CANADA
DEPARTMENT OF MINES
GEOLOGICAL SURVEY BRANCH

Hon. W. Templeman, Minister; A. P. Low, Deputy Minister;
R. W. Brock, Director.

MEMOIR No. 15-P

ON A TRENTON ECHINODERM FAUNA

AT

KIRKFIELD, ONTARIO

BY

FRANK SPRINGER.

OTTAWA
GOVERNMENT PRINTING BUREAU
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LETTER OF TRANSMITTAL.

R. W. BROCK, ESQ.,
Director Geological Survey,
Department of Mines, Ottawa.

SIR,—I beg to submit a Report on the Echinodermata from the Trenton limestone, near Kirkfield, Ontario: accompanied by five plates of drawings and explanatory notes.

I have the honour to be,
Sir,
Your obedient servant,
(Signed) **Frank Springer.**

BURLINGTON, IOWA, U.S.A.,
June 28, 1910.

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TEXT.

ON A TRENTON ECHINODERM FAUNA AT KIRKFIELD, ONTARIO.

BY

Frank Springer.

In the course of excavating the Trent canal, a considerable cutting was made through the lower part of the Trenton limestone at a point near Kirkfield, in Victoria county, Ontario, Canada. Some of the layers proved to be extremely fossiliferous, and extensive collections were made there during the years 1906-9 by the staff of the Geological Survey of Canada. Among these were a considerable number of Echinodermata, which, through the courtesy of Mr. R. W. Brock, Director of the Geological Survey, have been placed in my hands for examination. These specimens, together with others previously collected for the author by Mr. Edwin Kirk from the same locality, form the subject of this report. During the years 1908 and 1909, collections were also made in the Kirkfield beds for the University of Toronto, which have been studied by Dr. W. A. Parks, of that institution, and some new species described in papers which will be referred to later. He has obligingly furnished me for comparison a list of the species as identified by him, and allowed me the fullest opportunity for examination of the specimens in the University Museum under his charge.

The fauna of the Canadian Trenton was investigated at an early day, and most thoroughly described, by that eminent palæontologist, E. Billings—the Echinodermata in the two fine Memoirs on the Cystidea and Crinoidea known as Decades III, and IV, of 'Figures and Descriptions of Canadian Organic Remains,' published respectively in the years 1858 and 1859. Many of the species were preliminarily described, without figures, in reports of the Geological Survey for 1856 and 1857. These treatises were largely based upon collections made by Mr. Billings himself in the vicinity of Ottawa and Hull, and his many careful references to the exact stratigraphic position, within the general limits of the Trenton, of the species described, furnish us the means of interesting comparison with the similar occurrences in Victoria county.

Billings' descriptions in the works above mentioned include eight genera and twenty species of Cystids, Starfishes, etc., and three genera and thirty-three species of Crinoids, from the Trenton, all new to science—besides several new genera and species from other Ordovician horizons.

Further valuable contributions to our knowledge of the Trenton crinoidal fauna were made by Mr. Walter R. Billings, who in 1881 to 1887, in the Transactions of the Ottawa Field Naturalists' Club, described several new species and one new genus from Ottawa and Belleville. Some additional species were described by Dr. J. F. Whiteaves, Sir James Grant, Mr. L. M. Lambe, and Dr. W. A. Parks.

By far the greater part of the Echinodermata described by these authors was derived from the lower and middle parts of the Trenton beds at Ottawa and vicinity. Among considerable collections made in the same region by Mr. John Stewart, and afterwards acquired for the Museum of the Geological Survey, were some which are believed to have come from the upper part. Of the forty or more species found at Kirkfield, thirty are readily recognized as among those described by E. and W. R. Billings, chiefly from the lower and middle beds at Ottawa, whereas some forms believed to be from the upper beds at Ottawa are wholly wanting. Mr. W. A. Johnston, who made the fine collections at Kirkfield for the Geological Survey, informs me that the zone from which these fossils were obtained probably extends from twenty-five to seventy-five or eighty feet above the heavy coral beds which are regarded as the base of the Trenton, or the top of the Black River beds; and that the Echinodermata are most abundant in the lowest twenty-five feet of this zone. The almost complete identity of the crinoidal fauna in the two regions would, therefore, seem to indicate the approximate continuity of the fossil-bearing beds, and to confirm the statement of Dr. Ami, in his paper on the 'Outliers of the Ottawa Palæozoic Basin' (Royal Soc. Canada, 1896, p. 154, Sec. IV) that 'the echinoderms abound in the shaly and thin-bedded portions of the lower Trenton of Hull and Ottawa.' The fossils at Kirkfield also occur chiefly in thin, shaly layers; and while the preservation of the specimens is often very good for the study of structural details, many of them are much flattened by pressure. In general, however, the fossils are in better condition than those studied by Billings, and in many cases species described by him from imperfect material are represented by specimens far more perfect than were at his disposal, affording new and important information upon their morphology and relations.

Direct comparison with the types of Billings' species was found to be highly desirable in the study of this material, and upon being informed of this Mr. R. W. Brock, with a liberality for which he has my sincere thanks, promptly placed the whole of the original collection in the Museum at Ottawa at my disposal for examination, and authorized such portions of it as I desired for more detailed study to be shipped to me at Burlington. I am much indebted to Mr. Lawrence M. Lambe, Palæontologist, Geological Survey, for his careful and courteous attention to the packing and shipping of these valuable specimens.

The following list will show the character and extent of this echinoderm fauna, sufficiently for comparison with that of other localities; and along with it I will give an account of some new and notable occurrences brought to light by this study.

CRINOIDEA.

Order *CAMERATA.*—

Reteocrinus (Billings).

Several specimens belonging to this genus, described by Billings from fragmentary material, and of which he said 'none of the specimens collected are perfect, and the characters of the species, therefore, have not been fully ascertained,' fully confirm the interpretation of the genus given by Wachsmuth and Springer in their 'Remarks on *Glyptocrinus* and *Reteocrinus*' (Am. Jour. Sci. xxv, p. 256), to the effect that instead of having, as Billings supposed, 'no perfectly formed plates,' and its cup consisting of 'a reticulated skeleton, composed of rudimentary plates, etc.,' the plates of the base and radial series are perfectly formed, connected with each other by distant sutures; the interbrachial areas only being occupied by a large number of small plates, without definite arrangement. In the original description by Billings the column of the type species is stated to be round. The revised description by Wachsmuth and Springer (N. A. Crinoidea Camerata, p. 178) gives the column as 'obscurely pentagonal.' This was a mistake in the text, and does not agree with our own figures on Plate IX. The column is absolutely round in the type specimens, not only those refigured by us on that Plate, figs. 3*a*, *b*, but still better in the original of Billings Plate IX, fig. 4b, of Decade IV, which I have here refigured after additional preparation (Plate I, fig. 6). It is now interesting to find that all the specimens from Kirkfield, some fifteen in all the collections, while very similar to *R. stellaris* in every other particular, have a very large and sharply pentagonal column, so sharp, in fact, that in very mature specimens the sides are concave (Plate I, figs. 3, 4). In the first of these, having about 6 inches of the stem preserved, the pentagonal feature obtains throughout, with no sign of becoming round; but in one rather small specimen, with about two inches of stem intact, it passes from pentagonal to round at about half the distance (Plate I, fig. 5). This would indicate a tendency to variation in this character sufficient to justify the retention of both forms within the genus, and its diagnosis should be modified accordingly. The difference is really a matter of secondary growth, as the axial canal is of the same character in both. This is shown for the new form by figures 1*b* and 2*b*, of Plate I, giving cross-sections of the column near the calyx in two specimens; the first, at one of the thin interpolated joints, consisting of a large central, surrounded by five peripheral canals wholly separated from it; and the second, somewhat nearer the base, and at one of the larger, projecting joints, having a larger central canal connecting with the five peripheral ones. In fig. 1*b*, the central canal is itself pentagonal, with the orientation reversed, *i.e.*, interradial, but this does not hold good in sections of other stems farther down, where it is round. In *R. stellaris* the stem, while round externally, has the same quinquepartite canal, as is shown by the cross-section of one of Billings' types, 4*d*, (Plate I, fig. 7), the peripheral canals being radial.

The persistence of the pentagonal stem at Kirkfield, and the constant absence of it in the Ottawa specimens of *R. stellaris*, seem to indicate a distinct species, which may be identical with one having this character from the Trenton of Kentucky, viz:—

RETEOCRINUS ALVEOLATUS Miller and Gurley.

Plate I, figs. 1, 2, 3, 4, 5.

The pentagonal column sufficiently characterizes the species; there are some minor differences, such as the deeper pits at the sides of the calyx plates, and lateral buttresses on the brachials in some specimens (fig. 7*a*), but these are probably not important, and the latter is not constant.

ARCHAEOCRINUS LACUNOSUS (Billings).

Glyptocrinus lacunosus.—Dec. IV, p. 61, Plate VIII, fig. 3.
Rare and doubtful.

ARCHAEOCRINUS PYRIFORMIS (Billings).

Glyptocrinus pyriformis.—Dec. IV, p. 61, Plate VI, figs. 1*a-d*
Rare.

ARCHAEOCRINUS MICROBASALIS (Billings).

Rhodocrinus microbasalis.—Dec. IV, p. 63, Plate VI, fig. 2.
Rare.

PERIGLYPTOCRINUS PRISCUS (Billings).

Glyptocrinus priscus.—Dec. IV, p. 56, Plate VII, figs. 1*a-f*.
Rare, and showing much stronger ornamentation than the types.

PERIGLYPTOCRINUS BILLINGSI (Wachsmuth and Springer).

N. A. Crin. Camerata, p. 227.
Rare.

GLYPTOCRINUS ORNATUS (Billings).

Dec. IV, p. 60, Plate IX, fig. 2*a*.
Rare.

GLYPTOCRINUS RAMULOSUS Billings.

Dec. IV, p. 57, Plate VII, figs. 2*a-f;* VIII, figs. 1 *a-e*.

Abundant throughout the strata in the crinoidal part of the zone. This is a widely distributed species, being also found in the lowest part of the Trenton in Kentucky.

Order *FLEXIBILIA*.

PROTAXOCRINUS LÆVIS (Billings.)

Figs. 10, 11*a*, *b*, Plate III.

Lecanocrinus lævis.—Dec. IV, p. 47, Plate IV, fig. 3.

Two specimens, probably of this species, were found. This and its companion species, *P.* (*Lecanocrinus*) *elegans,* which as stated by Billings are but slightly different, are the earliest known representatives of the Flexibilia type. The original specimens did not disclose the construction of the anal side, but for reasons then stated I expressed the opinion in 1906, in the course of a discussion of the general characters of the Crinoidea Flexibilia (Journal of Geology XIV, p. 502), that they must have possessed the Taxocrinoid anal structure, viz., a tube-like series of anal plates, united to the adjacent rays by perisome, and not by suture. This opinion was confirmed while the paper was in press, by the discovery of the two specimens above mentioned, in each of which the anal side is exposed. Afterward, among some specimens from Ottawa in the Museum of the Geological Survey, sent me for examination by Dr. Whiteaves, I found another small individual in which the same structure is shown. Not only do they possess the Taxocrinoid anal structure, but, as should be expected from their geological position in the lower Ordovician, they have it in its most primitive form, in which the radianal is a part of the right posterior ray, and lies directly under the radial—being thus in the same developmental condition as the contemporary Inadunate genus *Dendrocrinus*. This fact becomes of considerable interest in connexion with the discoveries hereinafter discussed under the genus *Cupulocrinus*, showing a probable line of divergence between the orders Inadunata and Flexibilia.

Billings, in describing these two species, gave as the only points of distinction that *lævis* 'is shorter, and has only four joints instead of five in the secondary rays.' In six other small specimens from Ottawa considered to be *lævis*, since found, the number of secondary brachials is mostly four, sometimes five, and some arms have but three, thus indicating a tendency to the greater shortness on which he relied. In my specimens from Kirkfield, one about the size of the type of *lævis* and the other very small, the number of secondary brachials is mostly five, which would suggest their reference to *P. elegans*. But the type, and only known specimen heretofore, of *elegans* has the arms very angular in the lower part, and tending to become flat above, while in the type and other Ottawa specimens of *lævis* the arms are evenly rounded throughout. The Kirkfield specimens agree with them in this, and also in being of small size, while the type of *P. elegans* is much larger. Considering how variable the number of secundibrachs is, I am at present inclined to refer the Kirkfield specimens to *P. lævis*. For comparison in the discussion later I have figured the Kirkfield specimen showing the anal structures, and another of supposed *P. lævis*, from Ottawa (Plate III, figs. 10, 11*a*, *b*).

Order *INADUNATA.*

Hybocystis eldonensis Parks.

Ottawa Naturalist, 1908, Vol. XXI, p. 232.

Hybocystis problematicus Parks, loc. cit., *non* Wetherby.

Plate II, figs. 1 to 10.

This singular Crinoid, which Dr. P. Herbert Carpenter called 'one of the most remarkable fossil echinoderms yet discovered,' is represented by the remains of a small colony, in which the specimens, to the number of a hundred or more, were found crowded together into a space of a few square feet. This was, of course, broken up in the removal of the rock from the cutting, and probably not all the individuals were recovered, but not a single specimen was found outside of the one small spot. Some idea of their crowded condition when embedded may be had from the fact that in a small piece of shaly rock less than two square inches in area are the remains of nine individuals, more or less distorted by contact with each other. This genus was evidently of a strongly gregarious habit, as it is usually found similarly crowded, with many specimens injured by being pressed against their fellows.

Of the two species named the smaller one, *H. eldonensis,* was by far the more abundant, comprising about four-fifths of the specimens. The two forms were apparently commingled, and the colony seems to have been embedded just as it grew on the sea bottom, in quiet waters; for the Crinoids all have their stems and arms attached, although, owing to the usual accidents of quarrying and collecting, but few are saved for our studies in that condition.

This genus was first recognized here in 1908, by Dr. W. A. Parks, among collections made for the University of Toronto at the same locality (Ottawa Naturalist XXI, p. 232). In addition to describing his new species, *H. eldonensis,* he gave a very full redescription and discussion of *H. problematicus,* which as the type species of the genus was originally described by Prof. A. G. Wetherby, from specimens collected in the Trenton of Mercer county, Kentucky. The genus is one of singular interest, and was the subject of much discussion by Dr. P. Herbert Carpenter (Quarterly Journal Geological Society, London, 1882, pp. 298-312), and Wachsmuth and Springer (Revision of the Palæocrinoidea, 1855, Part III, p. 199). It is remarkable on account of having only three arms, two of the brachial series in Crinoids generally being replaced by ambulacra extending downward upon the dorsal side of the calyx plates, as in some Cystids. The three arms also differ from the usual arms in Crinoids in that, instead of tapering to a point by the growth of young brachials, the distal end is blunt and rounded, and the ambulacra curve around it from the ventral to the dorsal side, and extend downward along the back of the arms, being what are called 'recurrent' ambulacra.

The better preservation of his specimen enabled Dr. Parks to add some new and useful information touching the species, and with the considerably more extensive material at my command I am able to confirm his excellent description in most particulars. I must, however, come to the support of Carpenter, and Wachsmuth and Springer, on one or two points wherein he disagrees with them. He says: 'The above description differs in many points from the assertions of Wetherby, Carpenter, and Wachsmuth and Springer,' and he specifies as among the chief differences the construction of the arms, and the mouth and anus. As to the arms he says, 'only two joints have been previously observed; five certainly occur, and no more.' Ordinarily in Crinoids the number of ultimate brachials in an arm is of little moment, being merely a matter of growth in the individual, the arm becoming longer by the addition of new brachials at the distal end as the size of the organism increases. In a form like this, with recurrent ambulacra, it is clear that such growth could not take place by additions distally, for the presence of the ambulacrum around the end would preclude the formation of any articulating surface; and in view of the presence of the same ambulacrum along the dorsal side of the arm it is not easy to see how there could have been any increase of the arm by interpolation of brachials after the developmental stage was passed. The enlargement of food-gathering area incident to increase in size must have been provided for by extension of the ambulacra farther downward upon the calyx. In one specimen this is indicated by the extension of an ambulacrum not only to and across the basal plates, but also a short distance down the stem (Plate II, fig. 7*a*). Hence in this case the number of brachials in the arm may be supposed to have become fixed in the young, and therefore to have more importance for the distinction of species than in Crinoids of the usual type.

Carpenter, in the paper above cited, figured and described the ambulacral furrow as curving over the summit of the second arm-joint. Wachsmuth and Springer, in describing the arms, said, 'they consist, so far as known, of two quadrangular joints.' I can confirm Dr. Parks' statement, in criticism of this, that in the Canadian form there are five joints, and if he had added the cautionary words of Wachsmuth and Springer, 'so far as known,' I could have done so without qualification. But when he says, 'five, *and no more*,' I am obliged to bring his criticism home to himself. For out of three specimens before me with the arms preserved to their full length, two have five joints, and the third has six (Plate II, fig. 6). Since the original descriptions and discussions of this genus I have also obtained considerable accessions of material from the typical locality and others, in Kentucky, some of which show the arms much better than those first found. In eighteen specimens preserving the arm in one or more rays, the number of brachials runs as follows:—

With 1 brachial	1
" 1 and 2 brachials	1
" 2 brachials	7
" 2 and 3 brachials	2
" 3 brachials	6
" 4 brachials	1

In the one with four brachials they are unusually short, together not longer than the two in other specimens, so it may be disregarded. Thus while the number originally stated proves to be rather the most common among the Kentucky specimens, there is a variation from one to three.

Second, as to the mouth. Dr. Parks says: 'The ambulacra meet at or near the centre of the disc, and do not enter the calyx at the edge of the radials, as stated by Wachsmuth and Springer. A central oral aperture must exist, but it is not observable.' By this I understand him to mean an aperture opening outward through the tegmen. Wachsmuth and Springer's statement on this point was not quite so clear as it might have been, being chiefly concerned in combatting Wetherby's interpretation of the mouth as being situated centrally upon the upper surface, producing likewise an external oral aperture, which would be after the manner of the Recent Crinoids. It is true that the ambulacra converge at the centre of the disk, as described by Dr. Parks; but, as he also correctly says, 'the furrows are arched over by rigid covering pieces, so that the oral aperture is entirely hidden.' But they do not pass downward between the oral plates into a central opening, as in the case of *Taxocrinus* (N. A.

Crinoidea Camerata, Plate III, fig. 2) and other Flexibilia, and the Recent Crinoids; the ambulacra pass over the apposed edges of the orals, meet, and roof over every possible opening with their rigid plates, becoming morphologically fixed and permanent (Plate II, figs. 7*a*, 8*b*, 9, 10*b*); so that the mouth must have been subtegminal, and supplied by food grooves running underneath the rigid plates from some point along the ventral furrow of the rays into which food was gathered by brachioles, pinnules, or tentacles. It is the same kind of a disk as in *Hybocrinus, Carabocrinus, Euspirocrinus, Cyathocrinus,* etc. (N. A. Crin. Camerata, Plate III, figs. 2, 4, 5; and Bather, Treatise on Zoology, Plate III, pp. 125-127) where the ambulacra overlie the apposed edges of the orals, and close over the oral centre by fixed and rigid structures. That this is the case here is well shown by a specimen of *H. problematicus* from Woodford county, Kentucky, in which the orals are in very perfect condition, divested of the ambulacral plates (Plate II, fig. 11). They are produced inward by extensions beyond what is seen when the ambulacra are in place, until they meet by close sutures near the centre; the edges are depressed where the ambulacral plates rested upon them, and there is a passage underneath these joined edges where the food grooves could pass inward to the subtegminal oral centre. The condition of the orals in this specimen is the same as shown in fig. 153, Plate V, of Bather's Crinoidea of Gotland, of the oral plates of *Euspirocrinus.*

The arrangement of the ambulacral plates is somewhat peculiar. There is first at the outside a double series of transversely elongate plates—outer side-pieces—then a second series of smaller plates—inner side-pieces—interlocking with them, whose apposed angular faces approach each other, leaving a narrow space between (Plate II, fig. 7*b*). In perfect specimens this furrow is arched over by two rows of very minute covering pieces, which are partly erect and interlock closely above it, forming a narrow, keel-like ridge at the median line of the ambulacrum (fig. 7*c*). This ridge may be seen at some place on most of the specimens where the ambulacra are preserved, but the small plates of which it is composed are difficult to identify, and cannot be shown in drawings except by great enlargement, as in fig. 7*c*. Similar sets of plates corresponding to the two orders of side pieces are seen in *Hybocrinus conicus* (Plate V, fig. 6*b*); there they all lie perfectly flat, and the row of arched plates has not been observed. But I call attention to a still different set of plates in the latter figure, viz., a double row of large alternating plates at the bottom of the groove formed by the lateral extensions of the orals; v are sub-ambulacral in position, and much more massive and larger than the side pieces superimposed upon them.

The posterior oral is surmounted by a small, raised tubercle, which is perforated, and marks the presence of a hydropore, the same as in *Hybocrinus*. This was evidently not preserved in Dr. Parks' specimens, as nothing is shown of it in the figures. It is very plain, however, in many specimens, both of the large and small forms, and the little pit in the centre of the tubercle is clearly seen (Plate II, figs. 7*a*, 8*b*, 9.)

Dr. Parks' description of the disk and anal structures is otherwise perfectly correct, and adds to previous knowledge of the genus the fact that the valvular pyramid of plates closing the anal opening is surrounded by numerous small plates. These small plates formed an integument which was doubtless somewhat flexible, and perishable. It was attached to the posterior oral, which is concave on that side, and the remnants of these small plates can be seen there in several specimens (Plate II, figs. 9, 10*b*); and it was also attached to the margin of the anal plate, which is distinctly crenulated. In 7*b* they are *in situ* and remarkably plain, but unfortunately the pyramid and anal plate are broken off in this specimen. The space occupied by this structure is always found depressed in these specimens, with the little pyramid in the centre of it. It is really a misnomer to call it a ventral sac; it probably did not project much above the surface, simply yielding to motion with the protrusion or retraction of the anus, which seems to have been in the latter condition when the Crinoids were fossilized.

The crenulation of the anal plate above mentioned is produced by a number of small grooves passing over the margin of the plate towards the interior. Similar grooves pass from the central portion of this plate to the sutures on all sides, where they connect with other like grooves from the adjoining plates, producing at the suture lines deep pits, which probably penetrated to the interior, as they certainly do at the distal margin (Plate II, figs. 8*a*, *b*, 10*a*, *b*). Some of these, and similar ones along the radials, running into the margins of the ambulacra, may be connected with hydrospire pores. This crenulation is similar to that found on the highly elevated and curved distal margin of the anal plate in *Hybocrinus tumidus.* This was described by Wetherby in his account of the discovery of *H. tumidus* in Kentucky, but denied by Wachsmuth and Springer (Rev. Pal. III, 199) upon the strength of specimens found by Mr. W. R. Billings showing the margin of that plate to be bordered by small plates, constituting the edge of the anal protuberance; and it was suggested that the so-called crenulation was merely an appearance due to weathering. It now turns out that the difference in the above views of this structure is actually due to a marked and persistent difference in the species, and not to imperfect preservation. The plate is crenulated and highly specialized in *H. tumidus,* but not in *H. conicus,* thus furnishing a decisive character for distinguishing the species not known before. This will be discussed further on.

Dr. Parks' new species, *H. eldonensis,* is the first one described since Wetherby's type. I have had similar specimens for some years among the new material from Kentucky, laid aside as a possible new species, and welcomed its discovery at Kirkfield as a fresh evidence of the intimate connexion between the Trenton faunas of Canada and Kentucky. From the Kirkfield locality I have a very good series of this form, from which I can supplement Dr. Parks' description with some facts not disclosed by his specimens. He was unable to identify the anal ('upper azygous') plate, saying: 'its presence is more to be inferred than observed.' It is, however, present in upwards of fifty specimens (Plate II, figs. 8*a,* 10*a*), but in many it is not recognizable by reason of injury to the calyx from being cemented by pressure to other specimens. On account of the unequal swelling, or 'humping,' of the anal side in this genus and *Hybocrinus,* the specimens seem to have found their centre of gravity best by lying on that side.

The description says: 'There is no trace of an ambulacral furrow on the arm-bearing radials, nor can such a depression be made out on the external aspect of the arms themselves.' The first part of this I can confirm, but not the last. The ambulacra are perfectly plain on the dorsal side of the arms in many specimens, extending over several brachials (Plate II, figs. 1, 2, 5), and are undoubtedly present in all; but whereas in *H. problematicus* they frequently, in fact usually, pass down more or less upon the arm-bearing radials, I have not seen this in a single case of the small form described as *H. eldonensis.* This fact, with the correlative one that the ambulacra from the two non-arm-bearing rays do not extend, or extend but little, over the basals, but are chiefly confined to the radials, and the generally smaller size and more delicate appearance of the specimens, are the characters, if any, which must be depended upon to separate the species in practice.

Dr. Parks' specimen had a maximum of three joints to the arm, but was not perfect enough to enable him to say 'that the arm was complete in three segments.' On this point my evidence is abundant and interesting. In thirty-four specimens from Kirkfield having one or more arms complete, the number of brachials appear thus:—

With 3 brachials	1
" 4 brachials	10
" 5 brachials	14
" 6 brachials	9

And variations of 3 and 4, 4 and 5, 5 and 6, in the same specimen (Plate III, figs. 1 to 5).

In the Kentucky specimens of similar size and appearance there are:—

With 2 brachials	3
" 3 brachials	5

It results, therefore, that in both forms the number of brachials to the arm is not a fixed one, but there is considerable variability in this character. The variation, however, is within limits which are not common to the two. The average in *H. problematicus* is for the Kentucky form 2·2, and for the Canadian 5·2—the maximum of the former not equalling (except as to one isolated case) the minimum of the latter. The difference in the smaller form, *H. eldonensis,* is not quite so great, the average being 4·9 for the Canadian specimens against 2·6 for the Kentucky; but the relative number of specimens compared is considerably different.

A further question remains as to the relation between the larger and smaller forms themselves in each locality. Taking the specimens of *H. eldonensis* and *H. problematicus* from Kirkfield, where we know they all came from a single crowded colony, we find that the differences between them are precisely those which might arise from individual growth. The small, delicately marked form would tend with age, or with any advantage inducing further growth, to become larger, more rugose, and its food gathering ambulacra to become longer, so that those on the arm-bearing rays, from being confined to the arms (Plate II, figs. 1 to 5) would creep down upon the radials (figs. 6, 7*a*, 10*a*), and those on the other two would tend to pass the limits of the radials (figs. 2, 4), and enter the basals (fig. 6)—even, perhaps, as in one of my specimens injured during life, extending down an eighth of an inch upon the column (fig. 7*a*). There are no other differences between them; and the same thing is true of those from the Kentucky localities, where they are also always found closely associated. In the extension of the ambulacra there is, in fact, a wide range of variation among the specimens of both localities. In those where the two lateral ambulacra pass down upon the basals, the ambulacra on the other rays encroach in very different degrees upon the radials, as was also pointed out in 1882 by Carpenter in his paper already cited. In some they pass down over the calyx almost as far as they do in the lateral rays; in some they only touch the radial for a short distance; in some they fail to reach one, or perhaps two radials at all. Then there are forms intermediate in size, where the lateral ambulacra traverse the basals to a much smaller extent, and in which the other ambulacra either touch the radials but little, or only one or two, or not at all. Finally, among the small forms of the size of the type of *H. eldonensis* (Dr. Parks' figures of both forms are enlarged, although the explanation does not mention it), there are many in which the lateral ambulacra touch the basals but very slightly, or not at all (Plate II, fig. 12).

So it is possible to construct a series of specimens ranging from those in which the lateral ambulacra are limited to the radials and the others do not reach them at all, through the above intermediate stages, to those in which the lateral ambulacra traverse the basals completely, even entering upon the stem, and the others cross the radials and go on to the basals; and having, concurrently with these modifications, a variation from small and delicate to large and rugose. The following table gives the actual data for such a series, taken upon 104 Canadian and 43 Kentucky specimens, divided roughly into three sizes, which I call large, medium, and small:—

Extent of Ambulacra on—		Size of Specimens.	No. of Specimens.	
Non-arm-bearing Rays.	Arm-bearing Rays.		Canada.	Kentucky.
Fully on BB...........	Fully on RR...........	Large	15	18
		Medium....	1	3
Fully on BB...........	Slightly on RR or only on some..............	Large	5	2
		Medium....	0	10
Fully on BB...........	Not on RR...........	Large	1	0
		Medium....	1	0
Slightly on BB.........	Not on RR.	Medium....	0	3
		Small.......	30	0
Not on BB.............	Not on RR...........	Medium....	0	0
		Small.......	51	7

Upon the small specimens the ambulacra are often very delicate, and it is hard to see where they end. In the thirty above noted where the ambulacra pass to the basals, while in some very plain, they mostly pass just a little beyond the basi-radial suture, but still quite enough to show that the ambulacrum is not morphologically limited to the radials; different stages of this are shown on Plate II. One specimen has four arm-bearing rays, and only one calyx ambulacrum. A number have a slightly tubercular surface, but are not otherwise different.

On the other hand, as between the specimens from the two localities respectively, there is the difference in arm development which is constant within the respective limits, and which, so far as we can judge from present knowledge of growth in the living Crinoids, must have originated during the developmental stage, and not during adult growth. The Kentucky form is characteristically short-armed, while the Canadian form is distinctively long-armed—thus suggesting a specific separation upon grounds much more decisive than can be pointed out between many described species in this group of fossils.

These considerations lead to the final question whether the Canadian forms identified as *H. problematicus* should be made a new species on account of the difference in arm structure, or whether they should be held to be simply the older stage of *H. eldonensis,* and the diagnosis of the latter modified accordingly. In view of the fact that Dr. Parks was the first to investigate and describe the Canadian forms, I prefer to place the foregoing facts at his disposal and leave the decision of the question to him, hoping that he will publish his conclusion; but the weight of evidence seems to me to favour the latter view.

Before leaving this subject, a word should be said about the relations between this genus and *Hybocrinus*. In the elements of the calyx and the construction of the tegmen the two genera are substantially identical, as is the case with various genera in other family groups. The asymmetry of the calyx, due to the greater size of the plates on the posterior side, and the excentric position of the column, are common to both; but this, only moderately developed in *Hybocystis,* becomes strongly pronounced in *Hybrocrinus* (at least in *H. tumidus*), producing the peculiar 'hump' posteriorly which suggested the name. The anal plate, relatively small and slightly projecting in *Hybocystis,* is greatly enlarged, and its distal margin highly arched and projecting much above the level of the radials in *Hybocrinus;* but it is without any of the deep furrowing towards the sutures such as I have described in *Hybocystis*—the grooves being confined to the distal margin, where they form a regular crenulation. The 'hump' in the calyx of *Hybocrinus tumidus* is no doubt due to some unusual functional peculiarity of the hind gut; in the silicified specimens from Mercer county, Kentucky, there is always found a large cavity corresponding with the bulging anal and radianal plates. In the brachial structure, however, they are as far removed as any two genera in the same family can be. No sexual difference, as suggested by Wetherby, if one may judge from what we know of sexual conditions in the living Crinoids, could account for the wide departure of *Hybocystis* from the normal arm structure. *Hybocrinus* has such normal structure: regular and equal arms, with ambulacra confined to the ventral side, tapering to points, and increasing by addition of new brachials at the distal end; whereas *Hybocystis* departs from it in such an extraordinary way as to lead to elaborate discussion and wide difference of opinion whether it is a Cystid, a Blastoid, or a Crinoid. Dr. Bather, in the Treatise on Zoology, p. 95, *et seq.,* upon perfectly satisfactory reasons, considers it an ancestral Crinoid, confirming the view of Wachsmuth and Springer that it is 'a Crinoid of low organization.' He finds the decisive crinoidal affinities of the genus in the two brachial ossicles (all that were then known), supported on the summits of the radials, over which the ambulacral grooves pass from between the deltoids (orals) down on to the outer surface of the radials. 'These ossicles,' he says, 'form exothecal, jointed outgrowths of the abactinal thecal plates,' and 'therefore, though incipient, they constitute true *brachia*.' This view is strongly reinforced by the present discoveries showing the extension of these *brachia* to five and six ossicles. As an ancestral type, traces of its dominant character may be found recurring frequently among the Crinoidea, as in the flexible genus *Cholocrinus* (*Forbesiocrinus obesus* of Angelin), where the anterior and two posterior rays are increased enormously by division, at the expense of the lateral rays which are dwarfed and insignificant; and in many Batocrinoid genera like *Megistocrinus, Agaricocrinus*, etc., where increase in the number of arm openings is first effected by additions in these same three rays.

Three species of *Hybocrinus* have been described, two from the Trenton and one from the Chazy. The two Trenton species, *H. tumidus* and *H. conicus*, hitherto separated chiefly on account of size and proportions of the calyx, occur together at Ottawa, but perhaps not in the same strata. It is rather singular that the two genera have not been found together at the Canadian localities. *Hybocystis* has not, to my knowledge, been recorded from Ottawa, where the original *Hybocrinus* were obtained, and in all my collections from Kirkfield, and those of the Geological Survey and Toronto University, covering five seasons' careful work on the well-weathered dumps of the canal cutting, and yielding the *Hybocystis* numerously as before stated, I have not seen a single specimen of *Hybocrinus*. But in Kentucky, in two different localities in Mercer and Woodford counties, the two genera are found indiscriminately mingled in the debris of the same beds. There the *Hybocrinus*, all clearly belonging to *H. tumidus*, have been separated, in collecting, into two forms which I find myself unable to distinguish by any constant characters, except that the basal part of the calyx in the smaller one is more rounded, as is the case in younger specimens generally. So it appears that we have here a case similar to that of *Hybocystis*, where the specimens as found merely represent the extremes of individual growth in one species.

Returning now to the apparently conflicting views upon the structure of the anal plate: Prof. Wetherby and Mr. Billings were both right in their observations, and Wetherby's figures of *H. tumidus* from Mercer county, Kentucky (Jour. Cin. Soc. Nat. Hist. III, July, 1880, Plate V, figs. 2*c, d*) are perfectly correct. This species has since been found in considerable numbers, both at the original locality in Mercer county, and in much better preservation at another in Woodford county. I have upwards of fifty specimens showing the anal plate, and in every one of them it is large, highly arched above the level of the radials, and strongly crenulated by grooves passing over its rounded distal margin in a dorso-ventral direction (Plate V, figs. 1, 2, 3). There is no sutural face whatever for the attachment of succeeding plates, but the rounded margin is of a character suitable for the attachment of perisome. I find upon examination of Billings' type specimens of *H. tumidus* that the same structure is perfectly evident in them also. It is plain in the originals of figures 1*a*, and *c*, of Dec. IV, Plate II, and is in fact well indicated in the figure, 1*a*, though the crenulation is not shown, being concealed by the matrix. I have figured the posterior side of the type, 1*e*, where the structure is entirely clear (Plate V, fig. 5). Both the arched form and the crenulation appear in other specimens from Ottawa, and this must be taken as one of the strongest characters of the species. To it must be added the characters of the tegmen, hitherto unknown, but now observable in specimens from Woodford county, Kentucky. It is substantially the same as that of *Hybocystis,* though the exact details of the ambulacra and oral plates are not well preserved; and it is very different from that of *H. conicus.* The anal pyramid, composed of strong, upright, triangular plates, is in front of the arched anal plate, and in all the specimens is sunk down considerably below its margin, and separated from it. It is not connected with the anal plate by any succession of suturally united plates, but is no doubt surrounded by a flexible integument of small plates, extending from the posterior oral to the edge of the anal plate; although not preserved in the specimens, the space for such a bordering integument as is found in *Hybocystis* is apparent (Plate V, figs. 3, 4).

Now this is an entirely different structure from what is found in *H. conicus,* which is the species upon which Mr. W. R. Billings made his observations mentioned in Revision of the Palæocrinoidea, III, p. 199. A diagram founded on his drawings is published in Lankester's Treatise on Zoology, III, p. 125, fig. 36; but as this does not bring out clearly the contrast in details which I wish to point out, I give figures from a specimen of my own, lateral and summit views (Plate V, figs. 6*a*, *b*). From these it will be seen that the anal plate, instead of being arched, rounded, and crenulated, has its margin in about the same line as the radials, and is directly succeeded by small, but well-defined plates suturally attached to it, passing gradually to a small anal opening at the upper margin. The anus, instead of being through a valvular pyramid of triangular plates surrounded by perisome, is a simple opening through these small plates. These are supported at one side by the anal plate, being flush with its outer surface, instead of lying entirely inside of it, and separated from it by other structures. The anal plate is here more like an ordinary one, forming the support for a regular diminishing series of plates leading to the anus, and by no means such a prominent and peculiarly shaped affair, apparently terminating the calyx wall, as in *H. tumidus* and *Hybocystis.* The two species, therefore, hitherto only separable by differences in the relative proportions of the calyx and arms, are thoroughly distinguished, in addition to the very different form and position of the anus, by the presence or absence of this highly specialized anal plate.

CASTOCRINUS ARTICULOSUS (Billings).

Heterocrinus articulosus.—Dec. IV, p. 51, Plate IV, fig. 8.

CASTOCRINUS INEQUALIS (Billings).

Heterocrinus inequalis.—Dec. IV, p. 51, Plate IV, fig. 7.

Rare; only a single specimen of the last species has been found. These two species, described by Billings from imperfect material under *Heterocrinus,* with the suggestion that they probably belonged to some other genus, are of the most primitive type of the Calceocrinidae. Their generic relations have been fully discussed in the works of Ulrich, Ringueberg, and Bather. *C. articulosus* also occurs in Kentucky.

HETEROCRINUS TENUIS Billings.

Dec. IV, p. 50, Plate IV, fig. 6; Plate X, fig. 1.

Not uncommon at Kirkfield. Specimens with part of the column attached show that while it is pentagonal near the calyx, it enlarges and becomes round as it recedes, until it presents a very different appearance. But it probably does not continue to enlarge to the same extent as that of *Ohiocrinus.*

OHIOCRINUS BELLEVILLENSIS (W. R. Billings).

Heterocrinus bellevillensis. Trans. Ottawa Field Nat. Club, 1883, No. 4, p. 45; and Plate.

This species was excellently described and illustrated by Mr. Walter R. Billings from a good specimen found at Belleville. He recognized the marked heterotomy of the arms, consisting of two main branches to the ray bearing armlets instead of pinnules. The species has been frequently mentioned in morphological discussions by various authors, diagrams of it having been made by Dr. Bather in his work on British Fossil Crinoids as representative of the genus *Heterocrinus.* Wachsmuth and Springer undertook to place it, along with *H. heterodactylus* and several other species, in a generic group under a new name—*Stenocrinus*—a nomenclatorial adventure which was unsuccessful, as will be shown presently. The association of species was not more fortunate than the naming of them, since *H. bellevillensis* is wholly different in its arm structure from *H. heterodactylus,* and belongs to the group for which we established the genus *Ohiocrinus* (Rev. Pal. III, p. 208).

At that time our investigation of the little group of Lower Silurian monocyclic Crinoids described under *Heterocrinus,* all having unequal rays by reason of the presence of compound radials or their equivalents in some of them, indicated the advisability of subdividing it into three genera, which we proposed as follows (Op. cit. pp. 207, *et seq*):—

Heterocrinus, with *H. simplex* as type.
Stenocrinus, with *H. heterodactylus* as type.
Ohiocrinus, with *H. laxus* as type.

This subdivision has been accepted by subsequent authors, but through some misunderstanding of types the name *Heterocrinus* was assigned by us to the wrong set of species. *H. heterodactylus,* being Hall's type of that genus, could not be taken for the type of a new genus; therefore, *Stenocrinus* must go into synonymy. *Heterocrinus* must be retained for the *H. heterodactylus* group, thus leaving the form represented by *H. simplex* and allied species without a name. For this S. A. Miller supplied the name *Ectenocrinus.* Hence the species listed by us in the Revision under *Stenocrinus* should be written *Heterocrinus,* and those under *Heterocrinus* should be written *Ectenocrinus.* From the latter, however, as already stated, must be excepted the species under consideration, *H. bellevillensis.*

The structure of the anal side is substantially the same in the three genera, having a radianal directly under the right posterior radial, bearing the anal *x* on its left shoulder; and they further agree in having unequal rays, because in three of them the radial is transversely divided, producing what are known as compound radials. They may be distinguished as follows:—

I......Column pentagonal, quinquepartite.

a. Arms irregularly dichotomous, divergent. Ventral sac straight and delicate....................*Heterocrinus.*
Species: *H. heterodactylus, H. juvenis, H. exilis, H. tenuis, H. milleri, H. geniculatus, H. pentagonus.*

b. Arms heterotomous, divergent, having 10 main branches, with ramules usually bearing subordinate branches. Ventral sac strong and convoluted..*Ohiocrinus.*
Species: *O. laxus, O. constrictus, O. œhanus, O. vaupeli, O. bellevillensis.*

II......Column round, tripartite.

c. Arms isotomous, abutting; 10 in number, with ramules or pinnules..............................*Ectenocrinus.*
Species: *E. simplex, E. grandis, E. canadensis.*

The species referred to *Ohiocrinus* are all from the Hudson river, or Cincinnatian group, except *O. bellevillensis.* This differs from the others very strongly in the fact that its ramules do not alternate, but are restricted to the inside of the dichotom—a feature which was noted by Mr. Billings, and which he said was 'unknown in any species of the genus previously described.' It might be suggested that this important modification of brachial structure would require further generic separation, as has been done in another group. Until a comprehensive study of the whole of the Palaeozoic Inadunata has been made, which I hope to accomplish hereafter, and the full taxonomic value of these characters is more thoroughly understood, I do not care to propose it. Whether the ramules themselves in turn bear subordinate branches or pinnules cannot be ascertained from the specimens; they are relatively stronger than in *O. laxus,* in which such secondary branching does occur.

The Kirkfield material enables me to add to the knowledge of this species furnished by Mr. Billings the fact that it has a convoluted ventral sac, which confirms its reference to *Ohiocrinus,* of which this is the most striking character shown by the Cincinnati specimens. We now also have the complete characters of the stem, which is beautifully shown in a magnificent specimen found by Mr. Kirk in 1905; the crown is preserved in perfect condition, and the stem continues from the calyx to what was evidently very near the end—a distance of over twelve inches. The remarkable thing about it is, that whereas the stem next to the calyx is, as described by Mr. Billings, sharply pentagonal, and divided into five longitudinal segments, after a few inches it becomes round, and increases in size to nearly double the diameter at the lower end. This is accomplished by secondary growth, clearly shown in cross-sections at the thickest part, in which the original pentagon with its five divisions can be plainly seen in the middle.

Ectenocrinus canadensis, described by Billings, from Ottawa, is not represented in the collections from Kirkfield.

CUPULOCRINUS JEWETTI (Billings).

Plate III, figs. 5*a, b,* 6, 7*a, b, c.*

Dendrocrinus jewetti.—Dec. IV, p. 43, Text-fig. Plate I, figs. 10, 11.

CUPULOCRINUS HUMILIS (Billings).

Plate I, figs. 8, 9; Plate III, figs. 1 *a-e,* 2, 3.

Dendrocrinus humilis.—Dec. IV, p. 39, Plate III, fig. 4.

These two species are by far the most abundant Crinoids at the Kirkfield exposures, and they are found in good preservation. The use of this long ignored generic name of d'Orbigny calls for explanation. The above species were described and figured by Billings at the places stated in the citation, to which must be added a figure of *D. jewetti* given by W. R. Billings in 1883 (Trans. Ottawa Field Nat. Club, No. 4, Plate without number). Comparing Billings' original figures of these and of *D. latibrachiatus* (Dec. IV, Plate III, fig. 5), with that of *D. gregarius* on the same Plate, fig. 1*a*, and of *D. longidactylus* of Hall (Pal. N. Y. II, Plate 42, fig. 7*a*), it is evident that the species referred to *Dendrocrinus* cannot all remain in the same genus. Forms in which the first brachials rest in small, horse-shoe-shaped sockets in the middle of the distal face of the radial, must be separated from those in which the facet bearing the first brachial fills the entire distal face of the radial; for this is a character elsewhere recognized as of family importance.

The first is of the form of (*a*) *D. longidactylus* (type of *Dendrocrinus*), *D. gregarius, D. acutidactylus,* etc., which seem to have a round stem. It also includes (*b*) *D. casei,* etc., from the Hudson River group at Cincinnati, and *D. proboscidiatus,* from the Canadian Trenton, except that they have a pentagonal stem. The second is the form of (*c*) *D. jewetti* and *D. humilis* from the Trenton of Belleville and Ottawa, *D. latibrachiatus* from the Hudson River group of Anticosti, and *D. polydactylus* (described by Shumard as *Homocrinus*) from the Hudson River at Cincinnati.

Forms *a* and *b* have a similar anal side and ventral sac, viz., a broad and very long sac of about uniform hexagonal plates immediately following the anal plate: text-fig. 1. Form *c* has a wholly different anal structure; the anal *x* being followed by a median, tube-like and relatively short row of large plates in vertical series, bordered by small irregular pieces on either side, much resembling that of some Flexibilia: text-fig. 2.

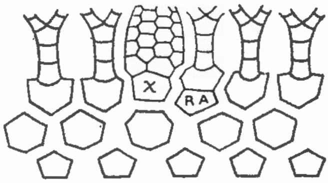

Fig. 1.

Dendrocrinus longidactylus.

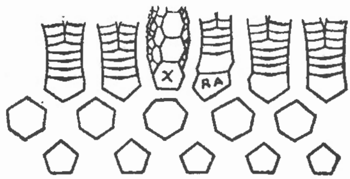

Fig. 2

Cupulocrinus humilis.

Hence the following analysis—all being of course dicyclic, with five infrabasals, a large radianal under the right posterior radial, and having arms dichotomous, without pinnules:—

1......Anal *x* followed by ventral sac of hexagonal plates in longitudinal rows, without distinct median ridge. Radial facets round, not filling distal face of radial.

a. Column round.. .. ..*Dendrocrinus*.
Species: *D. longidactylus, D. gregarius,* etc.

b. Column pentagonal.. .. ..*D. casei,* etc.

II......Anal *x* followed by median row of large plates bordered by irregular plates on either side. Radial facets linear, filling distal face of radial.

c. Column round.. .. ..*D. jewetti*
—humilis.
—conjugans.
–latibrachiatus.
—polydactylus.
and *'scyphocrinus' heterocostalis,* of Hall.

The last named species gives the clue to a generic name for section *c*. Hall described it in 1847 (Pal. N.Y., I, p. 85, Plate 28, figs. 3*a-f*), as the sole species upon which he proposed the genus *Scyphocrinus*. His generic description is as follows:—

'Pelvis (base) composed of five pentagonal plates; costal (radial) plates five, four of them heptagonal and one irregular and octagonal; a second row of costal plates, or perhaps more properly a double row of scapular plates, which are similar, uniform, and quadrangular, except over the irregular costal plate; scapulae (brachials) supporting a cuneiform arm joint, interscapular and interbrachial plates.'

This description, like many others made at a time when knowledge of the Crinoids was in its infancy, is meaningless as genera are now understood, and furnishes no basis whatever for a determination of any definite characters for the genus, or the reference of any specimen to it. It would fit any monocyclic Crinoid having five basal plates with one truncated for an anal, and some interbrachials. For describing the species Hall had two specimens: one a calyx only, fig. *3a*, and another with a considerable portion of the arms preserved, *3d, e*. As figured, they appear to represent very different types, and in the specific description he included characters taken from both of them. These specimens are now in the American Museum of Natural History, New York, and I have had an opportunity, thanks to the courtesy of Dr. E. O. Hovey, Assistant Curator, to examine and make figures of them. The original of fig. *3a* is imperfect, and has some cracks which Hall mistook for sutures, thus giving an erroneous representation of the arrangement of the plates, both in the figure and diagram. The other specimen, *3d, e*, is more complete, but Hall's figures were made from positions which failed to show its most important diagnostic character. The base is imperfect (Hall's figures show the stem attached, but the fragment of the matrix containing this and part of the base has disappeared), but enough remains to show that it was a dicyclic Crinoid, with five infrabasals, and a prominent anal series. The accompanying drawing, text-fig. 3, was made after some additional cleaning, and is sufficient to show that it belongs in all substantial respects to our form *c*, as above defined:—

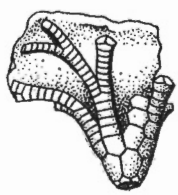

Fig. 3.

'Scyphocrinus' heterocostalis Hall; from the principal type specimen, Pal. N.Y., Vol. I, Pl. 28, fig. *3d*.

Hall's diagram—fig. *3b*—was constructed chiefly from *3a*, but evidently included characters taken from both specimens. It shows a monocyclic Crinoid, with five basals, and three primary brachials following the radials; whereas the original of 3*a* has clearly but two primibrachs, with the number of basals uncertain—being in fact a Camerate Crinoid with radials in contact all around, belonging to the family Melocrinidea; 3*d* has more than two primibrachs (in fact five) and the number of basals is clearly five, with the addition of another circlet below them.

In the circumstances, I think it proper to leave the doubtful specimen, 3*a*, out of consideration, and to take the characters of the genus and species from 3*d*, from which they can be definitely ascertained.

The name *Scyphocrinus* was pre-occupied by Zenker, and instead of it d'Orbigny (Prodr. Pal. I, p. 23) proposed the name *Cupulocrinus*, with C. (*Scyphocrinus*) *heterocostalis*, Hall, as first species and type. He gave the following generic diagnosis: 'Calyx cupuliform, composed of five series of pieces, and having five basal plates'; which represented what he could extract from Hall's definition, and was equally non-luminous. Further on, page 46, no doubt induced by Hall's fig. 3*a*, he ranged *Cyathocrinus tuberculatus* Miller (a flexible Crinoid), from the Wenlock Limestone of Dudley, England, under the same genus. So the case comes to this: that while both Hall's and d'Orbigny's generic definitions are absolutely worthless, and the specific description no better for any diagnostic purpose, there is an authentic type specimen, accessible to the scientific public, which discloses definite characters of generic rank uniting a considerable assemblage of species. These facts, under the rules of nomenclature, are sufficient to establish the genus as valid under d'Orbigny's name, and its definition will be as given above under section *c*, including the species there listed. The only alternative, if the confusion arising out of Hall's two types renders this doubtful, is to propose a new genus for this group, which I am not prepared to do.

The forms of this generic type at Kirkfield fall readily into two principal and well marked species, which, in view of their predominance in the fauna, it may be advisable to define more fully. Both are characteristic examples of the genus as I have defined it; having five infrabasals, very wide primary brachials, completely filling the face of the radials, so that the rays are closely abutting, except at the anal side, where they are separated by the tube-like base of a large ventral sac (or anal tube, whichever it may finally be called), which rises to about the third bifurcation of the arms; excepting, however, as to occasional small, irregular interbrachials hereafter mentioned.

No. 1 has calyx plates convex, and more or less strongly marked with ridges or folds radiating from the centre to adjoining plates, with the sutures much depressed; inter-basal sutures sharply bevelled; brachial sutures strongly gaping and often sinuous, resembling those of some Flexibilia; number of primibrachs differing in different rays according to a definite and fairly constant plan, viz., three in each posterior ray, four in the lateral rays, and three in the anterior ray. There are slight variations from this, as five in the lateral rays, or four in a posterior, but the rule holds good in three-fourths of a large number of specimens. Ventral sac with prominent keel along median plates. Base well rounded; stem small, not enlarging at the calyx, and with alternate long and short columnals, none of them projecting. General form of crown rather short and stout (Plate III, figs. 5*a, b*, 6, 7*a, b;* Plate I, figs. 10, 11).

No. 2 has calyx plates perfectly smooth and flush with each other; no depressed sutures in the calyx, and those between the brachials less strongly gaping; number of primibrachs 4, 5, or 6 to the ray, apparently without regular plan. Ventral sac evenly rounded, without median keel. Stem strong, enlarging next to the calyx to the diameter of the truncate base; composed of uniformly thin columnals for some distance, when they begin to alternate in size and differ in diameter, there being a projecting one at intervals of four or five, or more; it is short, and tapers rapidly to a fine point. General form of crown elongate, with arms becoming long and slender (Plate III, figs. 1a, b, c; 2, 3; Plate I, figs. 8, 9).

No. 1 agrees very well with *C. jewetti,* though in the description and original figure the definite arrangement of primibrachs does not appear; in fact, if correctly shown, the type specimen must have been of the irregular kind, as it shows four in the posterior rays. E. Billings' type cannot be found, but the original of W. R. Billings' figure, now in the museum at Ottawa, conforms exactly to the rule. There is a very similar form from Kentucky in which, while having strongly bevelled sutures, the calyx plates are smooth, without any ridges or raised centres; in this, among a number of specimens, the primibrachs are much less regular, being mostly three in the anterior and right posterior rays, with four or five irregularly in the others;

it still shows, however, the tendency to an excess of brachials in the lateral rays (Plate III, figs. 8, 9).

Compared with Billings' figures, it would seem that our No. 2 might be referred to *D. latibrachiatus* rather than to *D. humilis.* The type specimen of *humilis* cannot be found in the collection at Ottawa (having probably been mislaid at the time of the removal from Montreal), and there are no duplicates. It was evidently a flattened specimen, and thus the figure gives the impression of a broader and lower calyx than was probably the fact. *D. latibrachiatus* was said by the author to be closely related, the only difference being in the greater breadth and length of the arms. Examination of the type specimen, however, and some others from the same locality, shows that it is thoroughly differentiated from the Kirkfield form by the base and stem characters. While, as Billings said, the stem is not preserved, the facet for its attachment shows that it was very small, with a strongly rounded base curving in towards it—nothing at all like the broad, truncate base passing into a large, tapering stem, of the Kirkfield species. Measurements are quite decisive on this point; the width of the stem-facet in several specimens of *latibrachiatus* is to the width of the calyx at the top of the infrabasals as 1 to 3, while in the Kirkfield species it is about 1 to 1·3. So *latibrachiatus* may be eliminated; but I will say about it in passing that while the arms are more closely abutting than in any of the other species, some specimens show a slight development of the same kind of small interbrachial plates hereinbefore described. *D. conjugans* is distinguished by its narrower and much more rounded arms, and is distinctly represented by a few specimens of that character found. Of Hall's *C. heterocostalis* from New York we do not know the base well enough for comparison. Considering the great general similarity of the faunas of Kirkfield and Ottawa, and that *humilis* is associated at the latter with *jewetti,* which is thus distinctly recognized from both localities, I think it best to apply the name *humilis* to our species No. 2, with the characters above set forth.

C. latibrachiatus was described from the Hudson River beds of Anticosti. *C. polydactylus,* another well-known Hudson River species from the Cincinnati region, is of the type of *C. jewetti,* with strongly convex plates and deep sutures. So we have the two forms persisting from the lower Trenton into the Hudson River; thus making the genus, with its wide geographical range, one that must be recognized as a very strong type of an early Palæozoic Crinoid.

Referring now again to the suggestion of the Flexibilia in connexion with Hall's fig. 3*a*, it is to be remarked that there is a striking resemblance superficially in specimens of this type to some forms of that group. The closely abutting arms, and the widely gaping and often strongly sinuous sutures between the brachials, all recall the characters of many Flexibilia (Plate III, figs. 7*a, b, c*). The anal side, with its tube-like row of median plates, is remarkably similar to that of *Protaxocrinus, Gnorimocrinus,* etc.; but this tube-like series is produced into a strong ventral sac rising to half the height of the arms, which is not found among known Flexibilia (figs. 2, 5*a*, 6; Plate I, fig. 9). In addition to this, and of much significance, is the fact that in many of these specimens of both species there are to be seen between the ray divisions a large number of small plates. They are irregular, and seem mostly to be parts of perisome pushed out between the rays, often in a small rounded fold (Plate III, fig. 1*c*, 5*b*); in rare cases, however we find a small, well-defined plate fitting exactly into the axil, just as a regular interbrachial plate (Plate III, fig. 3).

The ventral sac in these species is much longer than we find in any form of the Flexibilia, and this would ordinarily be taken to indicate the possession of a rigid tegmen inconsistent with the structure of that group. A long and strong ventral sac has heretofore been considered to negative the presence of a pliant disk, being supposed to require a solid tegmen for its support. In many Inadunata the sac is itself the chief part of the tegmen, the anus not being located at its extremity, but at various places below it—sometimes at its very base, on the anterior side. In most Recent Crinoids the posterior protuberance represents the anus alone; it is simply a portion of the perisome raised above the level of the disk by the protrusion of the hind gut, forming a tube with the anal opening at the end of it. The anal tube of *Onychocrinus,* etc., is similarly formed, except that it has a vertical series of strong plates supporting it on the posterior side, thus making possible a considerably greater length of tube. I have traced the sac in both the present species to the extremity, and I see nothing which might not be a mere exaggeration of the anal tube of *Onychocrinus, Taxocrinus,* etc. The strong vertical series of median plates runs all the way up, but the sides of the sac do not seem to be much different from those of the protruding perisome in those genera. I have not identified the anal opening in these species, but have little doubt that it is at the distal end. For further comparison I have figured a specimen of a small undescribed species found associated with '*Dendrocrinus*' *polydactylus* in the Hudson River group, near Cincinnati, with the tube-like series curving over upon the tegmen, almost exactly like we find it in *Onychocrinus* (Plate III, figs. 4*a, b*).

If now the small, perisome-like interbrachials became constant, we should have nothing lacking to proclaim a Flexible Crinoid, similar to those we know, except to transform the five infrabasals into three—apparently one of the easiest of changes in the Crinoids. Fusion of two pairs of the primitive five plates, as has actually occurred within the limits of a family between *Cyathocrinus* and *Gissocrinus*, and the thing is done. Even the incorporation of interbrachials is not essential, as there are several genera of the Flexibilia without any. The enlarging stem of *Cupulocrinus humilis* next to the calyx is also a very common character among the Flexibilia, but rarely found in other groups.

The number and distribution of primibrachs, however, is different from those in the Flexibilia generally. There the rule in the pre-Devonian genera is not exceeding two primibrachs, with one or two exceptions in the Silurian having three. More than three are unknown in any normal Flexibilia until found in the Carboniferous *Oligocrinus* and *Onychocrinus*—about the last important modification that occurred before the non-pinnulate division of the order became extinct. Furthermore, except in occasional abnormal specimens, whatever the number may be, it is constant for all five rays—an apparent but not actual exception being in forms like *Ichthyocrinus*, where the radianal so much resembles a radial that it looks as if there were an extra brachial in the right posterior ray. The presence of three and more primibrachs in the species before us, and their unequal, and in *C. humilis* irregular, distribution among the rays, and of five infrabasals—a character so far unknown among the Flexibilia—are facts which would incline us to range them rather under the Inadunata, as causing less confusion in the definition of the larger groups. But there is very clearly an intermingling of the characters of the two orders, and it is evident that we have here to deal with a transition form whose exact status is difficult to decide from what we can see in the fossil.

The order Flexibilia is considered to be an offshoot from the dicyclic Inadunata, through modifications resulting in an open mouth and the loose incorporation of brachials in the calyx. We have not hitherto been able to point out the origin or probable course of these modifications, but it was reasonably to be expected that the connexion would be found through the non-pinnulate Dendrocrinidae, the exact nature of whose tegmen has never been discovered. It is now of much interest to note that the earliest known genus of the Flexibilia occurs in this same lower Trenton Limestone, and that species of it—*Protaxocrinus elegans* and *P. lævis*—are found in the same horizon and localities as *Cupulocrinus,* and directly associated with two of its species in which the above-mentioned tendencies towards the Flexibilia are observed. We do not know the length of the anal tube or ventral sac in *Protaxocrinus,* but we know it was very strong, and constructed in a very similar way, so far as can be seen (Plate III, figs. 10, 11*b*). It is to be remembered, also, that these two genera are in the same stage of development as to the radianal, a character which is conceded to be of high importance in the phylogeny of the Crinoids. In both of them the radianal is in what we call the primitive position, being located within the ray in the form and position of a radial, directly under the right posterior radial—infer-radial—giving to that ray one more plate below the brachials than the other four.

Having, therefore, two contemporaneous genera in the earlier Ordovician, existing in the same locality, and being in the same morphological condition as regards one of their strongest characters; the one flourishing in profusion and the other extremely rare; we have the very conditions under which we might expect to find evidence of developmental changes marking the divergence of two higher groups, which are of an admittedly common origin. This divergence is of such a degree in these two forms that we need not look so very far back for a probable common ancestor, and may yet hope to find it in the Ordovician. With the three unequal infrabasals of *Protaxocrinus* separated into the primitive five, and the number of primibrachs increased from two to three or more, it would tax the ingenuity of any palaeontologist to show wherein it differed generically from one of these *Cupulocrini* having an interbrachial in the axil. So it may be that d'Orbigny made a shrewder guess than he knew of when he placed Hall's '*Scyphocrinus*' *heterocostalis* and '*Cyathocrinus*' *tuberculatus*—one of the most widely known Flexibilia—in the same genus.

CUPULOCRINUS CONJUGANS (Billings).

Dendrocrinus conjugans, Dec. IV, p. 41, Plate IV, figs. 1, 2.

This species, of which there are some specimens in the collections, exhibits a considerable variation from the last two, but has the transition characters still indicated. It wholly lacks the closely abutting rays, and deeply excavated brachial sutures; the arms are rounded, long, and very much more slender, and the first brachial does not quite fill the face of the radial, thus leaving rather wide interbrachial spaces. These are occupied by an integument of perisomic plates which is broader and higher than in the other species, and without any well-defined lower plate; it is very similar to the structure found between the rays in *Pycnosaccus,* and *Nipterocrinus.* The median series of the anal tube is relatively rather stronger than the arms, and it was probably longer than in the other species. The stem is enlarged next to the calyx, as in *C. humilis,* but the projecting joints farther down are closer together, and the stem is much longer and tapers less rapidly. It is another evidence of the tendency to variation in this genus that the stem is different in these three species, that of *C. humilis* and *C. conjugans* being more like the most frequent stem in the Flexibilia, while that of *C. jewetti* rather more resembles the stem of such exceptional Flexible genera as *Gnorimocrinus,* etc. Comparison of the type specimens shows that *D. cylindricus* is clearly identical with this species, and must be held a synonym.

DENDROCRINUS PROBOSCIDIATUS Billings.

Dec. IV, p. 38, Plate III, figs. 3*a-c*.

Fairly well represented, especially in the Toronto University collection. The species was described from the upper part of the Trenton at Montreal, and afterwards figured and redescribed by W. R. Billings, from a specimen found at Division Street, Ottawa.

Dendrocrinus gregarius, which is from the middle Trenton at Ottawa, was not found at all at Kirkfield.

OTTAWACRINUS TYPUS W. R. Billings.

Plate IV, figs. 5, 6, 7.

Tr. Field Nat. Club, Ottawa, 1887, Vol. I, p. 49, Plate.

The new material enables us to supplement the description of this genus and species by important additional information not disclosed by the original specimens, and to confirm by further facts the recognition of this by Mr. Billings as a perfectly distinct generic type. The most striking thing about it now appears to be that it is the first genus of the Dendrocrinidea to show a tendency to pinnulation, its character in this respect being quite remarkable. In the original specimen the rays were preserved only to near the first bifurcation, leaving the nature of the arms and ventral sac beyond that level unknown. The principal distinction relied on in separating the genus from *Dendrocrinus* was the construction of the ventral sac, which is formed of hexagonal plates not in longitudinal rows, as is the case in that genus, and slight differences in the form of the anal and radianal plates. The specimens now in hand give the complete arm structure.

There is a bifurcation on the fourth or fifth brachial into two long and slender main branches; these bear ramules on each side alternately from every fourth joint, occasionally third, or fifth. The ramules are notably smaller than the arm—about half its diameter—and they subdivide on the fifth or sixth joint into two very slender branches, which may one or both branch again on the seventh or eighth joint, giving final divisions of extreme tenuity. It is about the stage of incipient pinnulation shown in *Botryocrinus ramosus* (See Bather, Treatise on Zoology, fig. XXI, 1). This is the mode of branching in *O. typus;* it is varied somewhat in another species, as will be shown presently. The ventral sac is long, extending to the full height of the arms, and is composed throughout of irregularly hexagonal pieces, without any longitudinal arrangement. In *O. typus* it is delicate, and the plates smooth. I have figured three specimens illustrating these characters (Plate IV, figs. 5, 6, 7).

This genus is further well distinguished from *Dendrocrinus* by the fact that the radial facets here fill the entire distal face of the radials, instead of being mere rounded sockets in the middle of them, as in that genus. Except for this last character there would be nothing in the generic diagnosis to distinguish *Gothocrinus,* established by Dr. Bather in 1893 (Crinoidea of Gotland, p. 114), from *Ottawacrinus.* The author characterized it as 'a *Dendrocrinus* cup with *Botryocrinus* arms,' which would still hold good in view of my proposal (*supra*) to restrict *Dendrocrinus* to forms having small, round radial facets. There is, however, a great difference in the details of the arm branching. If, as stated in the text, p. 115, the armlets of *Gothocrinus* are given off from each side, then according to the figure (Plate V, fig. 158) they must be borne on every successive brachial, like true pinnules, since on each side of the arms, where visible, there appears to be an armlet on every second brachial.

Another fact is developed in this genus which is of considerable interest in connexion with the previous discussion of the modifications of the genus *Cupulocrinus* in the direction of the Flexibilia. For here we have another Ordovician Inadunate genus showing a decided development of interbrachial structures, having the effect of incorporating, to a slight extent, the lower brachials into the calyx. In both the typical species and the new one described below, are found distinct plates in the axils between the rays. This is not entirely constant in *O. typus,* but is observable in the majority of the specimens. In the new species, it is quite pronounced in all the specimens. With strict regard for the definitions of the respective orders, such a form would have to be excluded from the Inadunata, whose leading character is the non-incorporation of brachials. But the same objections exist to referring it to the Flexibilia that were found in *Cupulocrinus,* besides the possession of an extremely large ventral sac, of the true fistulate type. So the only rational course is to recognize its intermediate position, and see in this modification of a second genus among the Dendrocrinidæ a further indication that in this Ordovician Inadunate family we are not far from the origin of the order Flexibilia, as an offshoot from the more primitive order. The Dendrocrinidæ seem to be a sort of synthetic family, embracing a number of variable characters to which no very close limits can be assigned, but which in later geological time became fixed in different groups. The form and construction of the anal series and ventral sac are not very constant; there is considerable shading between genera in the form of the radial facet; round and pentagonal stems tend to fall into the same genus; the characters of Flexibilia and Inadunata are found within the family; there is a tendency towards pinnulation in *Ottawacrinus*; and a peculiar arm structure in *Dendrocrinus acutidactylus* suggests the strangely folded side pieces of the Silurian *Cyathocrini.*

The new facts thus brought to light suggest some addition to the generic diagnosis of Mr. Billings' genus, which may be stated thus:—

Dicyclic, with five infrabasals.
Radianal large, almost under right posterior radial.
Radial facets filling distal face of radial.
Anal *x* followed by small plates of sac not in longitudinal rows; sac long.
Arms heterotomous; 10 main branches bearing branched ramules.
Column round.. .. ..*Ottawacrinus.*

OTTAWACRINUS BILLINGSI n. sp.

PLATE IV, figs. 1, 2*a*, *b*, 3.

Specimens of the genus are very rare, and in addition to the few of *O. typus* the collection has yielded another fine species. The principal specimen is fully twice as large as the largest specimen of *O. typus,* has arms at least three inches long, and a huge ventral sac of equal length, composed of sharply elevated, stellate plates, with deep pits between them, giving a very rough surface as contrasted with the smooth and delicate sac in *O. typus.* The most remarkable difference, however, is in the arms, which are relatively stronger; and in the ramules, which, instead of branching by one or two more or less equal bifurcations, give off secondary and sometimes branched ramules to the number of seven or eight or more, from every fourth joint, not alternately, but from the same side. I do not recall any variation in arm structure elsewhere quite comparable to this. Definitely formed interbrachials are well developed. The stem, as in *O. typus,* is round and quinquepartite, composed of very thin ossicles, slightly alternating near the calyx. As it is known in that species to be very long, enlarging distally to a strong root, it is probable that certain large stem fragments, some as much as 13 mm. in diameter, belong to this species. The central canal is very large, and the walls thin; at some places along the division lines between the segments into which the stem is divided are to be seen pores in longitudinal rows at the suture lines between the columnar ossicles (Plate IV, figs. 4*a*, *b*, *c*). They somewhat resemble the interarticular pores in the column of the recent *Isocrinus.*

I esteem it a privilege to associate with this remarkable and thoroughly distinct species the name of Mr. Walter R. Billings, the author of the genus.

CARABOCRINUS RADIATUS Billings.

Dec. IV, p. 21, Plate II, figs. 3*a*-*e*.

CARABOCRINUS VANCORTLANDTI Billings.

Dec. IV, p. 32, Plate II, fig. 4.

Both these species were found at the Trent Canal cutting, *radiatus* represented by a few individuals limited to one place, probably the remnants of a small colony, while *vancortlandti* is fairly plentiful, and apparently distributed throughout the Crinoid-bearing formation. This material shows the distinction between the two species as pointed out by Billings to be remarkably constant. He described *C. radiatus* as having a globose calyx, with the arms dividing on the second free plate, *i.e.*, on IBr_2, as against *C. vancortlandti* with an ovoid calyx, and arms dividing on or beyond the third free plate—IBr_3. This holds absolutely good in all the specimens from Kirkfield. *C. radiatus* is also uniformly much the smaller, and has a stronger calyx, that of *vancortlandti* being composed of thinner plates and usually found crushed. *C. radiatus* also occurs in the basal Trenton of Kentucky, showing there, too, its characteristic arm division. Dr. Parks has a new species of *Carabocrinus* among the University of Toronto material, which he will soon describe.

PALÆOCRINUS ANGULATUS Billings.

Dec. IV, p. 45, Plate III, figs. 6*a, b*.

Rare.

POROCRINUS CONICUS Billings.

Dec. IV, p. 34, Plate II, figs. 5*a-d*.

This species is well represented, associated with *Hybocystis* and *Edrioaster*. *P. smithi,* described by Dr. Grant from Belleville, was not found, but occurs in the Trenton of Kentucky associated with the same genera.

INSERTÆ SEDIS.

CLEIOCRINUS REGIUS Billings.

Plate V, figs. 7, 8, 9.

Dec. IV, p. 53, Plate V, figs. 1*a-g*.

Specimens of this very perplexing and anomalous Crinoid were found, mostly fragments. One of these, however, preserving the lower part of the calyx, is of special importance, because it gives us for the first time, in connexion with some others to be mentioned, a perfect view of the base from the exterior. It will be remembered that I was able, by a difficult preparation of one of Billings' type specimens, to discover the true construction of the base in this genus, which had before been a complete puzzle to palæontologists. This was explained in my Memoir on *Cleiocrinus* (Mem. Mus. Comp. Zool. Harvard, XXV, No. 2, p. 93, *et seq,* 1905), showing the base to be composed of five large infrabasals, resting upon the column, with a circlet of ten plates, consisting of five basals and five alternating radials, surrounding them; that is, the basals and radials have been pushed down over the infrabasal ring and top of the stem, so that they are not in direct succession, either with the infrabasals or with each other, but overhang the stem; and the radials, instead of resting upon the shoulders of the basals, as in other Crinoids, are interposed between them at the same level—a structure absolutely unprecedented in Crinoid morphology. These facts were ascertained by exposing the interior of the base in the specimen mentioned, it being impossible to discover them in other known specimens, because in all of them the base was concealed by the few column joints which were always held in place by the surrounding ring, and impossible to detach.

In the Kirkfield specimen the column is completely detached by weathering, so that the same parts are perfectly seen from the exterior, or opposite side (Plate V, fig. 7). The arrangement is precisely as shown in my fig. 5*b*, Plate I, of the work cited; the five large infrabasals, with the alternating basals and radials enclosing but not resting upon them, are plainly visible. The evidence of these facts is still further confirmed by two other very instructive specimens from the equivalent Trenton of Kentucky, in which the calyx, divested of all the upper stem joints, is to the top of the first primibrachs completely freed from the matrix, both dorsally and ventrally. They were embedded in a coarse sand which did not adhere, but left all surfaces well exposed after cleaning with a soft brush (Plate V, figs. 10*a*, *b*, *c*). All the plates above mentioned are in perfect condition, in the same singular departure from the normal order as already described. Thus there can no longer be any doubt that this structure is the usual one in this Crinoid, and not in any respect accidental or sporadic.

I wish to emphasize the fact that this remarkable structure is not a mere invagination, as some authors have supposed, producing a concavity like that in the base of the contemporary *Archæocrinus*. In such cases the calyx is folded inward upon itself from below, and the normal succession of the plates forming its wall is retained; whereas here there is a complete displacement of the plates from their normal and natural order, so that the basals, instead of abutting upon the infrabasals at their distal faces, lie outside of them dorsally; and the radials, instead of resting upon and being supported by the basals, are interposed between them in the same range—a sort of telescoping, as it were, of the infrabasals circlet and upper stem joint into the ring of basals, separating the latter so that the radials came down between them to fill up the space. I am as much in the dark as ever for an explanation of the probable origin of this extraordinary structure.

The study of these weathered fragments has thrown new light upon the construction of the calyx wall in this genus. As shown by the specimens formerly studied, the mode of union of the plates seemed to be by a sort of crenulation, such as is found at the margin of the sutures of the Flexibilis generally, and was so described by me. It is in fact something entirely different. In *C. regius,* when the exterior surface is perfectly exposed, the sutures are crossed by a number of parallel slits arranged in diamond-shaped rhombs (Plate V, figs. 8, 9*a*). These slits lead from either side to pores on the suture lines, which do not pass directly through the test, but turn to the right and left of the middle and converge from the half of each sutural face into a large, funnel-shaped pore, opening to the interior at each corner of the plate (fig. 9*b*). The course of these converging passages is better shown by the figures of the sutural face in the two other species (figs. 10*e*, 11*b*, *c*). Except where the surface is much eroded, the large, inward opening pores are not visible from the exterior. The whole structure is thoroughly illustrated by a series of drawings on Plate V, from specimens of three species, the details of which are explained with the plate.

It is evident that we have here the equivalent of the pore-rhombs of the Cystids, similar to those of *Echinosphaera, Glyptocystis,* etc.; and they occur on every plate throughout the entire calyx to the arm bases. The test of *Cleiocrinus* is very thin, and must have been extremely pliant; as shown by the figures, the actual sutural surface is less than the apparent cross-section of the plates, and besides the plates are deeply curved and channelled on the ventral side (Plate V, fig. 9*b*), forming a system of longitudinal fluting which extends from the base throughout the entire brachial series to the arm bases. I have a large specimen of *C. magnificus* in which this is shown throughout by the exfoliation of the plates.

Cleiocrinus, therefore, is a dicyclic Pelmatozoan, with a definite quinqueradiate symmetry; five infrabasals, and non-successive basals and radials; pinnulate arms; a thin, pliant test; and the pore-rhombs and calycine pores of the Cystids. It is too symmetrically organized to remain with the Cystids, and will not fit into any of the recognized orders of the Crinoids. It was evidently a case of premature secession from the Cystids, without arranging for congenial association anywhere else; and until better proofs of its relations are furnished it will have to remain in a sort of palæontological no-man's-land.

The specimen represented by fig. 10*a-e*, on Plate V, is elaborately sculptured, and has a strong, angular median elevation of the plates. I have another broken calyx in similar condition, and a nearly complete crown, minus the arms, showing the superficial characters still better, but too large to figure here. They represent a well-defined species, for which I propose the name *Cleiocrinus sculptus*. It is probable that the sculpturing is made sharper than originally by replacement of pores and cavities by infiltration of siliceous matter, and the dissolving of the outer stereom; but this did not occur at the interior, where the large pores are still represented by openings in the proper position. Another species is represented by a good calyx, of which I only figure the details of a few plates; these are enough to show its marked difference from all others in its absolutely smooth surface, and I feel warranted on this character alone to rank it as a new species, *C. lævis*. It has an obscure median ridge in the lower part.

The geographic range of *Cleiocrinus* is greater than was formerly known. It is reported from Tennessee in the publication of Troost's Manuscript (U.S. National Museum, Bulletin 64, p. 100); two new species of it are here recognized from the lower Trenton of Kentucky; and a fine specimen, much resembling *C. magnificus*, was found by Dr. Bassler in the basal Trenton of Pennsylvania. We have also an important increase in its known stratigraphic range. Dr. G. H. Hudson has found it in the Chazy of Valcour island, and his specimens show also penetration of the test by pores at the suture lines. He informs me that he has a paper in press illustrating this.

EDRIOASTEROIDEA.

Edrioaster bigsbyi Billings.

Dec. III, p. 82, Plate VIII, figs. 1, 2.

Numerous in one spot, associated with *Porocrinus* and *Hybocystis*, The specimens here are in very fine preservation, showing the ambulacra both covered and open.

Agelacrinus dicksoni Billings.

Dec. III, p. 84, Plate VIII, figs. 3, 4.

Not uncommon.

CYCLOCYSTOIDES HALLI Billings.

Dec. III, p. 86, Plate X *bis*, figs. 1-7.

Several specimens of this very rare and obscure fossil were found, but they do not shed any new light upon its structure or relations.

LICHENOCRINUS.

A small, encrusting disk, composed of many small plates, occurs rather frequently, attached to other objects, evidently the terminal root of a column, such as have been described from the Cincinnati rocks under this name.

CYSTIDEA.

GLYPTOCYSTIS MULTIPORUS Billings.

Dec. III, p. 54, Plate III, figs. 1*a*-*n*.

G. LOGANI.

Ibid., p. 57, Plate IV, figs. 1*a*-*j*.

PLEUROCYSTIS SQUAMOSUS Billings.

Dec. III, p. 49, Plate I, figs. 1*a*-*e*.

P. ROBUSTUS.

Ibid., p. 49, Plate I, fig. 2*a*.

AMYGDALOCYSTIS FLOREALIS Billings.

Dec. III, p. 63, Plate VI, figs. 1*a*-*e*.

A. RADIATUS.

Ibid., p. 65, Plate VI, figs. 3*a*, *b*.

All of these species are fairly represented, but the specimens are mostly much crushed.

ASTEROIDEA.

STENASTER SALTERI Billings.

Dec. III, p. 78, Plate X, figs. 1*a*, *b*.

This species is quite abundant and in excellent preservation.

?TÆNIURA CYLINDRICUS (Billings).

Tæniaster cylindricus.—Dec. III, p. 81, Plate X, figs. 4*a*, *b*.

PETRASTER RIGIDUS Billings.

Ibid. p. 80, Plate IX, fig. 3*a*.

Rare, and of doubtful identity.

PROTASTER WHITEAVESIANUS Parks.

Trans. Canadian Institute, 1907-8, Vol. VIII, p. 363.

The last species was described by Dr. Parks from good specimens collected at Kirkfield for the University of Toronto.

ASTROPORITES OTTAWAENSIS Lambe.

Canadian Record Science, 1897, p. 287 and Plate.

Some specimens of this curious fossil were found, which are not sufficient, however, to determine with certainty its systematic position. It was described by Mr. L. M. Lambe with doubt as a Polyzoan. It appears to be a flat, discoid body having lines of large oval pores, with grooves between them radiating from the centre, and ramifying by several uniform and symmetrical bifurcations to very small ultimate divisions at the perimeter of the disc. These produce a reticulated appearance, somewhat resembling that of the ventral side of the arms of *Crotalocrinus*. We now know that it was a sessile organism of some kind, the opposite side being a perfectly flat, amorphous surface, and the disk as preserved being very thin. The grooves converge to a rounded area in the centre, which projects upward to a thickness considerably greater than the other parts. From some fragments found at the same horizon in Kentucky it would seem that there was a calcareous covering above this, of similar structure, whereby the grooves were roofed over, so that they were in fact tubular passages, so numerous, and so close together, that this covering was held by very weak connexions, and was readily detached in the fossil. There is thus some ground for believing that these discoid bodies may represent the lower part, or floor, of an unusually highly organized terminal root of a Crinoid, consolidated by growth into a calcareous plate for attachment to flat surfaces. It is found sometimes embedded in shale, sometimes adhering to hard limestone, and usually perfectly flat on the bottom. Expanded and consolidated roots are quite common among the Crinoids of this formation (see Decade IV, Plate V, figs. 1*g* and 2*a*), a number of smaller ones of different shapes being known, and also found with the present collections; but none has been known before with such complicated and extremely regular passages as this. The fact that none of the students of the Cœlenterates have been able to find a plate for this fossil in that group, would seem to lend additional force to the above suggestion.

INDEX.

PLATE I.

EXPLANATION OF THE PLATES.

All specimens figured are from the lower part of the Trenton Limestone; and, except where otherwise specified, are from Kirkfield, Ontario, and in the author's collection. All figures, unless differently indicated, are of natural size.

PLATE I.

Reteocrinus alveolatus M. and G. . . . . page 10.

FIG.

1*a*. A mature, slightly flattened specimen with complete crown, and a few pentagonal stem ossicles; r. post. radial view, showing keel-like anal series to about the level of fourth bifurcation, and the irregular, sharply sculptured iBr plates.

1*b*. Cross-section of stem at an interpolated columnal.

2*a*. Another specimen with nearly natural contour, from r. post. interradius; showing the deep pits at sides of basal and radial plates, the strong elevation and lateral buttresses of the brachial series, and depressed iBr areas filled with small plates.

2*b*. Cross-section of stem at a projecting columnal.

3. Large crown with long stem attached, anterior view; showing the prominent and rounded radial angles of the stem.

4. Infrabasal plates of very large specimen with part of stem attached, the sides becoming broadly concave.
(Following the terminology of Pentacrinine stems proposed by Dr. Bather in his recent beautiful Memoir on Triassic Echinoderms of Bakony, p. 24, the stem in this and the foregoing specimens would be more accurately called 'subconcavistellate'; but the work was received too late to enable me to adopt his terms in the text).

5. A rather young specimen, with stem pentagonal in proximal part and becoming rounded below.

Reteocrinus stellaris Billings. . . . . page 10.

FIG.

6. One of the types, original of Dec. IV, Pl. IX, fig. 4*b*, post. view, after removal of the matrix by further cleaning. It shows the stem to be perfectly round; the crook appearing in the original figure was due to unequal exposure in the matrix, and it was also much exaggerated in the drawing. Ottawa; Coll. Geological Survey, Canada.

7. Cross-section of stem of another type, Dec. IV, Pl. IX, fig. 4*d*; to show that the form of the axial canal is substantially the same in both species, the exterior form of the stem being due to secondary growth.

Cupulocrinus humilis (Billings). . . . . page 28.

FIG.

8. Complete specimen with stem tapering to a fine point; r. ant. view. Note the bell-like shape of the projecting columnals.

9. Posterior view of a specimen showing full length of the anal tube, and the fine distal branches of the arms.

Cupulocrinus jewetti (Billings). . . . . page 28.

FIG.

10. A mature specimen, showing the general proportions of the calyx and arms; from anterior radius. Coll. Geological Survey, Canada.

11. Distal face of a IBr., the articular markings indistinct.

12. A small specimen to show the characters of the stem; the proximal columnals alternating from the beginning, and not markedly enlarging.

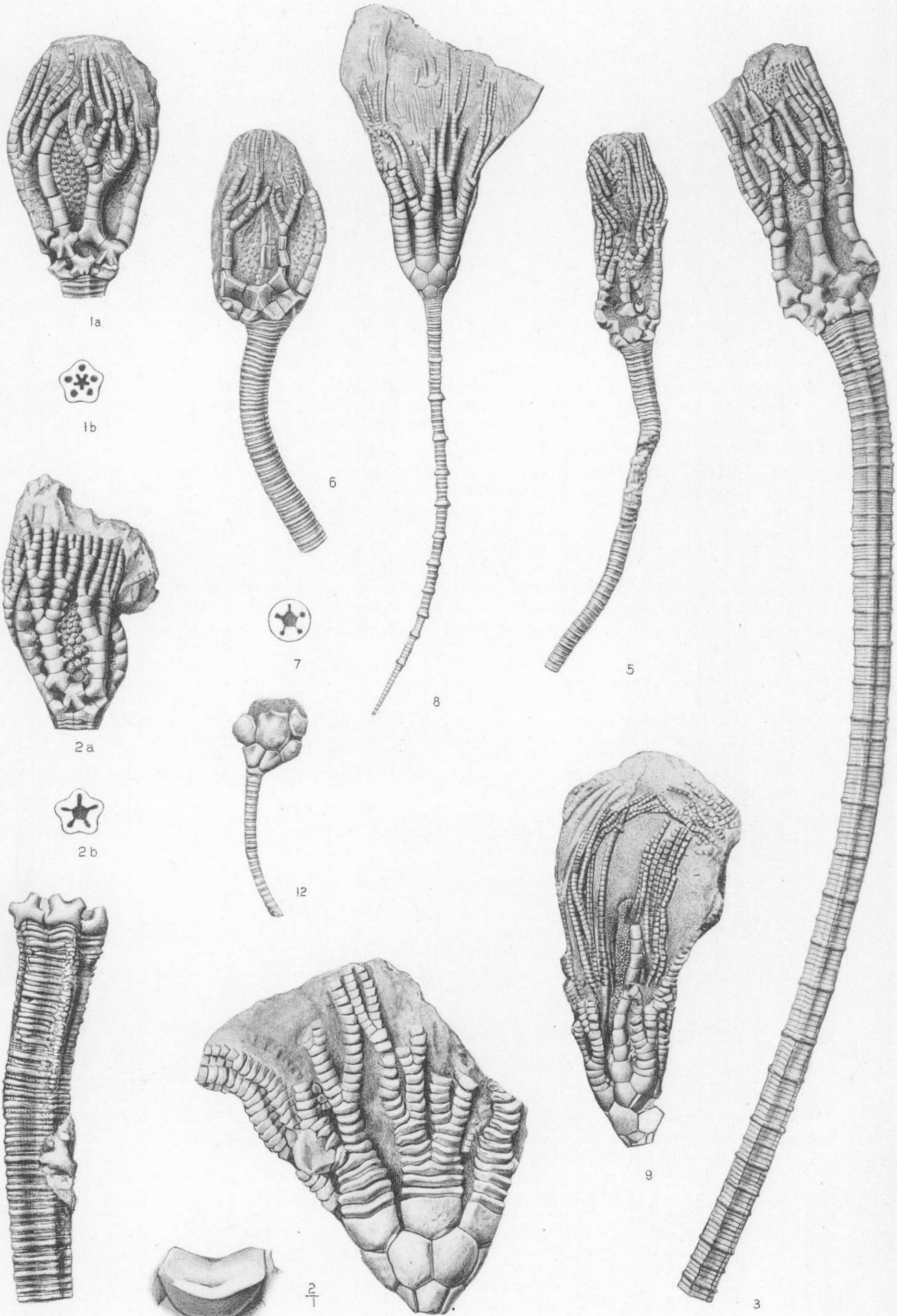

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PLATE II.

PLATE II.

Hybocystis eldonensis Parks.. .. ..page 13.

Fig.

1. A small specimen with 4 brachials to the arm, and ambulacra recurring on the dorsal side; from r. post. ray; lateral ambulacrum not passing the radial. x 2.
2. Small specimen with stem attached, left lateral view; 4 brachials to the arm; lateral ambulacra just passing the basi-radial suture. x 2.
3. Medium specimen with 5 brachials, anterior view; dorsal ambulacra passing only short distance from top of arm. x 2.
4. Medium specimen with 5 brachials, from left anterior ray; lateral ambulacrum passing down to basals. x 2.
5. Small flattened specimen with 6 brachials, anterior view. Dorsal ambulacra are seen on the arm to the left; the other brachials in sight are displaced, the upper four having the ventral side exposed; the lateral ambulacra in this specimen do not pass the radial. x 2.
6. Large specimen with 6 brachials, right anterior view; recurrent dorsal ambulacrum passing full length of arm and down to radial, and lateral ambulacrum fully across basals. x 2.

7*a*. Large malformed specimen, from anterior radius; the arm broken off during life and replaced by calyx-ambulacrum extending down upon the stem; right lateral ambulacrum imperfectly developed. x 2.

7*b*. Central part of tegmen of same, showing side and covering ambulacral plates, and integument of small plates between water pore and anal pyramid, which is broken off. x 3.

7*c*. Detail of ambulacrum in same, showing the two sets of side pieces, and small arched covering pieces forming a median ridge. x 12.

8*a*. Posterior view of small specimen, showing crenulated anal plate. x 2.

8*b*. Tegmen of same, showing ambulacral plates in place—the covering pieces too small to show in this drawing—the water pore, anal pyramid, and the shape of posterior oral when not covered by small plates. x 2.

9. Tegmen of another small specimen with all structures well preserved; the integument of small plates surrounding the anal pyramid is well shown. x 2.

10*a*. Posterior view of large specimen, showing the crenulated anal plate, and grooves radiating to other plates. x 2.

10*b*. Tegmen of same; posterior oral partly covered by integument of small plates surrounding the anal pyramid. x 2.

11. Tegmen of a specimen of *H. problematicus* from Woodford county, Kentucky, with ambulacra removed, and oral plates fully exposed; showing how they meet by lateral extensions around a central space—both covered by rigid ambulacra when in place. x 2.
12. Young specimen of *H. problematicus* from Mercer county, Kentucky, with lateral ambulacra not passing to basals. x 2.

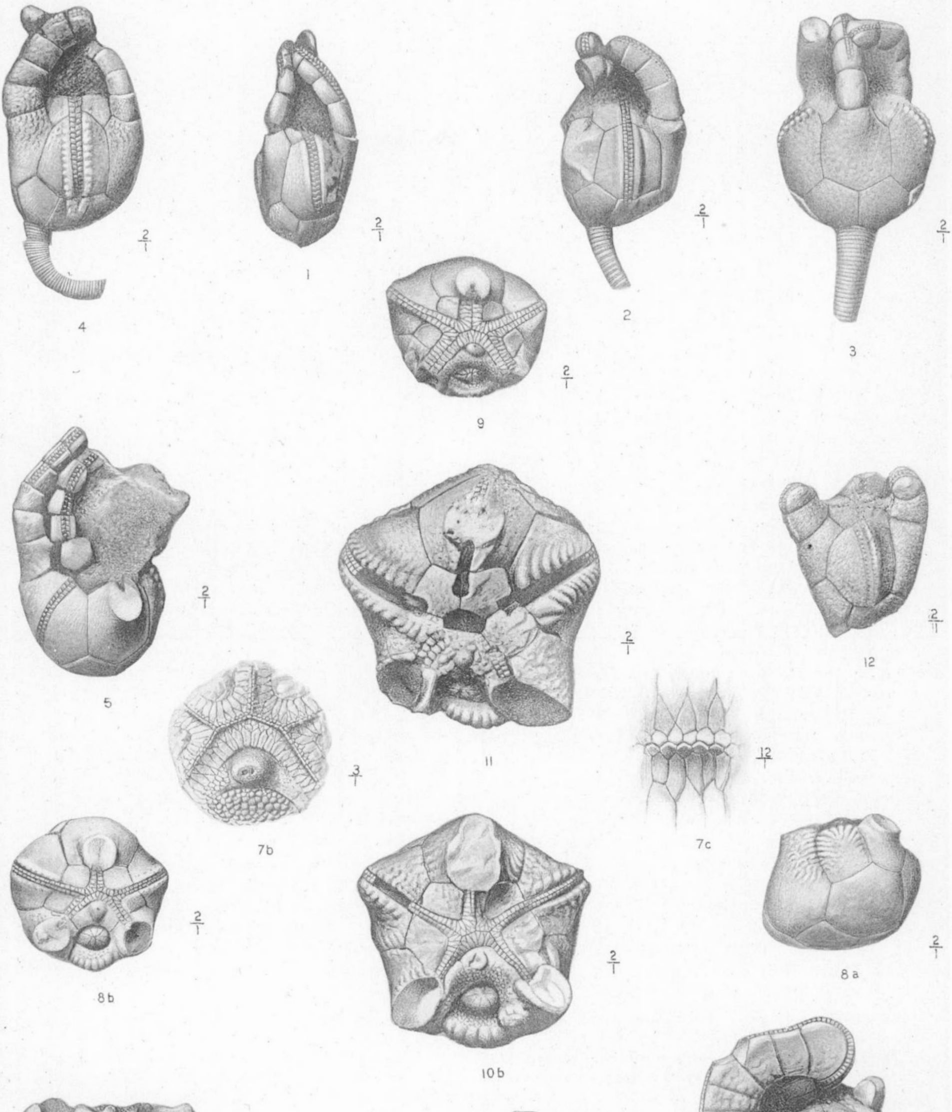

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PLATE III.

PLATE III.

Cupulocrinus humilis (Billings).. .. ..page 28.

FIG.

1*a*. A nearly complete crown, anterior view; showing (1) small irregular plates in three interradii, and (2) 4 IBr in anterior ray, and 5 in the two lateral rays.

1*b*. Posterior view of same; showing (1) the gaping sutures in the rays; (2) the base of the anal tube with its border of small plates on either side; (3) integument of irregular plates in left posterior interradius; (4) 4 IBr in the posterior rays.

1*c*. Detail of left posterior interradius at *c*, showing the character and number of small plates in the axil; they are more regular here than usual, being largely hexagonal. x 3.

1*d*, *e*. Detail of brachial sutures, showing the articulation seen from the dorsal side, and profile of the same; this is not a mere bevelling of the edge of the plates, but the distal faces are deeply sloped, indicating great mobility in the rays, as in many Flexibilia. x 3.

2. A broken specimen, showing (1) the anal tube to nearly its full length; the distal end is lost, but the imprint of it in the matrix is seen, showing what must have been the extremity, and how the tube tapers to a small size instead of expanding into a sac; (2) the median series of plates evenly curved, without keel.

3. Broken specimen with calyx and arms to the first bifurcation, anterior view; showing (1) the small interbrachial plates with lower one well defined and fitting closely into the axil; (2) the proximal part of the stem, composed of thin, non-alternating columnals, enlarging towards the calyx. x 2.

4*a*. Small specimen of an allied form associated with '*Dendrocrinus*' *polydactylus*, in the Hudson River Group near Cincinnati, Ohio; figured for comparison of anal structures; posterior view, showing the tube curving over upon the tegman. x 2.

4*b*. The ventral side, showing the tube merging into the tegmenal structures, which are indistinctly preserved. x 2.

Cupulocrinus jewetti (Billings).. .. ..page 28.

FIG.

5*a*. Nearly complete crown, posterior view; showing (1) anal tube with keeled median series of plates and bordering structures; (2) small plates in left posterior interradius. x 2.

5*b*. Detail of left posterior interradius at *b*. Here the left anterior ray is pulled out of position, so that we see the lateral face which is usually concealed by contact with the adjoining ray; it exposes a very peculiar surface marking—as of very small plates or the imprint of them—above the interbrachial plates, extending outward between transverse keels on the brachials, and obliterating the sutures. x 4.

6. Posterior view of an injured specimen with arms partly removed, showing anal tube complete; it bends to the right at the distal end, and the exact construction there cannot be ascertained, but there is some indication of an opening.

7*a*. A very mature, flattened specimen with calyx and lower part of rays—anterior view—to show the deeply indented and waving sutures; plates almost smooth, without connecting ridges or furrows; small plates in iBr areas.

7*b*. Posterior view of same, showing base of anal tube.

7*c*. Detail of IIBr at *c* in the right posterior ray, showing the strong sinuosity of the sutures. x 3.

Cupulocrinus jewetti, var. *kentuckiensis*.. .. ..page 32.

FIG.

8. Specimen with smooth plates, posterior view, with part of arms removed; showing anal tube about complete. Woodford county, Kentucky.

9. Similar specimen from same locality with arms nearly complete, from left anterior interradius; showing (1) a large, well developed interbrachial plate in only one interradius—a sporadic occurrence, not found in other specimens; (2) proximal part of stem with alternating columnars, very different from that of Figure 3.

Protaxocrinus lævis (Billings).. .. ..page 11.

FIG.

10. A complete crown, posterior view; showing the anal tube, and radianal in primitive position under right posterior radial; for comparison with structures in preceding figures. x 2.

11*a*. Smaller specimen from Ottawa, anterior view; showing interbrachial plates. Coll. Geological Survey, Canada. x 2.

11*b*. Posterior view of same, showing anal tube. x 2.

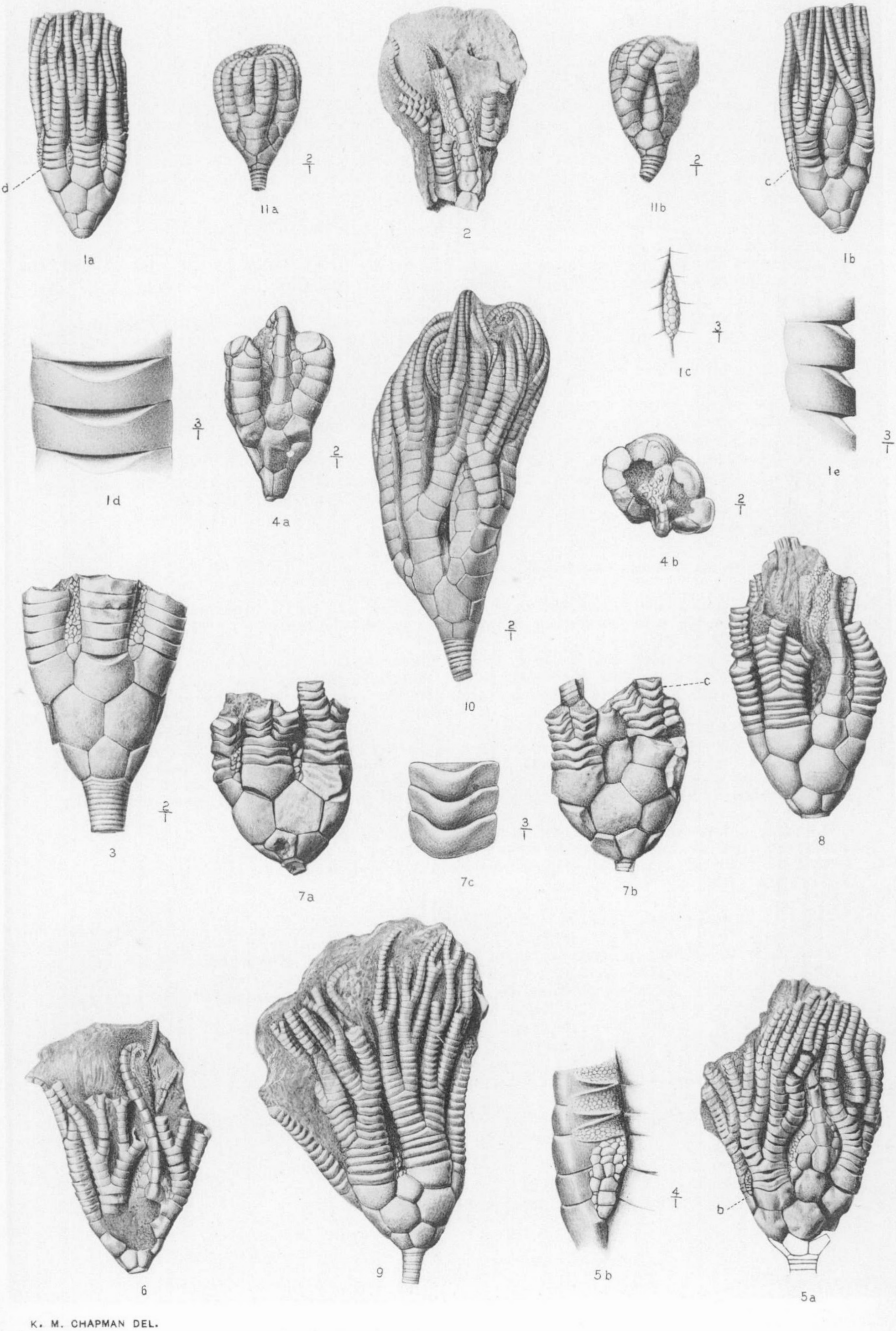

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PLATE IV.

PLATE IV.

Ottawacrinus billingsi n. sp.. .. ..page 40.

FIG.

1*a*. A mature specimen seen from the anterior side, natural size; showing (1) the rugose ventral sac preserved to about its full length, with sharply raised stellate sculpturing on the plates; (2) the arms, in two main divisions to the ray, with ramules from alternate sides of the dichotom bearing secondary ramules from one side only. The imprints of the unilateral secondary ramules, as well as the ramules themselves, are seen at several places.

1*b*. Cross-section of stem of same, showing its division into 5 longitudinal segments.

2*a*. Enlarged view of another specimen, from left posterior radius; showing the anal side, and the sac, with details of its highly sculptured plates, and of the arms. Note the strong interbrachial plates at the left posterior interradius. x 2.

2*b*. Opposite view of calyx of same specimen, natural size; to show the iBr plates.

3. Another specimen from the anal interradius, showing the mode of succession of anal plates following posterior basal into the sac.

4*a*. Cross-section of large stem found associated with the foregoing, probably of this species, natural size.

4*b*. Side view of small portion of same, showing the extreme thinness of the columnals, and the lines of the longitudinal segments, with interarticular pores.

4*c*. The pores at a place where two segments have slightly slipped upon one another, out of the same level. x 4.

Ottawacrinus typus W. R. Billings.. .. ..page 37.

FIG.

5. Specimen showing the heterotomous branching of the arms, from antero lateral interradius; the line of longitudinal division of the stem is also seen.

6. A complete crown, with ventral sac of smooth plates rising to the full height of the arms; posterior view. x 2.

7. Another specimen from posterior side, showing arm-branching and part of ventral sac.

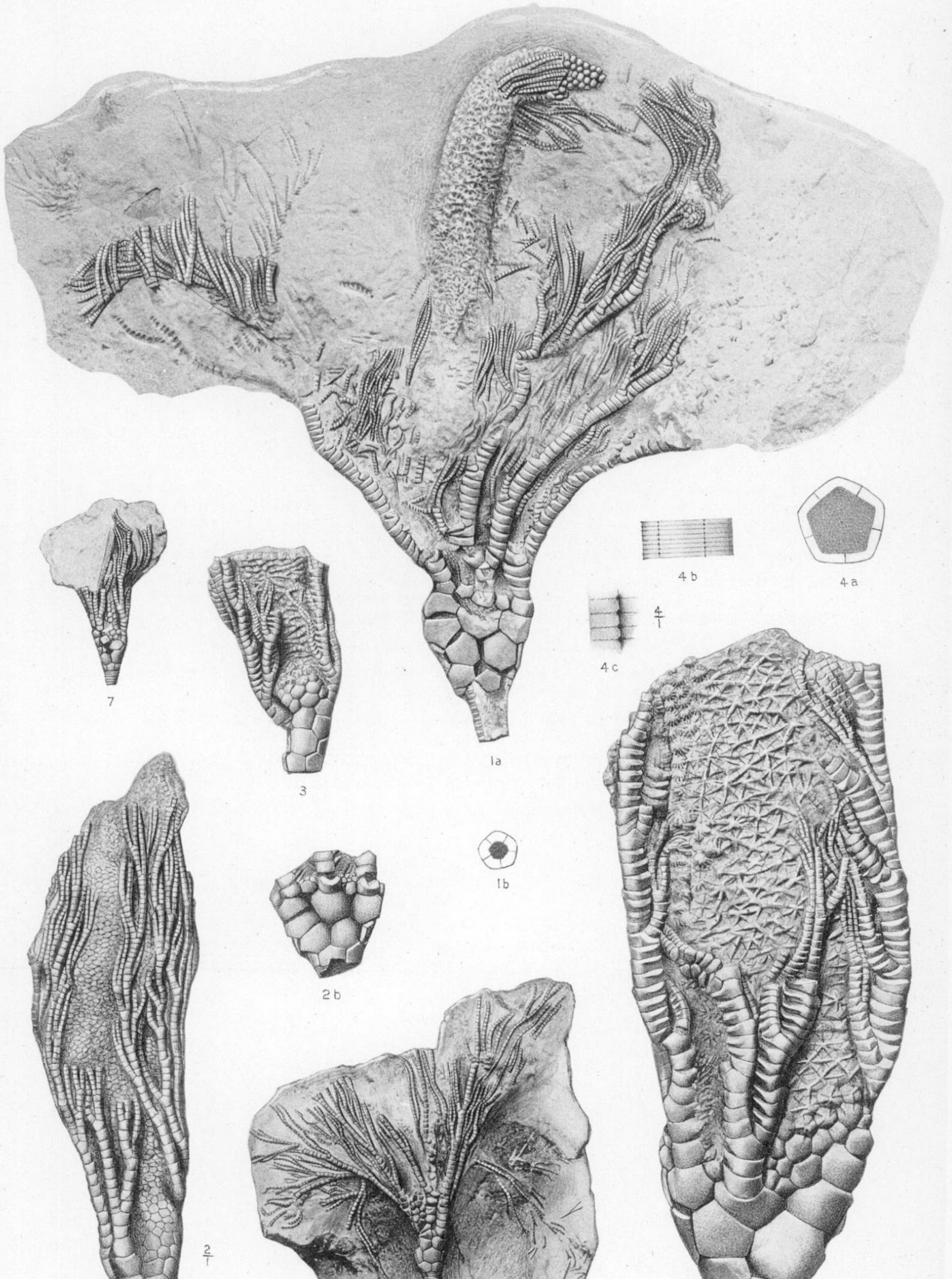

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PLATE V.

PLATE V.

FIG. *Hybocrinus tumidus* Billings.. .. ..page 24.

1. Specimen from Woodford county, Kentucky, posterior view; showing the highly arched and crenulated anal plate, and lower part of arms with transverse grooves leading to ventral side.
2. Ventral side of another specimen, showing the extreme arching of the anal plate, and traces of ambulacra; same locality.
3. Another specimen from same locality with anal pyramid well preserved; drawn with posterior side up, for better view of the structures; water pore indistinctly shown.
4. Small specimen from Mercer county, Kentucky, with tegmen preserved; anal pyramid distinct, but ambulacral plates wanting.
5. One of the types, original of Dec. IV, Pl. II, fig. 1*c*, posterior side, after additional cleaning; showing crenulated anal plate. Ottawa. Geological Survey, Canada.

FIG. *Hybocrinus conicus* Billings.. .. ..page 24.

6*a*. Posterior view of large specimen from Ottawa, showing anal plate with smooth distal margin, followed directly by plates leading to anal opening.

6*b*. Tegmen of same, showing extreme marginal position of anal opening, directly through a cluster of small plates without any defined pyramid; also the ambulacral structures. Note the large sub-ambulacral plates.

FIG. *Cleiocrinus regius* Billings.. .. ..page 44.

7. Small specimen from Kirkfield, basal view; showing external form of the 5 large infrabasals lying within the ring of alternating basal and radial plates. To be compared with figures on Plate I of the paper on *Cleiocrinus*, Mem. Mus. Comp. Zool., XXV, No. 2.
8. Fragment of another specimen from IAx upward, showing rhombic areas with slits traversing the sutures. x 3/2.

9*a*. Exterior of an axillary plate, probably IIIBr, from another weathered fragment in which the usual median ridge is worn off; showing the rhombic areas with slits leading to a line of pores on each suture. x 3.

9*b*. Inner surface of same plate and the two next below it, showing the large pores opening to the interior at the corners of the plates, and the broad ventral grooves. x 2.

Cleiocrinus sculptus n. sp.. .. ..page 44.

FIG. Mercer county, Kentucky.

10*a*. Lower part of calyx to $IIBr_2$, with stem detached, and free from matrix inside and out, posterior view; it has elaborate sculpturing, with rhombic areas of bars and grooves crossing the suture lines, and plates strongly elevated in the middle; the lower visible range of plates are the alternating basals and radials, the posterior basal being much higher than the others. x 2.

10*b*. Basal view of same, showing the 5 large infrabasals 'telescoped' into the ring of basals and radials, and the shallow channels at the inner edges of the plates. x 2.

10*c*. Interior of same, showing large pores opening inward at the corners of the plates, and the lip-like projections from the channels on infrabasals leading towards the interior: also the strong curvature of the inner surface of the plates generally. x 2.

10*d*. Detail of r. post. IIBr and adjoining anal plate, showing the rods, ridges, and grooves radiating from the median, keel-like elevation, and the rhombs crossing the suture lines. The sculpturing may be accentuated from replacement of cavities by infiltration of siliceous matter, and dissolving of the outer stereom, the usual granular surface being destroyed; the pores on the suture lines are obscure at the exterior. x 4.

10*e*. Distal face of the same plates, showing course of the tunnels running from the pores on the suture lines right and left, converging to form the large openings to the interior; also the inner curvature of the plates, and relative thinness of the actual sutural face; the anal plate has a peculiar central pit not seen on the others. x 4.

10*f*. Vertical section at middle of brachials, showing their median elevation. x 3.

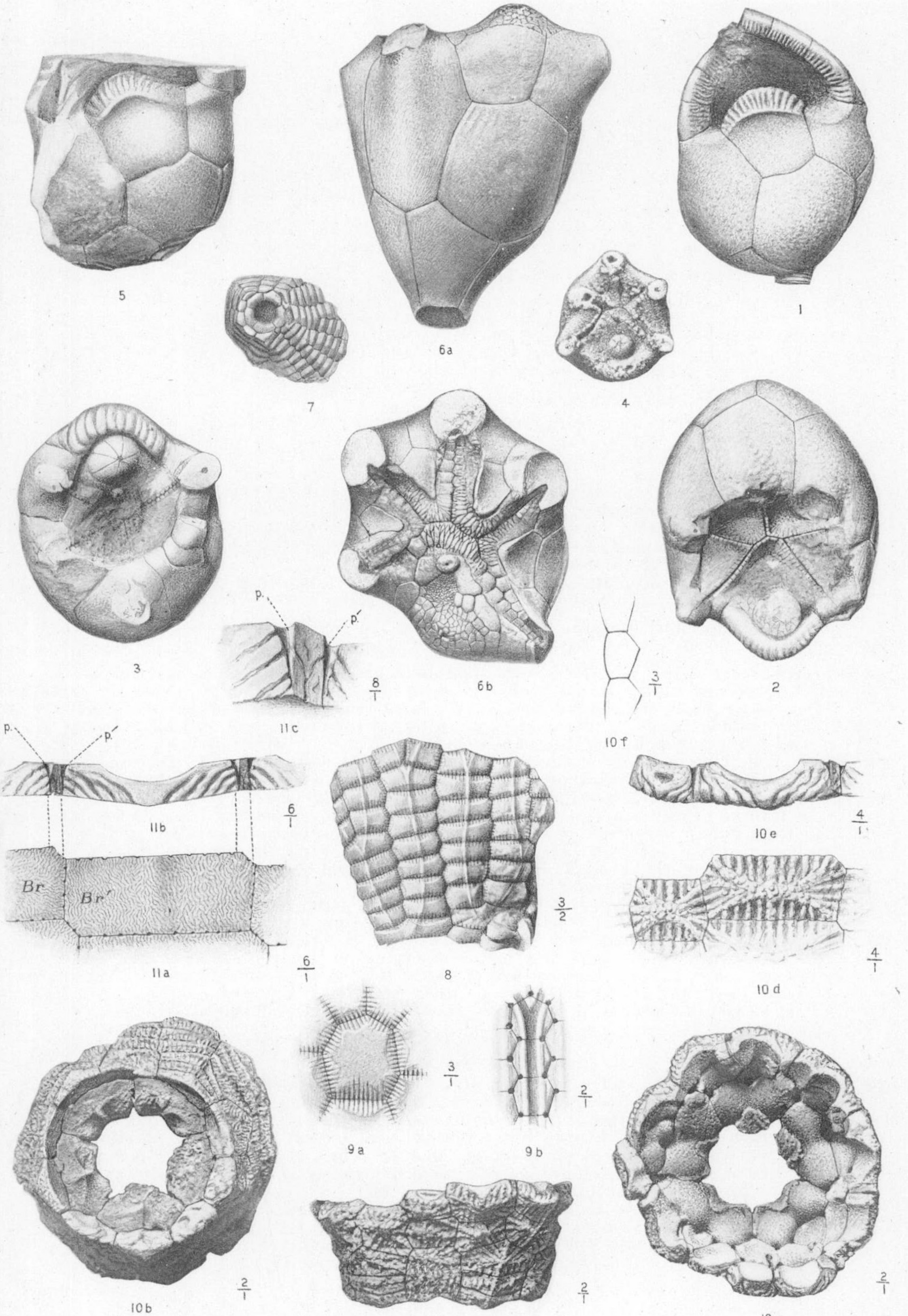
Cleiocrinus lævis n. sp... .. ..page 44.

FIG. Shelbyville, Tennessee.

11*a*. Dorsal side of a IIBr and connecting plates of the type specimen, which has the calyx preserved to about the second bifurcation; the original surface is in perfect condition, showing the meshes and folds of stereom; the plates are without sculpturing, flush with each other, having but a faint, broad median ridge, and no slits or pore-rhombs visible; but with pores along the suture line of each face. x 6.

11*b*. Distal face of same plates, showing the course of tunnels at either side discharging into large, funnel-shaped openings to the interior at the corners of the plates; the structure of these is shown in greater detail in the next figure. x 6.

11*c*. The two funnel-shaped pores, p and p^1, of the last figure; p is entirely within plate 'Br' and the apposed one above it, while p^1 is confined to plate 'Br^1' and its successor. x 8.



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*300	" "	1888.	718	" "	1899.
301	" "	1889.	744	" "	1900.
334	" "	1890.	800	" "	1901.
335	" "	1891.	835	" "	1902.
360	" "	1892.	893	" "	1903.
572	" "	1893-4.	928	" "	1904.
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*415	"	1887.	*555	"	1894.	719a	"	1901.
*416	"	1888.	*577	"	1895.	813	"	1902.
*417	"	1889.	*612	"	1896.	861	"	1903.
*418	"	1890.	623	"	1886-96.	896	"	1904.
*419	"	1891.	640	"	1897.	924	"	1905.
*420	"	1886-91.	671	"	1898.	981	"	1906.
*421	"	1892.	686	"	1899.			

Mineral Resources Bulletins:—

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851. Coal.	869. Mica.	882. Copper.
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857. Infusorial Earth.	*877. Graphite.	953. Barytes.
858. Manganese.	880. Peat.	984. Mineral Pigments. (French).
859. Salt.		

Reports of the Section of Chemistry and Mineralogy:—

No. *102.	Year	1874-5.	No. 169.	Year	1882-3-4.	No. 580.	Year	1894.
*110	"	1875-6.	222	"	1885.	616	"	1895.
*119	"	1876-7.	246	"	1886.	651	"	1896.
126	"	1877-8.	273	"	1887-8.	695	"	1898.
138	"	1878-9.	299	"	1888-9.	724	"	1899.
148	"	1879-80.	333	"	1890-1.	821	"	1900.
156	"	1880-1-2.	359	"	1892-3.	*958	"	1906.

* Publications marked thus are out of print.

REPORTS.

GENERAL.

745. Altitudes of Canada, by J. White. 1899.
*972. Descriptive Catalogue of Minerals and Rocks, by R. A. A. Johnston and G. A. Young.
1073. Catalogue of Publications: Reports and Maps (1843-1909).
1085. Descriptive Sketch of the Geology and Economic Minerals of Canada, by G. A. Young, and Introductory by R. W. Brock. Maps No. 1084; No. 1042 (second edition), scale 100 m. = 1 in.
1086. French translation of Descriptive Sketch of the Geology and Economic Minerals of Canada, by G. A. Young, and Introductory by R. W. Brock. Maps No. 1084; No. 1042 (second edition), scale 100 m. = 1 in.
1107. Part II. Geological position and character of the oil-shale deposits of Canada, by R. W. Ells.

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943. Upper Stewart river, by J. Keele. Map No. 938, scale 8 m. = 1 in. } Bound together.
951. Peel and Wind rivers, by Chas. Camsell. Map No. 942, scale 8 m. = 1 in. } Bound together.
979. Klondike gravels, by R. G. McConnell. Map No. 1011, scale 40 ch. = 1 in.
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1050. Whitehorse Copper Belt, by R. G. McConnell. Maps Nos. 1,026, 1,041, 1,044-1,049.
1097. Reconnaissance across the Mackenzie mountains on the Pelly, Ross, and Gravel rivers, Yukon, and North West Territories, by Joseph Keele. Map No. 1099, scale 8 m. = 1 in.

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*235. Vancouver island, by G. M. Dawson. 1886. Map No. 247, scale 8 m. = 1 in.
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*271. Mineral wealth, by G. M. Dawson.
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*573. Kamloops district, by G. M. Dawson. 1894. Maps Nos. 556 and 557, scale 4 m. = 1 in.
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1035. Coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling.

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*949. Cascade coal-fields, by D. B. Dowling. Maps (8 sheets) Nos. 929-936, scale 1 m. = 1 in.

968. Moose Mountain district, by D. D. Cairnes. Maps No. 963, scale 2 m. = 1 in.; No. 966, scale 1 m. = 1 in.

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868. Souris River coal-field, by D. B. Dowling. 1902.

1035. Coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling. Map No. 1,010, scale 35 m. = 1 in.

MANITOBA.

264. Duck and Riding mountains, by J. B. Tyrrell. 1887-8. Map No. 282, scale 8 m. = 1 in.

296. Glacial Lake Agassiz, by W. Upham. 1889. Maps Nos. 314, 315, 316.

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MAPS.

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