTOCRINUS gen. nov.

Mictocrinus robustus sp. nov.

Page 362

4 Basal view of a specimen showing part of the dorsal cup and arms. The posterior basal is at the upper, lefthand side. Collection of State Museum
Onondaga limestone, Clarence, near Buffalo

5 Lateral (right posterior) view of the dorsal cup of the same specimen. Anal plate shown at the left, slightly pushed out of place; width of the plate at the top exaggerated in the figure (*see* text figure 58). Left posterior radial badly crushed and distorted



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GENERAL INDEX

The names of genera and species figured and larger divisions considered valid are printed in black face type; those regarded as synonyms or nomina nuda, in italics. Black face figures indicate principal page references

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