CANADA

DEPARTMENT OF MINES AND RESOURCES

MINES AND GEOLOGY BRANCH

GEOLOGICAL SURVEY BULLETIN
No. 4

# ECHINODERMATA OF THE OTTAWA FORMATION OF THE OTTAWA-ST. LAWRENCE LOWLAND

BY

Alice E. Wilson

OTTAWA
EDMOND CLOUTIER
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1946

*Price, 25 cents*

CANADA

DEPARTMENT OF MINES AND RESOURCES

MINES AND GEOLOGY BRANCH

GEOLOGICAL SURVEY BULLETIN
No. 4

# ECHINODERMATA OF THE OTTAWA FORMATION OF THE OTTAWA-ST. LAWRENCE LOWLAND

BY

Alice E. Wilson

OTTAWA
EDMOND CLOUTIER
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1946

*Price, 25 cents*

# CONTENTS



## Illustrations



51687—1½

## PREFACE

This report is the first of a series of planned reference texts on the palæontology of the Palæozoic strata of the Ottawa-St. Lawrence Lowland. The series commences with studies of the fauna of the Ottawa formation, a thick, highly fossiliferous, limestone formation of Middle Ordovician age that occupies a prominent place in the Palæozoic section. This initial contribution deals with the Echinodermata of the Ottawa formation, and it is intended that succeeding bulletins will deal, first, with other significant faunal classes of this formation, and, later, with the fauna of other formations. Together they will represent the outcome of investigations commenced more than a century ago, and more recently carried on by the present author. The studies are based upon fossil collections made throughout the years by former officers of the Geological Survey and by the present author, and upon several loaned private collections.

Information on the geology and economic resources of the region is contained in Memoir 241 by the author on the "Geology of the Ottawa-St. Lawrence Lowland" (Geol. Surv., Canada, Mem. 241, 1946). That report includes a full bibliography on the geology and palæontology of this early Palæozoic basin.

GEORGE HANSON,
*Chief Geologist, Geological Survey*

OTTAWA, October 26, 1945

# ECHINODERMATA OF THE OTTAWA FORMATION OF THE OTTAWA-ST. LAWRENCE LOWLAND

## INTRODUCTION

### GENERAL STATEMENT

The Ottawa-St. Lawrence Lowland is the early Palæozoic basin drained by Ottawa and St. Lawrence Rivers. It is bounded on the north and south by the Canadian Shield and Adirondack Mountains respectively, on the west by the Frontenac axis, which connects the Shield with the western Adirondacks, and on the east by the Beauharnois anticline, a lesser axis partly concealed by the earliest Palæozoic sediments and extending from St. Jerome, Quebec, to the eastern Adirondacks.

Within this basin the Precambrian floor is overlain by about 2,300 feet of Lower, Middle, and Upper Ordovician sediments. The Ottawa formation occurs at the top of the Middle Ordovician and is of Black River-Trenton age. It overlies deposits of Chazy age and underlies the shales of Collingwood-Gloucester age. The formation has a thickness of 690 feet. It is composed mainly of thick beds of limestone, though some shale and sandstone is interbedded at the base. The lower beds, consisting of about 75 feet of limestone and dolomitic limestone interbedded at the base with some sandstone and shale were originally considered to be of Chazy age, and were mapped as such. The remaining 615 feet of limestone was designated the Black River-Trenton group by early geologists. Both are included in the Ottawa formation because there was no interruption in the deposition of the sediments and no significant change in lithology, and because fossils found in the lower beds show that they, too, are of Black River age. The more recent New York term "Mohawkian" cannot be applied here because it does not include the lower beds.

The 690 feet of Black River-Trenton sediments have been broken up into seven divisions, variously called "members" or "formations". These several divisions are here considered to be beds of faunal associations. They are not sharply differentiated either in lithology or, except in a very few cases, in the occurrence of fossils. A change in fauna would occur inevitably during the length of time required to deposit 690 feet of sediments, and such a change does occur, but it is gradual. Certain groupings of fossils can be recognized, but passing upward, first one and then another species or genus of each group gives place to other species or genera so that the grouping changes gradually with an overlapping of species and without a definite line of demarcation. These groupings or associations of fossils are not faunal zones because most of the species range irregularly through two or more groupings. For these reasons, then, the grouping of fossils within certain beds are faunal associations rather than faunal zones, or rather than "members" or "formations" as previously defined. The original names of the so-called "members" or "formations", however, are retained here in conjunction with the more elastic term "beds" to designate the general level at which each fossil species occurs and to show its range.

The Ottawa formation carries the most prolific fauna of the Ordovician formations of the region. All the formation within the basin lies north of the International Boundary, and its best exposures are found in the vicinity of the city of Ottawa and below the city in the valley of Ottawa River, from which area its name is taken.

## OCCURRENCE OF ECHINODERMATA

The Echinodermata are one of the most interesting phyla of the Ottawa formation within the Ottawa-St. Lawrence basin. The abundance of crinoids at some levels in the thick limestones of the cement quarries at Hull, Quebec, led Raymond to refer to these limestones as the "Crinoid beds".[1] Later he named them the "Hull beds"[2]. Subsequent work, however, has shown that a greater variety of species is to be found near the top of the Cobourg beds, most of them in the "Cystid beds"[1] of Raymond, which, in addition, hold an abundant cystid fauna.

The present study has not resulted in the discovery and identification of many new species, but scattered information has been brought together, and some types described earlier are re-illustrated by modern methods. The following table shows the range of the species within the formation. The widths given the columns represent the approximate comparative thicknesses of the "separately named beds" from the Pamelia at the base to the Cobourg at the top. The comparative widths are shown because it is felt that the frequent use in the literature of the separate names, particularly those representing the lower series of beds, has given a wrong impression of the relative importance of the lower as compared with the higher beds; for instance, the uppermost or Cobourg beds, about 355 feet thick, contain a more abundant fauna and have a greater economic value than the Lowville, Leray, and Rockland beds, which are each 30 to 35 feet thick. The lines defining the columns are broken because the writer believes that there are no definite boundaries between these beds of faunal association, and that their thicknesses vary irregularly from place to place as a result of local conditions at the time of deposition.

---

[1] Raymond, P. E.: Inter. Geol. Cong. XII, 1913, p. 143.
[2] Raymond, P. E.: Geol. Surv., Canada, Sum. Rept. 1912, p. 348 (1914).

TABLE SHOWING RANGE OF SPECIES

| Species | OTTAWA FORMATION FAUNAL BEDS | | | | | | |
|---|---|---|---|---|---|---|---|
| | Pamelia | Lowville | Leray | Rockland | Hull | Sherman Fall | Cobourg |
| **CYSTOIDEA** | | | | | | | |
| *Amygdalocystites florealis* Billings | | | | | | | × |
| *A.* (?) *radiatus* Billings | | | | | × | | × |
| *A. tenuiradiatus* Billings | | | | | | | × |
| *Ateleocystites huxleyi* Billings | | | | | × | | |
| *Cheirocrinus logani* (Billings) | | | | | | × | × |
| *Comarocystites punctatus* Billings | | | | | × | | × |
| *Dendrocystites* (?) *paradoxicus* (Billings) | | | | | | × | × |
| *Glyptocystites multiporus* Billings | | | | | ? | | × |
| *Lichenocrinus crateriformis* Hall | | | × | | | | |
| *L. ottawaensis* n.sp | | | | | | × | × |
| *L.* cf. *subaequalis* Foerste | | | | | | | × |
| *Ottawacystites laevis* (W. R. Billings) | | | | | × | | |
| *Pleurocystites elegans* Billings | | | | | × | × | × |
| *P. filitextus* Billings | | | | | | | × |
| *P. robustus* Billings | | | | | | | × |
| *P.* cf. *robustus* Billings | | | | | × | | |
| *P. squamosus* Billings | | | | | × | × | × |
| **EDRIOASTEROIDEA** | | | | | | | |
| *Astrocystites ottawaensis* Whiteaves | | | | | | | × |
| *Carneyella* ? *platys* (Raymond) | | | | | | | × |
| *Cyclocystoides billingsi* n.sp | | | | | | | × |
| *C. halli* Billings | | | | × | | | × |
| *C.* sp | | | | | | × | |
| *Edrioaster bigsbyi* Billings | | | | | × | | × |
| *Hemicystites chapmani* (Raymond) | | | | | ? | | ? |
| *Isophorus* (?) *inconditus* (Raymond) | | | | | × | | × |
| *Lebetodiscus dicksoni* (Billings) | | | | | × | | × |
| *Lepidiconia loriformis* (Raymond) | | | | | | | × |

TABLE SHOWING RANGE OF SPECIES—*Concluded*

| Species | OTTAWA FORMATION FAUNAL BEDS | | | | | | |
|---|---|---|---|---|---|---|---|
| | Pamelia | Lowville | Leray | Rockland | Hull | Sherman Fall | Cobourg |
| CRINOIDEA | | | | | | | |
| CAMERATA | | | | | | | |
| *Archaeocrinus desideratus* W. R. Billings | | | | | | | × |
| *A. lacunosus* (Billings) | | | | | | | × |
| *A. microbasalis* (Billings) | | | | | × | | × |
| *A. ottawaensis* n.sp | | | | | | | × |
| cf. *A. ottawaensis* n.sp | | | | | | | × |
| *A. pyriformis* (Billings) | | | | | | | × |
| *Cleiocrinus grandis* Billings | | | | | | | × |
| *C. magnificus* Billings | | | | | × | | × |
| *C. regius* Billings | | | | | × | | × |
| *Glyptocrinus ottawaensis* n.sp | | | | | × | | |
| *G. marginatus* Billings | | | | | | | × |
| *G. quinquepartitus* Billings | | | | | | | × |
| *G. ramulosus* Billings | | | | | × | × | × |
| *Periglyptocrinus billingsi* W. and S. | | | | | × | | |
| *P. priscus* (Billings) | | | | × | | | |
| *Pycnocrinus ornatus* (Billings) | | | | | × | | × |
| *Reteocrinus stellaris* Billings | | | | | × | | × |
| FLEXIBILIA | | | | | | | |
| *Protaxocrinus elegans* (Billings) | | | | | | | × |
| *P. laevis* (Billings) | | | | | | | × |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **INADUNATA** | | | | | | | | |
| *Carabocrinus radiatus* Billings | | | | | × | | | × |
| *C. vancortlandti* Billings | | | | | | | | ? |
| *Cremacrinus articulosus* (Billings) | | | | | | | | × |
| *C. billingsiana* Ringueberg | | | | | | | | × |
| *C. furcillatus* (W. R. Billings) | | | | | | | | × |
| *C. inaequalis* (Billings) | | | | | | | | × |
| *Cupulocrinus conjugans* (Billings) | | | | | | | | × |
| *C. humilis* (Billings) | | | | | | × | | × |
| *Dendrocrinus acutidactylus* Billings | | | | | ? | | | ? |
| *D. gregarius* Billings | | | | | | | | × |
| *D. proboscidiatus* Billings | | | | | | | | × |
| *D. rusticus* Billings | | | | | | | | × |
| *Ectenocrinus canadensis* (Billings) | | | | | × | × | | × |
| *Euspirocrinus obconicus* W. R. Billings | | | | | | | | × |
| *Heterocrinus tenuis* Billings | | | | | × | × | | × |
| *Hybocrinus conicus* Billings | | | | | | | | × |
| *H. tumidus* Billings | | | | | × | ? | | × |
| *Iocrinus similis* (Billings) | | | | | | | | × |
| *I. subcrassus* M. and W. | | | | | × | | | × |
| *I.* cf. *subcrassus* M. and W. | | | | | | | | × |
| *Ottawacrinus typus* W. R. Billings | | | | | | | | × |
| *Palaeocrinus angulatus* (Billings) | | | | | | | | × |
| *P. pulchellus* Billings | | | | | | | | × |
| *P. rhombiferus* Billings | | | | | | | | × |
| *Porocrinus conicus* Billings | | | | | × | | | × |
| **ASTEROIDEA** | | | | | | | | |
| *Hudsonaster matutinus* (Hall) | | | | | | | | × |
| *H. narrawayi* (Hudson) | | | | × | × | | | |
| *Petraster rigidus* Billings | | | | | | | | × |
| *Promopalaeaster wilsoni* (Raymond) | | | | × | | | | |
| *P.* sp. | | | | | × | | | |
| *Schuchertia stellata* (Billings) | | | | | | | | × |
| *Stenaster salteri* Billings | | | | | | | | × |
| *Taeniaster cylindricus* (Billings) | | | | | | | | × |
| *T. spinosus* Billings | | | | | | | | × |
| *Urasterella pulchella* (Billings) | | | | | × | | | × |

FOSSIL LOCALITIES

1. Fourth Chûte of Bonnechère River, Renfrew, Ontario
2. McNab tp., Renfrew, Ontario
3. City View, southwest of Ottawa, Ontario

Ottawa, Ontario

4. An unspecified locality
5. East of Dow Lake
6. St. Louis dam
7. Lakeside park
8. Corner Carling avenue and Booth street
9. South end of LeBreton street
10. Booth street (formerly Division street)
11. Bureau of Mines, Booth street
12. Behind the Government Fuel Testing plant, Booth street
13. Corner Rochester and Lydia streets
14. Corner Booth and Elm streets
15. Rochesterville
16. Mount Sherwood
17. Cliff at west end of Sparks street
18. Pooley bridge, Queen street
19. Lemieux Island
20. Victoria Island
21. Chapel street
22. St. Patrick street
23. Nepean Point
24. Lady Grey drive
25. Steamboat landing, foot of Sussex street
26. Between Steamboat landing and mouth of Rideau canal
27. Research Council Laboratories
28. Cliff west from Rideau Falls
29. Rideau Hall grounds
30. West of Governor Bay
31. East side of Governor Bay

32. Val Tetreau along Ottawa River, Quebec
33. North side of La Petite Chaudière, Ottawa River, Quebec.

Hull, Quebec

34. Exact locality not specified
35. Small island off lumber slide
36. Long Island, Chaudière Falls
37. Table rock, Chaudière Falls
38. Booth Mill
39. Philemon Island
40. Armouries
41. Between two railways near Beaver Meadow
42. C.P.R. cutting south of Alymer road
43. North of the axe factory
44. Brewery Creek
45. Wright quarry
46. Cement quarry
47. Brigham quarry

48. Notre Dame cemetery, Eastview, Ontario
49. Robillard quarry, Montreal road, east of Eastview, Ontario
50. Stewart quarry, Rockland, Ontario
51. Lot 10, con. IV, N. Plantagenet tp., Ontario
52. Lot 16, con. II, N. Plantagenet tp., Ontario
53. Bourget, Ontario
54. Quarry 1½ miles west of Finch, Ontario
55. Alfred, Ontario
56. Ange gardien road, west of L'Orignal, Ontario
57. Near Cassburn, Ontario
58. West of McAlpine, Ontario
59. Indian Lands, con. III, Kenyon tp., Ontario

## DESCRIPTIONS OF SPECIES

Concise generic descriptions are included, because personal experience has shown that self-contained accounts are most useful. For the same reason, each description of genus and species is followed by the outstanding characteristics separating that form from those with which it is most easily confused.

Many of the older descriptions give just "Ottawa" or "Hull" as the locality. All "Ottawa" specimens come from the Cobourg beds, as there are no other outcrops of the Ottawa limestone within the city. Most of the "Hull" specimens come from the Hull beds, but faulting has also brought up some Sherman Fall, and at least one small slice of the Cobourg beds.

### CYSTOIDEA

### Genus, **Ateleocystites** Billings

Genotype, *A. huxleyi* Billings

Not all aspects of the genus are described because only imperfect specimens are known.

Small, concave or flat on one side, convex on the other, oblong-suboval in outline; convex side made up of a number of small irregular plates within larger bordering plates as in *Pleurocystites;* concave side having the two lower rows of plates systematically arranged and making up two-thirds of the height of the cystid, two marginal plates of the lowest row being also the marginal plates of the convex side; upper plates irregular.

This genus has been considered synonymous with *Anomalocystites* Hall by various authors. In spite of the poor preservation of the specimens of the genotype it is evidently not *Anomalocystites,* though allied to it. Hall's genus differs on the concave side in the less regular arrangement of the two lower series of plates, and on the convex side it lacks the long bordering plate in the lower part.

Meek's form *Anomalocystites balanoides* was referred by him to Hall's genus, but has been included in Billings' *Ateleocystites* by later authors. Meek's species has large basal plates on the convex side and lacks the numerous irregular plates of the convex side. It could hardly belong to either genus.

It is concluded, therefore, that in North America *Ateleocystites* at present is represented only by the type species. Haekel describes another species, *A. gegenbauri* from Dudley, England.

### *Ateleocystites huxleyi* Billings

Plate II, figures 1-4

*Ateleocystites huxleyi* Billings, Geol. Surv., Canada, Can. Org. Rem., dec. 3, 1858, p. 72, fig. 4; Woodward, Geol. Mag. 7, 1870, p. 261, footnote; dec. 2, vol. 7, 1880, Pl. VI, fig. 1.

A re-examination of Billings' type of *Ateleocystites huxleyi* and of some specimens found later suggests a different interpretation in two particulars. First, only about one-half of the transverse ornamental lines of the two outer basal plates extend irregularly over the two inner basal plates, not all, as given in the original illustration. No indication of such ornamentation can be found on any other plate. Second, Billings' original diagram illustrates a number of tiny parallel hairs or pinnules rising from the oral region. A close examination of the specimen shows that these hair-like processes are not separate, as in the diagram, but are part of a plate half buried in the matrix, which might be a broken side plate out of place. Another specimen (Plate II, figure 2) shows another and perhaps truer branching arrangement of the pinnules.

In a footnote to deKonick's description of *Placocystites forbesianus*, Woodward suggested that it and *A. huxleyi* are synonymous, to which Billings agreed, later publishing a diagram entitled *"Ateleocystites huxleyi-Placocystites forbesianus"*. The implication that the diagram represents *A. huxleyi* is erroneous. Woodward's later paper (op. cit., p. 197) shows this illustration to be a diagrammatic representation of a specimen of *P. forbesianus* from the Silurian of Wenlock. If *Ateleocystites* and *Placocystites* are regarded as the same genus, Billings' name has priority, but there are definite specific differences. The ornamentation of the basal plates is not similar. Also, at the oral end of *A. huxleyi* there are three plates, from two of which the arms rise directly, leaving one plate between the arm-plates. The illustration of *P. forbesianus* shows three plates across the top, but the arms rise from between the end plates and the marginal plates of the next inferior row. In addition, what appears to be the anal plate of *A. huxleyi* is not in the median line as in *P. forbesianus*. Preservation of the types is poor, and a better specimen may show more clearly the exact relationship of the two species.

*Occurrence.* Hull beds, localities 34 and 47.

*Type.* G.S.C.,[1] holotype, No. 1392; paratypes, Nos. 1392a-1392c.

### Genus, **Dendrocystites** Barrande

Genotype, *Dendrocystites sedgwicki* Barrande

Irregular in outline; thecæ composed of numerous smooth or slightly granular irregular plates. At the upper end the plates assume a slight regularity from which group of plates projects an oral tube formed by four or five rows of small plates, wider than high and often alternating; at the base the irregular thecal plates are produced downwards forming the top of a "stem", about one-third the width of the calyx, at its upper end, and tapering downward. The column plates gradually become larger and more regular and finally merge into a regular tubular attachment composed of more than one series of plates.

The inclusion of a considerable number of the irregular body plates into the upper part of the column and into the basal part of the oral extension differentiates this genus from any other.

### *Dendrocystites? paradoxicus* (Billings)

*Syringocrinus paradoxicus* Billings, Geol. Surv., Canada, Can. Org. Rem., dec. 4, 1859, p. 65, Pl. X, fig. 14.

*Dendrocystis ? paradoxicus* (Billings), Bather, Roy. Soc. Edinburgh, Tr. 49, pt. 2, 1914, p. 372, and p. 397, fig. 13.

*Dendrocystis (?) paradoxicus* (Billings), Bather, Geol. Surv., Canada, Mus. Bull. 49, 1928, pp. 7 and 8, fig. 2.

The type specimen came from Beauport, Quebec. Bather considers the specimen is a stem only and doubtfully refers it to *Dendrocystis* (=*Dendrocystites*) because it shows the peculiar, alternating impression of thin wide plates at the proximal end. If better forms should prove that *Dendrocystites* and *Syringocrinus* are synonyms, Billings' genus will have priority.

The Ottawa form does not add to the knowledge of the calyx of the Canadian species.

*Occurrence.* Cobourg beds, localities 39 and 57; Sherman Fall beds, locality 31.

*Type.* G.S.C., holotype, No. 1521a, not from this area, but from Beauport, Quebec.

---

[1] The abbreviation G.S.C. is used for the type specimens in the collections of the Geological Survey, Canada.

## Genus, **Amygdalocystites** Billings

Genotype, *A. florealis* Billings

Body oval, flattened laterally; numerous, irregular, thecal plates, generally ornamented; arms near the summit; two, large, recumbent arms of different lengths, composed of a double series of plates, one beneath the other; ambulacral groove not in the median line of the arms; column round, smooth, and tapering.

The genus differs from others in that the anterior and posterior plates are more equal in size than in other genera of the family, and in its two recumbent arms.

### *Amygdalocystites florealis* Billings

Plate I, figures 1, 2

*Amygdalocystites florealis* Billings, Can. Jour. 2, 1854, p. 270, figs. 4-6; Geol. Surv., Canada, Can. Org. Rem., dec. 3, 1858, p. 63, Pl. VI, figs. 1a-1e.

*Emended Description.* What Billings considered the mouth is here regarded as the anus, and the face upon which it is situated is the posterior. Oriented thus, the body is compressed in an antero-posterior plane, but still biconvex, like an egg somewhat flattened lengthwise; greatest width in the upper half; greatest thickness at or above the middle; the margins curving upward into the apex, and almost oblique to the base whether viewed anteriorly or in profile; length, width, and thickness, 30 mm. to 45 mm., 18 mm. to 25 mm., and 12 mm. to 15 mm. respectively. Billings' holotype is shorter and thicker, more compact than his paratype, which has the same proportions as another, better preserved specimen found later; body plates arranged diagonally across the anterior and posterior faces, with a centrally placed tubercle on each plate, from each tubercle radiate five to ten strong ridges or rays, most prominent at the plate margin, each having a wedge-shaped terminus; three termini, one from each of three adjacent plates, meet and fit exactly into one another with considerable variation of the angle of each of the several wedges to accommodate the variable number of rays on the plates; between the rays a depression that becomes deeper and wider as it approaches the margin. Like the rays, the depressions of adjacent plates meet end to end, continuing across the sutures. On worn specimens the ornamentation forms a group of three-pointed stars, the prominent termini of adjacent plates being the centre, the slender, concave-sided rays terminating at the central tubercle of each plate, each star separated from its neighbour by a canoe-shaped depression. Billings' original diagram of a restored plate (Can. Jour. 2, p. 271, fig. 6) suggests this ornamentation, but the type specimen is too poor to have completed its description. Several specimens show what appear to be striations extending across the depression from tubercle to tubercle. As seen in section (Plate I, figure 2c) these are in reality the top of the hydrospire-like water-vascular system, arranged like inverted triangular pyramids. The inverted apex is beneath the angles at the junction of three adjacent plates; the sides of the depressions are made up of four tiers of "hydrospires", each rising higher than the next, the topmost marking the radius from the centre of the covering plate to the middle of the side. In cross-section one "bank" of "hydrospires" has a fleur-de-lis-like pattern, with three instead of one coil on either side. The "hydrospires" suggest relationship to the Blastoidea, but they are situated beneath each plate not stemming from an ambulacral area. In this respect they have a resemblance to the subtegminal ambulacral grooves of the Aristocystidae, but the plates of that family are irregular. Externally specimens showing the top of the water-vascular system have a pattern that resembles a five- to ten-pointed star with the tubercle in the centre.

The holotype shows two lateral recumbent arms of different lengths, that on the left extending from orifice to base, that on the right from a quarter to halfway down the side; arm plates elevated above the body plate level, the most prominent ones near the apex; each arm plate composed of two sections, a rectangular prism at the base, upon which lies a narrow, recumbent cylinder, one side flush with the basal plate, the other having a groove at the line of juncture of the two sections. Within the groove probably lay the ambulacral canal, on the posterior of the long arm, on the anterior of the short arm; ambulacral grooves meeting at the top in a circular orifice; arms circular, protected by five double plates and placed just posterior to the short arm, about 8 mm. to 10 mm. from the orifice; traces of pinnules on some of the arm plates. The stoutness and spacing of the pinnules are shown in an illustration of a specimen from Kirkfield, Ontario, identified by Raymond[1] as *A. florealis*, but varying slightly from the typical species in the fineness of its ornamentation. One columnal only, oval in outline, is attached to the base of any specimen.

*Occurrence.* Cobourg beds, localities 4, 6, 10, 38; also cited from the Trenton Hull? beds at Kirkfield, Ontario.

*Type.* G.S.C., holotype, No. 1396; paratype, No. 1396a, Cobourg beds, both from an unspecified locality at Ottawa; plesiotypes, Nos. 9062 and 9062a, Cobourg beds, from Booth street, Ottawa.

### *Amygdalocystites ? radiatus* Billings

Plate I, figures 3, 4

*Amygdalocystites radiatus* Billings, Can. Jour. 2, 1854, p. 271, figs. 7 and 8; Geol. Surv., Canada, Can. Org. Rem., dec. 3, 1858, p. 65, Pl. VI, figs. 3a, 3b.

The species is here referred to this genus with even more doubt than Billings had. The pores are so arranged that they suggest *Comarocystites* rather than *Amygdalocystites*, but as it cannot yet be established that they pierce the upper covering of the outer plate the species is left as Billings designated it.

*Original Description.* "Body oval, plates somewhat convex, and ornamented with strong ridges which radiate from the centres to the angles; mouth ambulacral; orifice and arms unknown; column round, smooth, composed of thin joints.

"The spaces between the large radiating ridges are flat and covered with small tubercules, which disappear when the plates are a little worn.

"Of this fine and very distinct species, enough has not yet been found to show conclusively that it belongs to the present genus. The plates however are solid, or not poriferous, and the shape of the body and column is so much like the other species, in general aspect, that I have referred it to this genus for the present."

W. R. Billings found a specimen that he later described as *A. florealis laevis*, because of the smooth surface of the plate. It is evident, however, that he found the underside of *A. ? radiatus*, as can be seen from the specimen, Plate I, figure 3.

Billings' description of *A. radiatus* can, then, be still further emended by adding that the brachioles are stout and attain considerable length, as shown in a specimen from Healey Falls, Ontario, and described by Raymond[2]; that some plates show a thickening at the margins; and that on the underside of each plate two pores are present along each side of the margin across the suture, half of each pore in one plate and half in the adjacent one. They do not appear to penetrate to the surface, or if so, they have become too minute to be

[1] Raymond, P. E.: Geol. Surv., Canada, Mus. Bull. 31, 1921, p. 3, Pl. 2, fig. 4.
[2] Raymond, P. E.: Geol. Surv., Canada, Mus. Bull. 31, p. 3, Pl. 2, fig. 7 (1921).

visible in the state of preservation of the specimens at hand; that there is an inner row of pores, just within and parallel to the margin of each plate, is evident in worn and broken plates (Plate I, figure 4). The resisting centre with its ornamental rays still retains its angular outline and stands prominently above a fallen marginal rim perforated by pores that appear to be connected in some way with one another. The pores are not evident on an unweathered plate, and for this reason the species is doubtfully retained in the genus *Amygdalocystites*, as nothing is yet known of the underside of the plates of the genotype of that genus.

*Occurrence.* Cobourg beds, localities 4, 14; Hull beds, localities 34, 37; also cited from Healey Falls, Ont.

*Type.* G.S.C., holotype, No. 1394; paratypes, Nos. 1394a and 1394b; from Cobourg beds at an unspecified locality in Ottawa; plesiotype, No. 9063, from Cobourg beds, corner of Booth and Elm streets, Ottawa.

### *Amygdalocystites tenuiradiatus* Billings

*Amygdalocystites tenuiradiatus* Billings, Can. Jour. 2, 1854, p. 271, text fig. 9; Geol. Surv., Canada, Can. Org. Rem., dec. 3, 1858, p. 64, Pl. VI, figs. 2a-f.

Billings' type of this material has been lost, and no additional specimen has been found.

*Occurrence.* Cobourg beds, locality 4.

## Genus, **Comarocystites** Billings

Genotype, *C. punctatus* Billings

Body oval or pyriform, often large, convex, with antero-posterior diameter shorter than lateral; plates, 3 basals, above which, in known species, five to eleven rows of irregular polygonal plates, smaller towards the base; plates deeply concave, rising towards the margins, centres smooth; pores, one or more rows at the elevated margins of the plates; anus in a median position about one-quarter length down from the mouth; mouth, a slit at the summit in the plane of the lateral axis; arms, 2, round, erect, rising from the extremities of the mouth, bearing long, strong, uniserial pinnules; stem round, with numerous thin disks.

The genus is readily distinguished from any other by its concave plates, the sharply defined sutures, and the marginal system of pores.

### *Comarocystites punctatus* Billings

*Comarocystites punctatus* Billings, Can. Jour. 2, 1854, p. 270, figs. 1-3; Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 288; Can. Org. Rem., dec. 3, 1858, p. 61, Pl. 5, figs. 1 and 2; Grant, Ottawa Field Nat. Club, Trans. 1, 1880, p. 29, Pl. I, figs. 1-3; Foerste, Ottawa Nat. 30, 1916, pp. 69-79.

Billings' description of this is sufficient except in his interpretation of "the fissure-like striæ at right angles to the sutures" of the plates. It is here noted that wearing of the elevated plate margins reveals that the pores lead into slits that extend over half the radius of each of two adjacent plates, giving the peculiar effect described by Billings as surface ornamentation. The range of the species can also be more clearly defined.

*Occurrence.* Cobourg beds, localities 5, 8, 10, 21-23, 28, 38, 39; Hull beds, localities 37, 44, 45, 47, 49.

*Type.* G.S.C., holotype, No. 1391; paratype, No. 1391g; Cobourg beds, from an unspecified locality, Ottawa; plesiotype, No. 333a, Cobourg beds, from an excavation on St. Patrick street, Ottawa.

## Genus; **Pleurocystites** Billings

Genotype, *P. squamosus* Billings

Body with oval outline, anterior side convex, posterior flat or slightly concave; plates on the anterior, large, polygonal, and ornamented; posterior plates of three forms: raised marginal plates on the sides, curving back from the anterior margin; a number of plates similar to the corresponding anterior plates near the top; and, sunken below the marginal plates, numerous, small, irregular, polygonal plates forming a posterior covering with outline rounded above and having slightly angular basal corners; three pectinated rhombs on the anterior face, one on the lower and two on the upper half; anus on the lower left hand posterior corner; arms, two, free, having large, round, cylindrical joints excavated on the inner side, the excavation covered by two rows of smaller plates, two or three to each joint; groove between the two rows of smaller plates; mouth uncertain, no specimens show the top well, but several show a small opening on the posterior side, near the summit across the suture of two adjacent plates; column round and tapering.

The genus is distinguished from others by its three isolated pore rhombs, its stout erect arms, and the difference between the arrangement of its anterior and posterior plates.

### *Pleurocystites squamosus* Billings

Plate II, figures 5, 6

*Pleurocystites squamosus* Billings, Can. Jour. 2, 1854, p. 251, figs. 9-12; Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 286; Can. Org. Rem., dec. 3, 1858, p. 49, Pl. I, figs. 1a-d.

*Pleurocystis squamosus* (Billings), Bather, Trans. Roy. Soc. Edinburgh, 49, pt. 2, 1914, p. 464, figs. 63-65.

Three of Billings' cotypes are at hand, but the one showing the anal opening is missing. Two emendations may be made to the original description and illustrations. First, the illustration (Can. Org. Rem., dec. 3, 1858, Pl. I, fig. 1e) of the inner plates of the arms is misleading. The specimen is crushed. The pushing up of the two rows of plates covering the groove gives the appearance of one row with minute pinnules. In reality no pinnules are present, and the plates are set into the excavation of each joint, flush with its edge. Second, in the same illustration, there is an obscurity in the drawing of the opening near the summit of the posterior side. A narrow slit extends across the suture slightly beyond the edge of two adjacent plates. Immediately below it are two perforations, one on the margin of each of the two plates, one edge of each perforation truncated by the suture.

*P. squamosus* is distinguished from the other species of the genus by the great number and small size of the posterior plates; on the anterior side, by the ornamental striæ, parallel with the several edges of each plate crossed by a few, low, broad, radiating striæ, and by the shape of the pectinated rhombs, in the upper two of which the longer diameter lies at an angle of 90 degrees to the line of the upper margin.

*Occurrence.* Cobourg beds, localities 4, 9, 16, 39, 57; Sherman Fall beds, locality 35; Hull beds, localities 37, 40.

*Type.* G.S.C., cotypes, Nos. 1381a, b, and c, Cobourg beds, from an unspecified locality, Ottawa; and plesiotype, No. 9064, Cobourg beds, from the south end of LeBreton street, Ottawa.

### *Pleurocystites elegans* Billings

Plate III, figure 3

*Pleurocystites elegans* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 287; Can. Org. Rem., dec. 3, 1858, p. 51, Pl. II, figs. 2a-c.

*Pleurocystis elegans* (Billings), Bather, Trans. Roy. Soc. Edinburgh, 49, pt. 2, 1914, p. 466, fig. 67.

The anterior side has been well drawn and described except to note that the two upper pectinated rhombs lie in the plane of the upper margin. The specimen here illustrated shows a concave posterior side, with wide, raised margin, and a proportionally small inner area with fewer and larger plates than in the preceding species. The slit on the posterior side can be distinguished, but the perforations are either covered or not present.

*P. elegans* differs from other species in having numerous, fine, radial striations, in its wide posterior margin, resulting in fewer irregular posterior plates, which are larger than those of *P. squamosus* and smaller than those of *P. filitextus,* and in the slope of the upper two rhombs, similar to that of *P. filitextus,* but differing from that of *P. squamosus.*

*Occurrence.* Cobourg beds, localities 4, 19, 23, 39; Sherman Fall beds, locality 35; Hull beds, locality 37.

*Type.* G.S.C., cotypes, Nos. 1382a, b, and c, Cobourg beds, from an unspecified locality, Ottawa; plesiotype, No. 9065, Cobourg beds, from Lemieux Island, Ottawa.

### *Pleurocystites filitextus* Billings

Plate III, figure 4

*Pleurocystites filitextus* Billings, Can. Jour. 2, 1854, p. 253, figs. 13 and 14; Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 286; Can. Org. Rem., dec. 3, 1858, p. 50, Pl. II, figs. 1a, 1b.

*Pleurocystis filitextus* (Billings), Haekel, Amphoriden und Cystoideen, 1896, p 44, Pl. II, fig. 15; Wilson, Roy, Soc., Canada, 3rd ser. 26, 1932, p. 387, Pl. IV, fig. 1.

Billings' types are well illustrated except for the peculiar ornamentation of the plate shown here. Nothing can be added to the description given except that if not worn the rhomboid plates slope at 45 degrees towards the median line and have blunt, angular corners rather than curved, making them more truly rhomboid than the type illustrations would suggest. The lower rhomb is so much smaller than the others that it is difficult to distinguish the form from *P. elegans* if not accompanied by other evidence.

*P. filitextus* differs from other species in its roughened ornamentation and in the larger plates of the inner area of the posterior side, and from *P. squamosus* in the slope of the two upper rhomboid plates.

*Occurrence.* Cobourg beds, localities 4, 11, 30, 39, 55, 57-59.

*Type.* G.S.C., holotype, No. 1400, Cobourg beds, from an unspecified locality, Ottawa; plesiotype, No. 6607, Cobourg beds, from con. III, Kenyon tp., on the Maxville road.

### *Pleurocystites robustus* Billings

Plate IV, figure 4

*Pleurocystites robustus* Billings, Can. Jour. 2, 1854, p. 252, fig. 15; Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 287; Can. Org. Rem., dec. 3, 1858, p. 49, Pl. I, fig. 2a.

*Pleurocystis squamosa* var. *robusta* (Billings), Bather, Roy. Soc., Edinburgh, Trans. 49, pt. 2, 1914, p. 465, fig. 66.

Besides the ornamentation described, Billings' type specimen shows fine radial lines crossed by transverse lines parallel to the margins of the plates.

The ornamentation is very similar to a combination of *P. squamosus* and *P. elegans*. The holotype is illustrated to show the complete ornamentation.

*Occurrence.* Cobourg beds, localities 4, 19?. The holotype is from an unspecified locality at Ottawa, probably along the cliff generally known as Mount Sherwood. Another specimen is rather worn and is doubtfully assigned to this species.

*Type.* G.S.C., holotype, No. 1384, Cobourg beds, from an unspecified locality, Ottawa.

*Pleurocystites* cf. *robustus* Billings

Although too imperfect for definite identification the forms indicate a lower cystid horizon.

*Occurrence.* Hull beds, locality 37.

Genus, **Ottawacystites** nov. gen.

Genotype, *Amygdalocystites florealis laevis* W. R. Billings

Compressed in an antero-posterior direction, though still biconvex; ovate in outline; only face known having the central convex area covered with small hexagonal plates arranged in diagonal rows, but interrupted medially by larger, irregular plates; marginal plates thin edged, depressed below the body surface; pores in sutures between the plates; at least four free arms composed of comparatively large ossicles, oval in cross-section; three to four small ambulacral plates on the inner side of each ossicle.

The holotype was described as an *Amygdalocystites*, but the free arms indicate that it cannot belong to that genus. It is like *Pleurocystites* in having free arms, but it has four in place of two, and it also differs in having depressed marginal plates, and sutural pores, and it is not known whether there are pore-rhombs in addition on the hidden side.

*Ottawacystites laevis* (W. R. Billings)

Plate III, figure 1

*Amygdalocystites florealis laevis* W. R. Billings, Trans. Ottawa Field Club 4, 1883, p. 51, plate, fig. 4.

*Emended Description.* Compressed in an antero-posterior direction, biconvex ovate outline; greatest width above the middle, broadly rounded at the top, sides sloping towards an angle at the base; central convex area composed of small hexagonal plates arranged obliquely but interrupted by irregular larger plates, medially placed; small plates on the margin of the convex area cut off against the straight inner edge of the single row of true marginal plates, which are thin edged and depressed; pores in the sutures, one half-circle cut from each adjacent plate, one pore to each side of the smaller plates, two or even three in the sutures of the larger median plates; surface of all plates smooth; at least four arms, each rising from a heptagonal marginal plate and composed of comparatively large ossicles, oval in section; ambulacral plates small, wedge-shaped, interlocking, three or four to the inner side of each ossicle of the arms; apex, anus, mouth, and reverse face of the specimen not known.

The holotype of this species was identified by W. R. Billings as *Amygdalocystites*, but the free arms separate it from that genus. It bears no relation to *Pleurocystites laevis* Raymond.

*Occurrence.* Hull beds, locality 34.

*Type.* G.S.C., holotype, No. 1395, Hull beds ?, from an unspecified locality, Hull.

## Genus, **Glyptocystites** Billings

### Genotype, *G. multiporus* Billings

Body small, cylindrical, elongate, composed of four series of plates, 4 in the basal and 5 in each of the second, third, and fourth rows; plates with very irregular sides, straight, slightly curved convexly or concavely, many with re-entering angles to fit around the rhombs; periproct large, situated between the second and third row; pectinorhombs numerous, occurring in each of the four rows of plates, slits extending only partly across the rhombs from the edge inward giving place to a slightly elevated, smooth centre cut by a suture; ambulacral arms five, long, recumbent, reaching or almost reaching the basal plates; ambulacral opening in or near the top; small plates around the margins of the ambulacral opening and grooves.

Billings originally placed three species and one variety in this genus. Bather (Roy. Soc., Edinburgh, Trans. 49, pt. 2, 1914, pp. 434-450) follows Jaekel in removing two of the species and the variety to *Cheirocrinus*, leaving only *G. multiporus* Billings in the genus *Glyptocystites*. (Bather spells the genus differently throughout.)

Although the plate arrangement is the most vital characteristic of the restricted genus, the most easily recognized feature is the great length of the recumbent arms.

### *Glyptocystites multiporus* Billings

*Glyptocystites multiporus* Billings, Can. Jour. 2, 1854, p. 216, figs. 1-8; Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 281; Can. Org. Rem., dec. 3, 1858, p. 54, Pl. III, figs. 1a-k, n.

*Callocystis multipora* (Billings), Haekel, Amphor. u. Cystoideen, 1896, p. 132, Pl. III, figs. 19 and 20.

*Glyptocystites multiporus* Billings, Grabau and Shimer, North Amer. Index Fossils 2, 1910, p. 463 (pars), fig. 1770.

Nothing can be added to Billings' description or figures except to note that the species occurs in the Upper Trenton, information heretofore lacking because the types were recorded from an unspecified Ottawa locality.

*Occurrence.* Cobourg beds, localities 4, 17, 27, 39; Cobourg or Hull beds, locality 33. This is a much faulted area. A block of the Cobourg beds occurs within some of the lower beds.

*Type.* G.S.C., cotypes, Nos. 1387c, 1387f, 1387g, 1387k, 1387m, Cobourg beds, from an unspecified locality, Ottawa.

## Genus, **Cheirocrinus** Eichwald

### Genotype, *C. penniger* Eichwald

Body elongate, composed of four series of plates in which some of the plates of series III and IV are shifted, and plate 13 is almost lost; large periproct bounded by plates 7, 8, 12, 13, and 14 and filled with small plates; numerous pectinorhombs, varying in number but found in all four series; slits completely traversing the rhombs, or interrupted by a smooth area along the centrally bisecting suture, or in the form of a broken series of dashes; five recumbent grooves radiating from the mouth between the deltoids on the plates of series IV, each groove giving off at least two side branches.

The genus differs from *Glyptocystites* in the irregularity of the position of the plates of series III and IV, in the number and position of the plates about the periproct, and in the shortness of the recumbent arms. It is similar in having pectinorhombs in each of the four series of plates.

As mentioned above, Bather follows Jaekel in placing Billings' species *Glyptocystites forbesi* and *G. logani* with its variety *G. logani gracilis* in this genus, and leaves *G. multiporus* in the genus *Glyptocystites*. The species *G. forbesi* is from Chazy limestone, and is not discussed here. The plates of the type of *G. multiporus* are obscure around the periproct, not clearly defined as in the generalized drawings of Billings, modified by Bather. None of the specimens of *Cheirocrinus logani* or its variety *C. logani gracilis* shows the periproct. The only possible way to distinguish the genera by the specimens at hand is by the arm grooves. The ambulacral arms of *Glyptocystites* are long, those of *Cheirocrinus* short. No grooves show on the types of *C. logani*. The type of *C. logani gracilis* exhibits the crushed tip of one arm at the summit.

### *Cheirocrinus logani* (Billings)

*Glyptocystites logani* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 282; Can. Org. Rem., dec. 3, 1858, p. 57, Pl. IV, figs. 1a-1g.

*Cheirocrinus logani* (Billings), Jaekel, Stammesg., Pelmat., I, Thecoidea u. Cystoidea, 1899, p. 220.

The species has been transferred from the genus *Glyptocystites* because it lacks the long arms. Nothing can be added to Billings' description and figures. The types come from an unspecified Trenton horizon at Montreal. The specimens from the Ottawa-St. Lawrence Lowland show that it occurs in the Upper Trenton.

*Occurrence.* Cobourg beds, localities 4, 11, 17, 20, 39, 48, 51; Sherman Fall beds ?, locality 56.

*Type.* G.S.C., cotypes, Nos. 1385, 1385a, 1385d, 1385g, not from this region but from Montreal, Quebec.

### Genus, **Lichenocrinus** Hall

Genotype, *L. dyeri* Hall

The genus *Lichenocrinus* has been variously classified as a doubtful cystid, a doubtful crinoid, and the root of a crinoid, and more particularly the root of a species of *Heterocrinus*.

The form is parasitical, a small, flattened spheroid or hemi-spheroid, covered on the upper side with minute hexagonal or pentagonal plates, a depression or crater on the upper surface, the base generally flattened or concave when attached to a foreign body, interior filled with hydrospire-like coils. From the crater arises a stout, whip-like stem or proboscis formed of small, irregular plates having a general pentagonal arrangement.

The specimen described below as *L. ottawaensis* shows part of a coil-filled interior. Other species have been described as having radial striations that fill the interior. That the "striations" in reality have a vertical dimension is evident in the words "fill the interior". These "striations" probably are the worn tops of the coils seen in *L. ottawaensis*.

Foerste, Fenton, and others considered the form to be the root and stem of a species of *Heterocrinus*, basing their opinion upon the stout pentagonal tube issuing from the crater, and that the small parasitical spheroids have been found near *Heterocrinus* heads. Bather is content to call it merely the root of some pelmatozoa. But the presence of plates, more or less irregularly arranged, and the inner coils argue against a crinoid base.

*Lichenocrinus ottawaensis* n.sp.

Plate III, figure 2

Form small, slightly irregular in outline, perhaps a trifle distorted, quite convex, diameter 5 mm. to 5·5 mm., height preserved 2·5 mm.; crater steep and narrow, base of crater indistinct; plates lining inner side of crater in two rows, elongated pentagonal or hexagonal, the row bordering the crater base very minute with wedge-shaped tips, the second row having both upper and lower tips wedge shaped or truncated; plates on the crest generally larger and more regularly hexagonal, but with smaller irregular plates interspersed among them; outer plates, as far as can be seen, still larger, some of them elongated, but smaller plates continue to be interspersed among them; base not known, though one specimen suggests attachment to a foreign body. Where some of the plates along the crest are broken a series of coarse tubular coils is revealed, evidently filling the whole inner part of the specimen. On the lower left-hand side of the illustration can be seen two spires of a lower tier intercalated between the regular row, indicating that in part at least there is another row of coils.

*L. ottawaensis* differs from the genotype *L. dyeri* in its greater convexity and its fewer larger and more definitely arranged plates. It differs from *L. crateriformis,* with which it has heretofore been identified in this area, in its fewer and coarser coils or "striations" as described in that species.

*Occurrence.* Cobourg beds, locality 7; Hull beds, locality 41.

*Type.* In the private collection of W. Sinclair, Cobourg beds from Lakeside park, Ottawa.

*Lichenocrinus* cf. *subaequalis* Foerste

*L. subaequalis* Foreste, Jour. Cincinnati Soc. Nat. Hist. 21, 1914, p. 125, Pl. I, fig. 10.

Only one specimen of this species has been found. It measures 9 mm. in diameter, perhaps being a little crushed. It agrees with the description of Foerste's species, though a little larger. Upon the crest of the disk the larger plates are arranged very irregularly. In this respect, and in its size, it differs from *L. crateriformis* Hall. It is very much larger than *L. affinis* Miller. The so-called radial striations that fill the interior are faintly shown in a worn part of the disk.

*Occurrence.* Cobourg beds, localities listed 4, 15, 29; the specimen seen is from locality 4. Ami and W. R. Billings list *L. crateriformis,* probably this species, from localities 15 and 29.

*Lichenocrinus crateriformis* Hall

This form is considerably smaller than *L. subaequata* Foerste, less depressed, and comes from lower in the Ottawa limestone.

*Occurrence.* Leray beds, locality 50.

EDRIOASTEROIDEA

Genus, **Cyclocystoides** Hall

Genotype, *C. halli* Salter

The exact position of this genus is uncertain. Bather[1] considered it to belong to the *Edrioasteroidea,* but could not relate it to any known family.

Discoid, numerous, close-fitting polygonal plates on one side encircled by a ring of much larger, thick, subquadrate plates; on the other side, more delicate

[1] Bather, F. A.: Treatise on Zoology, 3, chinoderma, 1900, p. 210.

plates having a radial, bifurcating arrangement, and with numerous pores along the radial sutures; each marginal plate of this side has on its outer rim two, deep, spoon-like excavations covered by small plates; one pore from each excavation appears to connect with the central disk horizontally through the marginal plate.

What was described by Billings as a tube is fragmentary and entirely detached. It may belong to something else.

### *Cyclocystoides halli* Billings

*Cyclocystoides halli* Billings, Geol. Surv., Canada, Can. Org. Rem. dec. 3, 1858, p. 86, Pl. X, bis, figs. 1-7; Raymond, Geol. Surv., Canada, Mus. Bull. 1, 1913, p. 25, Pl. III, figs. 1, 3, 4.

Nothing can be added to the descriptions already given. Raymond cites this form from four horizons of the Ottawa limestone. Specimens from only three of these have been seen by the writer, but they range from Rockland up to Cobourg beds.

*Occurrence.* Cobourg beds, locality 4; Sherman Fall beds ?, locality 43; Hull or Rockland beds, localities 32, 46.

*Type.* G.S.C., cotypes, Nos. 1416 and 1416a, Cobourg beds, from an unspecified locality, Ottawa.

### *Cyclocystoides billingsi* n.sp.

Plate IV, figure 3

Specimens approximately 21 mm. in diameter; outer circle of surface covered by a fine reticulate pattern, inner disk apparently covered by a similar but coarser pattern very poorly preserved, but such as illustrated in part in Hall's specimen of *C. salteri;* marginal plates, forty-eight to fifty in number, almost square, and evidently with two of the spoon-shaped, submarginal excavations to each plate; one pore in the bottom of each excavation; central disk bearing fine, radiating ridges from the centre to the marginal plates; approximately one ridge to each plate.

The holotype is not well preserved, but is described because it cannot be assigned to any known species. The number of plates distinguish it from all but two species. It differs from the English form *C. davisi* in having a reticulate ornamentation, and in having the radiating ridges prolonged to the marginal plates. It is more nearly allied and probably ancestral to the Richmond form *C. huronensis* Billings, but is much finer and smaller.

*Occurrence.* Cobourg beds, localities 4, 25.

*Type.* G.S.C., holotype, No. 9066, Cobourg beds, from foot of steamboat landing, Sussex street, Ottawa.

### *Cyclocystoides* sp.

A small *Cyclocystoides* occurs at one horizon, the specimens of which are not well enough preserved for specific description. It is mentioned here in the hope that better specimens may later provide an adequate holotype.

The species has a diameter of 11 to 13 mm., and the circle has an average of twenty comparatively large plates, which are granulose on the upper surface. The circumference is covered by numerous, small, imbricating plates.

The species resembles *C. halli* in its large plates and the relative size of the two spoon-shaped cups to each plate, but differs in the number of plates.

*Occurrence.* Sherman Fall or Hull beds, locality 56.

## Genus, **Lebetodiscus** Bather

### Genotype, *L. dicksoni* Billings

Discoidal, upper surface convex, lower surface attached to a foreign body; ring of smaller marginal plates not well differentiated from the upper imbricating floor plates, which increase in size towards the centre; anus large, covered with small plates, situated about one-third of diameter distant from the centre; rays, broad, all contra-solar, flexed as they near the margin, covered by two sets of plates, side pair larger than those on top of the ambulacral groove; no accessory plates along the median ridge; one large pore between each of the side plates.

The oral plates of the type specimen are not clear. One large and two small plates are present as in *Carneyella* and *Hemicystites*, but at the anterior right-hand corner of the large plate is a tiny plate that may be a broken piece of the large plate or a minute fourth plate.

*Lebetodiscus* differs from *Agelacrinites* and *Lepidodiscus* in that all five arms are broad and contra-solar, and in having no accessory plates along the median line of the arms.

Clarke separated *Agelacrinites* and *Lepidodiscus* mainly on the basis of one and two solar arms. He made no provision for *Lepidiscus alleganius* Clarke with all contra-solar arms. Bather's name is very similar, but has an entirely different origin being named from Lebeto—a cauldron, referring to Chaudière Falls, Ottawa, where the type specimen was found.

### *Lebetodiscus dicksoni* (Billings)

*Agelacrinites dicksoni* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 294; Can. Org. Rem., dec. 3, 1858, p. 84, Pl. VIII, figs. 3, 3a, 4, 4a; Grant, Ottawa Field Nat. Trans. 1, 1880, Pl., fig. 9; Clarke, New York State Mus. Bull. 49, 1901, p. 191, fig. 3.

*Agelacrinus dicksoni* Billings, Haekel, Amphorideem u. Cystoideen, 1896, Pl. III, fig. 29.

*Lebetodiscus dicksoni* (Billings), Bather, Geol. Mag., dec. 5, vol. 5, 1908, pp. 544-548; Raymond, Geol. Surv., Canada, Mus. Bull. 31, 1921, p. 5, Pl. I.

This is the only species referable to the genus in this region. Nothing can be added to the complete descriptions and good figures of this form. The range, from the Cobourg to the Hull beds, is to be noted.

*Occurrence.* Cobourg beds, locality 25; Hull beds, locality 37. It is also reported from beds that have been correlated with these beds at Kirkfield, Ontario.

*Type.* G.S.C., holotype, No. 1415, missing, from an unspecified locality, Ottawa; plesiotype, No. 437, from Cobourg beds, steamboat landing, foot of Sussex street, Ottawa.

## Genus, **Carneyella** Foerste

### Genotype, *Agelacrinites pileus* Hall

Foerste[1] based his genus on the central plates at the junction of the arms. "The five plates occupying the interradial angles differ in form from the lateral covering plates characterizing the rays; this is true especially of the two anterior and of the conspicuous posterior supra-oral plates—and on the absence of accessory covering plates along the median line of the rays". To his genus he assigns "*Agelacrinus billingsi, Lebetodiscus chapmani, L. youngi, L. platys, L. multibrachiatus* and *Agelacrinus vetustus.*" The type of only one of these, *C. platys*, comes from this area. In it the vital oral region is obscure, as it is

[1] Foerste, A. F.: Sci. Lab., Denison Univ., Bull. 18, 1916, p. 341.

in some of the types of the other species. *Carneyella pileus* (Hall), the type species, has comparatively long and definitely flexed arms. Of the other species assigned to *Carneyella* by Foerste only *C. platys* Raymond has arms that are at all comparable in slenderness, and they are only slightly flexed.

Bassler[1] redefined *Carneyella,* limiting it to those forms that have four (1-4) arms with a contra-solar curve and one (5) with a solar curve, and assigned to *Hemicystites* the other species that have short, broad, and almost straight ambulacral arms.

### *Carneyella ? platys* Raymond

*Lebetodiscus platys* Raymond, Ottawa Nat. 29, 1915, p. 59, Pl. I, fig. 5.
*Carneyella platys* (Raymond), Geol. Surv., Canada, Mus. Bull. 31, 1921, p. 10, Pl. III, fig. 7.

Raymond assigned this species to *Carneyella,* but there is some cause for doubt. The central oral plates are not well preserved; the rays, almost straight, slightly curved contra-solar, are not flexed as in the type of the genus, and they end at the marginal ring of small plates.

*Occurrence.* Cobourg beds, locality 4.

*Type.* G.S.C., holotype, No. 7941, Cobourg beds, from an unspecified locality, Ottawa.

## Genus, **Hemicystites** Foerste

Genotype, *H. parasiticus* Hall

The genus is characterized by its short, broad, almost straight arms. Some species do show a tendency to a slight solar curve of the right posterior arm, and several have a curve to the right or the left of the anterior arm.

The genus is similar to *Carneyella* in having three oral plates, one large, posterior, and two small, anterior ones. For its differences see under *Carneyella.*

### *Hemicystites chapmani* (Raymond)

*Lebetodiscus chapmani* Raymond, Ottawa Nat. 29, 1915, p. 58, Pl. I, fig. 3.

This form is cited by Raymond from Ottawa, locality 4, and Hull, locality 34, but has not been seen by the writer from these localities.

It differs from *C. platys* in being smaller, having a proportionately wider outer ring of small plates, and the arms are less straight than in the preceding species, having a tendency to curve in a contra-solar direction. Like *C. platys* the arm-tips penetrate the edge of the large plates of the ring. It differs from *C. youngi* and *C. billingsi* in having a wider outer ring of plates and more slender arms.

*Occurrence.* Cobourg beds, locality 10(?); Hull beds, locality 47(?).

*Type.* G.S.C., holotype, No. 3235, not from this locality, but from the Sherman Fall beds at Peterborough, Ontario.

## Genus, **Isophorus** Foerste

Genotype, *Agelacrinites cincinnatiensis* Roemer

Foerste's original description of the genus merely states that the supra-oral plates differ only slightly from the lateral covering plates of the rays, and that accessory covering plates are present along the median line. To that it may be added that all the species cited as belonging to the genus have a number of small, irregular, supra-oral plates, and one of the rays is solar in direction. The arms usually are longer and more flexed than in the species described below. The genus differs from *Hemicystites* and *Carneyella* in having numerous oral plates instead of only three.

[1] Bassler, R. S.: Smiths. Instit. 93, No. 8, 1935, p. 4, and ibid., 95, No. 6, 1936, p. 10.

### *Isophorus ? inconditus* (Raymond)

*Lebetodiscus inconditus* Raymond, Ottawa Nat. 29, 1915, p. 61, Pl. I, fig. 1.
*Isophorus inconditus* Raymond, Geol. Surv., Canada, Mus. Bull. 31, 1921, p. 12, Pl. IV.

It is decidedly doubtful whether this species belongs in the genus *Isophorus*. It is like the genus in having small, irregular, oral plates and some accessory plates in the median line of the arms, but it differs in being much smaller than the other species described; in having a proportionately larger central oral region with more numerous, irregular plates, and in having short, stout arms, which end at a broad ring of marginal plates. The arms are straight, or rays I, II, and III show a faint contra-solar tendency, and V, and in some specimens IV, have a solar tendency.

Because of the lack of other species to confirm the constancy of these differences *I. inconditus* is left in *Isophorus* with a query.

*Occurrence.* Cobourg beds, localities 4, 23; Hull beds; cited, also, from beds that have been correlated with these beds at Kirkland, Ontario, but not in this region.

*Type.* G.S.C., holotype, No. 1409, not from this region but from Cobourg, Ontario.

### **Lepidiconia** nov. genus

(*lepis*—a scale, *eikos*—an image or likeness)

Genotype, *Lebetodiscus lorifrons* Raymond

The genus shows its likeness to *Lebetodiscus*, but is distinct from it. The distinguishing feature of *Lepidiconia* is the pore system. It has five pores on either side of each of its ambulacral covering plates. So far as can be ascertained, the pores on either side of each plate are opposite, but those of adjacent plates are alternate. The connection between the pores and the main ambulacral region cannot be ascertained.

In other respects *Lepidiconia* is small, the type measuring about 23 mm. in diameter; marginal ring wide, with very small plates; interambulacral plates few; oral plates indistinct, but apparently few and even smaller than the lateral arm plates; rays stout, standing well above the disk, without accessory plates along the median line, all flexed in a contra-solar direction, the upper surface of each turning outward as the arm approaches the edge, so that along the inner curve of the marginal ring the central ambulacral groove is oblique or vertical, to the upper disk.

*Lepidiconia* differs from other genera in its pore system. Raymond and Foerste apparently assumed that all Ordovician Agelacrinidae have one large pore between each side plate. In addition, the genus differs from *Carneyella* and *Isophorus* in the oral plates, and from *Lebetodiscus* in the well-defined ring of marginal plates.

### *Lepidiconia loriformis* (Raymond)

Plate IV, figure 2

*Lebetodiscus loriformis* Raymond, Ottawa Nat. 29, 1915, p. 56, Pl. I, fig. 6; Geol. Surv., Canada, Mus. Bull. 31, 1921, p. 7, Pl. II, fig. 9, Pl. III, fig. 2.

Besides the characteristics that separate this species from the genus *Lebetodiscus* it may be added to Raymond's description of this specimen that the arms are stout and long. They cover a large part of the disk surface, and rise considerably above it. The tip of one ray extends to, just touches, or ends beneath, the next, so that the outer coil of the rays is complete, leaving no space between them at this margin for interambulacral plates.

*Occurrence.* Cobourg beds, locality 4.

*Type.* G.S.C., holotype, No. 1414, Cobourg beds, from an unspecified locality, Ottawa.

## Genus, **Edrioaster** Billings

### Genotype, *Cyclaster bigsbyi* Billings

Large, discoidal; upper surface convex; under surface concave, probably attached; interambulacral plates not imbricate, covered with a membrane set with small plates and wrinkled in places. This feature has been described as tubercles on the plates, but the small plates can be seen over the sutures where the major plates have been separated, and wrinkles are present; on the under-surface inward from the edge are several rows of large plates with a central area of membrane, the small plates of which, according to Bather, pile up into five central lobes. In a specimen of *E. bigsbyi*, the only one to hand showing the aboral side, the membrane is piled in the form of an irregular triangular ridge surrounding a deep triangular depression; five rays, wide, but not very high above the disk, all but right posterior contra-solar, very long, passing to the underside; wide ambulacral groove with covering plates; side plates set alternately with two pores opening into the groove between adjacent plates; mouth with fine orals and some inter-orals.

Superficially *Edrioaster* more closely resembles *Lebetodiscus* than any of the other Edrioasteroidea. The most vital difference is in the ambulacral area. In *Lebetodiscus* the groove is narrow, and the single row of pores is along the outer side of the side plates. In *Edrioaster* the groove is a broad channel with covering plates, and has two sets of pores on the inner, groove-side of each of the side plates.

### *Edrioaster bigsbyi* (Billings)

*Cyclaster bigsbyi* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 293.
*Edrioaster bigsbyi* (Billings), Billings, Can. Org. Rem., dec. 3, 1858, p. 85, Pl. VIII, figs. 1 and 2; Jaekel, Stammes d. Pelmat. 1, Thecoidea u. Cyst., Berlin, 1899, p. 46, Pl. II, fig. 4; Bather, Treatise on Zool. pt. 3, Echinoderma, London 1900, p. 209, fig. 6.

This species has been well described and illustrated.

*Occurrence.* Cobourg beds, localities 4, 55; Hull beds, locality 34.

*Type.* G.S.C., cotypes, Nos. 1407, a, b, e, and f; plesiotype, No. 1403, Cobourg beds, all from an unspecified locality Ottawa.

## Genus, **Astrocystites** Whiteaves

### Genotype, *Astrocystites ottawaensis* Whiteaves

Pyriform, type specimen about 20 mm. in height and 17 mm. at the greatest diameter, which is above the middle; basals, 5?, radials 5, alternating with the basals, and receiving the distal ends of the ambulacrals; according to Bather's analysis, one large plate with a number of smaller ones in the interambulacral region; five spear-head plates at the summit between the ambulacrals, suggestive of the deltoid plates of blastoids; anus piercing one interambulacral plate and surrounded by numerous irregular plates; arms recumbent, broad, shallow, extending about halfway from the summit to the stem; floor a solid concave piece formed of the anchylosed plates; side of plates pierced by large pores, which, as shown by one broken area, lead down beneath the solid floor; ambulacral cover plates stout at the apex, where they combine with the spear-head plates to make a solid roof over mouth and food grooves; a clear space at the distal end of each arm from which radiate coarse striations or folds that cross the plates and meet corresponding folds on adjacent areas; a similar centre of radiation between each arm, the whole making a peculiar dendritic pattern; stem small, round, and composed of comparatively thin disks.

There is only one known species of the genus, so for lack of comparison it is not easy to define generic and specific characters.

The genus was originally defined as *Astrocystites* but changed by the author to *Steganoblastus* because of the similarity of the name to *Asterocystis*. Later Hudson again adopted Whiteaves' original name.

Its exact relationship is somewhat doubtful, but Bather considered the organization of the ambulacral area was more closely allied to *Edrioaster* than to any other.

*Astrocystites ottawaensis* Whiteaves

Plate IV, figure 1

*Astrocystites ottawaensis* Whiteaves, Can. Rec. Sci. 7, 1897, p. 287, figs. 1-3.

*Steganoblastus ottawaensis* Whiteaves, ibid., p. 395; Bather, Treatise on Zool., pt. 3, Echinoderma, 1900, p. 210, fig. 7; Whiteaves, Geol. Surv., Canada, Pal. Foss. 3, pt. 4, 1906, p. 316, figs. 21, 22, p. 321, figs. 23 and 24.

*Astrocystites ottawaensis* Whiteaves, Hudson, Jour. Geol. 33, 1925, p. 643, fig. 1, Pls. I-IV; Geol. Surv., Vermont, 15th Ann. Rept. 1927, pp. 97-110, Pls. VI-X.

This species has been well described and illustrated by drawings in the above papers. The actual photograph of the holotype is given here, and its exact horizon within the Trenton. The only three specimens known were loaned for study some years ago, and unfortunately only one was returned. The holotype then is the only specimen of the species and genus known in North America. It is rather remarkable that other specimens have not been found in view of the good preservation and the number of other cystids and edrioasteroids obtained from the same beds.

*Occurrence.* Cobourg beds, locality 10.

*Type.* G.S.C., holotype, No. 752, Cobourg beds, Booth street, Ottawa.

CRINOIDEA

CAMERATA

Genus, **Cleiocrinus** Billings

Genotype, *C. regius* Billings

Large, conical, pyriform or broadly expanding, dicyclic; 5 infrabasals covered by the stem, 5 basals and 5 radials, which alternate with one another; the resulting horizontal ring of ten plates rests upon the infrabasals and projects downward over the column; the second series above the radials bifurcates; brachials contiguous, bifurcating several times; plates at the sutures giving off fixed pinnules which when broken away leave a row of minute pore-like hollows; anal plate resting upon the truncated upper surface of one of the basals; no interbrachials except the vertical series upon the anal plate; pores in the sutures between the plates. Arms small, uniserial, simple; column obtusely pentagonal or nearly round.

The genus differs from others in the alternation of the five radials and five basals, all resting upon the infrabasals, in the great number of bifurcations of the brachials within the calyx, and in the lack of interbrachials.

*Cleiocrinus regius* Billings

Plate V, figure 2

*Cleiocrinus regius* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 277; Can. Org. Rem., dec. 4, 1859. p. 53, Pl. V, figs. 1a-1g; Miller, N. A., Geol. Pal. 1889, p. 232, fig. 264; Springer, Mus. Comp. Zool., Mem. 25, pt. 2, p. 110, Pl. I, figs. 1-10.

This form has been adequately described and illustrated. To the original description it may be added that there are from six to fifteen pores between the plate sutures. These are not to be confused with the pore-like scars of pin-

nules that, when seen at all, number only one to each plate and are not at the plate margin.

The form is distinguished from *C. magnificus* Billings by its smaller size and its elongate, conical shape, and from *C. sculptus* and *C. tessellatus* by its lack of ornament.

*Occurrence.* Cobourg beds, locality 4; Hull beds, locality 37.

*Type.* G.S.C., holotype, No. 1443a; paratypes, Nos. 1443 and 1443c; Cobourg beds, from an unspecified locality, Ottawa.

### *Cleiocrinus grandis* Billings

*Cleiocrinus grandis* Billings, Geol. Surv., Canada, Can. Org. Rem., dec. 4, 1859, p. 54, Pl. V, fig. 3.

Billings species is based on columns only.

*Occurrence.* Cobourg beds, locality 4.

*Type.* G.S.C., holotype, missing, though there are several other stems identified by Billings as belonging to his species.

### *Cleiocrinus magnificus* Billings

*Cleiocrinus magnificus* Billings, Geol. Surv., Canada, Can. Org. Rem., dec. 4, 1859, p. 54, Pl. V, fig. 3; Springer, Mus. Comp. Zool, Mem. 25, No. 2, 1905, p. 111, Pl. I, fig. 11.

This species has been well described and illustrated.

Billings' type is based upon a stem only, and comes from Ottawa. The exact locality is not specified, but all known Ottawa crinoids have been found in the Cobourg beds. Thirty years later a head was found by L. M. Lambe in the Hull quarries, in the Hull beds. A small, obscure piece of the stem is attached. It is much smaller than, but shows the thin ossicles characteristic of, the Billings type. In association with the calyx are other stems similar to the type. Springer, in his description of the calyx, has for this reason assumed that they belong to the same genus.

The form differs from *C. regius* in its great brachial development, resulting in a multiplicity of arms and a much broader, larger calyx; and the pores are less well preserved than in *C. regius*. They appear to be larger and fewer.

*Occurrence.* Cobourg beds, locality 4, Hull beds, locality 34.

*Type.* G.S.C., holotype, No. 1447, Cobourg beds, from an unspecified locality, Ottawa; plesiotype, No. 1592, Hull beds, from cement quarries, Hull, Que.

## Genus, **Reteocrinus** Billings

Genotype, *R. stellaris* Billings

Calyx obconical; dicyclic, infrabasals five, variable in size, sometimes barely protruding beyond the column; basals five, large, hexagonal, upper angles truncated to receive interbrachials; radials and brachials forming a strong median ridge that follows the bifurcations and passes into the arms; interbrachials depressed, numerous, small, separating the radials; anus on a small protuberance at end of anal series of plates, which is straight and ridged like the brachials; arms ten at origin, branching, uniserial, composed of interlocking cuneate ossicles; ventral disk depressed; column pentagonal.

*Reteocrinus* is readily distinguished by the prominence of the ornamental ridges on the radial, brachials, and anal series, elevated well above the depressions occupied by the small irregular interbrachials.

### *Reteocrinus stellaris* Billings

*Reteocrinus stellaris* Billings, Geol. Surv., Canada, Can. Org. Rem., dec. 4, 1859, p. 64, Pl. IX, figs. 4a-4e; Springer, Mus. Comp. Zool., Mem. 20, 1897, p. 178, Pl. IX, fig. 3a-3c; Geol. Surv., Canada, Mem. 15P, 1911, p. 10, pt. 1, figs. 6 and 7.

Nothing can be added to the description and illustrations of this species.

The species differs from *R. alveolatus* M. and G., the only other species cited from the Middle Ordovician, in the narrowness of the ossicles of the arms, giving them a more slender appearance.

*Occurrence.* Cobourg beds, locality 4; Hull beds, locality 37.

## Genus, **Archaeocrinus** Wachsmuth and Springer

Genotype, *Glyptocrinus lacunosus* Billings

Obconical or suboval; base usually concave; dicyclic; infrabasals small, rarely extending beyond the column and usually resting within the cavity formed by the basals; basals heptagonal, upper surface truncated; radials not in contact, pentagonal in three rays, in two posterior rays frequently hexagonal; brachials of second order incorporated in cup; interradials numerous, one between radials much larger, two in the second range; anal interradius slightly distinguished by an additional plate in the second range, without a tube; plates smooth or ornamented; radials and brachials marked by an obscure, flattened ridge, which becomes more conspicuous approaching the arms; arms ten at origin of free arms and branching, composed of two rows of cuneiform pieces alternating and interlocking; ventral disk of small irregular pieces; column round, nodal points projecting well over internodal ones; axial canal large, pentalobate.

*Archaeocrinus* differs from *Rhodocrinus* in having a relatively larger calyx, shorter arms, and only two interbrachials in the second range where *Rhodocrinus* has three. The genus differs from *Glyptocrinus* in being dicyclic, in having a concave base, in having radials not in contact, and in having the free arms made up of interlocking and alternating ossicles.

### *Archaeocrinus lacunosus* (Billings)

*Glyptocrinus lacunosus* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 261; Can. Org. Rem., dec. 4, 1859, p. 61, Pl. VIII, figs. 3a, 3b.

*Archaeocrinus lacunosus* (Billings), Wachsmuth and Springer, Mus. Comp. Zool., Mem. 20, 1897, p. 255, Pl. X, fig. 1.

This form has been well described and illustrated. It differs from other species in its pitted ornamentation and in the lack of prominence of the median ridge leading up to the arms.

*Occurrence.* Cobourg beds, locality 4.

*Type.* G.S.C., holotype, No. 1589a; paratype, No. 1589; Cobourg beds, from an unspecified locality, Ottawa.

### *Archaeocrinus desideratus* W. R. Billings

*Archaeocrinus desideratus* W. R. Billings, Ottawa Field Nat. Club, vol. 2, Trans. 6, 1884, p. 249, 2 plates; Wachsmuth and Springer, Mus. Comp. Zool., Mem. 20, 1897, p. 257, Pl. X, figs. 4a, 4b; Bather, Treatise on Zool. 3, Echinoderma, 1900, p. 200, fig. 125.

The form has been well described and illustrated. It differs from *A. lacunosus* Billings in its subglobose form, its coarser arms, large, broad basals, and its depressed basal areas.

*Occurrence.* Cobourg beds, localities 10, 18.

*Type.* G.S.C., cotypes, Nos. 1508c and 1508d; plesiotypes, Nos. 1508a and 5595. Wachsmuth and Springer state that 5595 is the holotype, but reference to W. R. Billings' illustrations shows that this is an error. All are from Booth street, Ottawa.

### *Archaeocrinus microbasalis* (Billings)

*Thysanocrinus microbasalis* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 264.

*Rhodocrinus microbasalis* (Billings), Can. Org. Rem., dec. 4, 1859, p. 63, Pl. VI, fig. 2.

*Archaeocrinus microbasalis* Billings, Wachsmuth and Springer, Mus. Comp. Zool., Mem. 20, 1897, p. 256, Pl. X, figs. 2a-c.

This species is adequately described and illustrated. It differs from *A. lacunosus* in being longer and proportionately narrower, in having the arms stouter at the base, and in the ornamentation. The plates of *A. lacunosus* are pitted, the pits in some cases more or less in rows from the centre. *A. microbasalis* has a radiate ornamentation; the ridges originating from the centre are the stronger, but they are often paralleled by shorter ridges.

*Occurrence.* Cobourg beds, locality 20; Hull beds, locality 46.

*Type.* G.S.C., holotype, No. 1450a; paratypes, Nos. 1450 and 1450b; Cobourg beds, from an unspecified locality, Ottawa; plesiotypes, Nos. 1500s and 1520, Hull beds, from cement quarries, Hull, Quebec.

### *Archaeocrinus pyriformis* (Billings)

*Thysanocrinus* (*Rhodocrinus*) *pyriformis* Billings, Geol. Surv., Canada, Rept. of Prog., 1853-56 (1857), p. 262.

*Rhodocrinus pyriformis* (Billings), Can. Org. Rem., dec. 4, 1859, p. 61, Pl. VI, figs. 1a-1d.

*Archaeocrinus pyriformis* (Billings), Wachsmuth and Springer, Mus. Comp. Zool., Mem. 20, 1897, p. 255, Pl. X, figs. 3a, b.

This form is well described and illustrated. It differs from both the preceding in having smooth plates, and from *A. microbasalis* in having its interbrachials 1, 2, 2, 2, instead of 1, 2, 3, 3.

*Occurrence.* Cobourg beds, localities 20, 25.

*Type.* G.S.C., cotypes, Nos. 1446b and 1446c, Cobourg beds, from steamboat landing, foot of Sussex street, Ottawa.

### *Archaeocrinus ottawaensis* n.sp.

Plate V, figure 1

The only specimen found is poorly preserved, but it does not belong to any other described species.

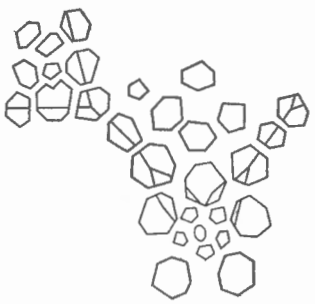


Figure 1. *Archaeocrinus ottawaensis* n.sp., showing the arrangement of the plates.

Calyx globose slightly flattened on top, 25 mm. in horizontal diameter, about 20 mm. in height, upper part obscure; infrabasals small; basals large, pentagonal; first and only complete brachial preserved branching on third radial;

two plates in secondary rays; interbrachials 1, 2, 1, followed by a few smaller plates; body plates pentagonal or hexagonal; cover plates numerous, rather obscure, but apparently irregular; ten unbranching arms both uniserial and biserial, pinnules long and slender, closely packed; ornamentation originating in basals as a V-shaped ridge, one branch to each of contiguous radials; these centrally placed ridges lead directly to the third radial, divide, and thence lead to arms; all plates have similar but less pronounced ridges radiating from the centre and directed towards the margins connecting with the ridges of adjacent plates; ornamentation more evident near the base.

The form is more simple than other Trenton species, more globose than any except *A. desideratus* W. R. Billings, but it differs from that as from the others in the number of arms, the number of plates in the secondary rays, and in the number, arrangement, and shape of the interbrachials.

*Occurrence.* Cobourg beds, locality 12.

*Type.* G.S.C., holotype, No. 9067, Cobourg beds, from the corner of Rochester and Lydia streets, Ottawa.

cf. *Archaeocrinus ottawaensis* n.sp.

A worn specimen is doubtfully referred to this species. The ornamentation is largely obliterated, but otherwise it corresponds.

*Occurrence.* Cobourg beds, locality 9.

Genus, **Glyptocrinus** Hall

Genotype, *G. decadactylus* Hall

Outline obconical to subglobose; monoclinic; basals five, radials five, all in contact; brachials elevated with a median ridge, leaving a depression between the arm plates; interbrachials numerous, 1, 2, 2 or 3; on the posterior side supplementary anals, which in some cases form a continuous series; anus at the end of a small protuberance; arms ten to twenty, rarely branching beyond the second bifurcation. Wachsmuth and Springer, in comparing the genus with *Mariacrinus* (Mus. Comp. Zool., Mem. 20, p. 269), refer to the arms as uniserial, but Billings' diagram of the genus, his paratype of *G. ramulosus*, and Wachsmuth and Springer's own illustration of *G. ramulosus* show biserial arms at the tips, on opposite sides of a single series of short, slightly wedge-shaped ossicles; plates ornamented by radial striæ.

The genus is most readily distinguished from *Archaeocrinus* in that the radials of *Glyptocrinus* are in contact.

*Glyptocrinus ottawaensis* n.sp.

*Glyptocrinus ramulosus* Billings, Geol, Surv., Canada, Can. Org. Rem., dec. 4, 1859, Pl. VII, fig. 2a; Wachsmuth and Springer, Mus. Comp. Zool., Mem. 20, 1897, p. 273, Pl. XX, fig. 5b.

This form, first illustrated by Billings as *G. ramulosus*, has been further described and re-illustrated by Wachsmuth and Springer. It differs from *G. ramulosus*, as originally described and figured, in general form, in being considerably larger, in having larger plates, and in that the secondary brachials are 5 to 6 in number instead of 4. For these reasons the form has been separated from *G. ramulosus*.

*Occurrence.* Hull beds, localities 34, 36, 37.

*Type.* G.S.C., holotype, No. 1456, Hull beds, cement quarries, Hull, Quebec. The stems, as illustrated by Billings, may or may not belong to this species.

### *Glyptocrinus marginatus* Billings

*Glyptocrinus marginatus* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-1856 (1857), p. 260; Can. Org. Rem., dec. 4, 1859, p. 59, Pl. IX, fig. 1a.

*Archaeocrinus marginatus* (Billings), Wachsmuth and Springer, Proc. Acad. Nat. Sci., Phila., 1881, p. 364.

*Glyptocrinus marginatus* Billings, Springer, Mus. Comp. Zool. Harvard, Mem. 20, pp. 254, 275, Pl. XX, fig. 2.

No further specimen has been found. It has been described and illustrated as adequately as the state of the specimen permits.

The species is monoclinic, and the radials are in contact, which precludes its being an *Archaeocrinus,* as listed by Springer in 1881. Springer later revised his classification. The posterior part with the crushed extra anal plates gives the form a superficial resemblance to *Archaeocrinus.*

The distinguishing feature of the species is the raised margin of each plate.

*Occurrence.* Cobourg beds, locality 4.

*Type.* G.S.C., holotype, No. 1523, Cobourg beds, from an unspecified locality, Ottawa.

### *Glyptocrinus quinquepartitus* Billings

*Glyptocrinus quinquepartitus* Billings, Geol. Surv., Canada, Can. Org. Rem., dec. 4, 1859, Pl. VIII, figs. 3a and 3b.

This species is based upon a worn stem, and has very little value.

*Occurrence.* Cobourg beds, locality 4.

*Type.* G.S.C., holotype, No. 1526, Cobourg beds, from an unspecified locality, Ottawa.

### *Glyptocrinus ramulosus* Billings

*Glyptocrinus ramulosus* Billings, Can. Jour., N.S. 1, 1856, p. 165; Can. Nat. and Geol. 1, 1857, p. 49, fig. 1, p. 54, fig. 3, p. 55, figs. 4-8; Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 258; Can. Org. Rem., dec. 4, 1859, p. 57, Pl. VIII, fig. 1a (possibly figs. 1b-1d).

Billings first described *G. ramulosus* as having its first radial division in the third plate, and four secondary brachials. The holotype (Can. Nat. and Geol. 1, p. 54, fig. 3) is poorly preserved, but has the proportions of this arrangement, and the small plates and pinnules as described. The calyx, however, was evidently described from the paratype, figured later (Can. Org. Rem., dec. 4, Pl. 8, fig. 1a), and from other specimens mentioned.

Later (Can. Org. Rem., dec. 4, p. 57, Pl. 7, fig. 2a) Billings repeated the description of *G. ramulosus,* but in addition figured a form that is larger than the original type and differs considerably from it in outline, and in size and number of the plates. The latter specimen is here described under the name *G. ottawaensis.*

*Occurrence.* Cobourg beds, locality 26; Sherman Fall beds, locality 35; Hull beds, locality 47.

*Type.* G.S.C., holotype, No. 1456m, Hull beds, from cement quarries, Hull, Quebec; paratype, No. 1579; Hull beds, from Brigham Lake, Hull, Quebec.

## Genus, **Schizocrinus** Hall

Genotype, *S. nodosus* Hall

Obconical; basals 5, narrow, pentagonal; radials 5, heptagonal; brachials branching on the fourth in the series, which seems to be longitudinally divided; arms stout, branching, single jointed; anal tube not known.

The distinguishing character is said to be the longitudinally divided fourth brachial. The original material was poor, and Wachsmuth and Springer[1] consider the genus may be a *Glyptocrinus* or, perhaps, an ancestor to it.

### *Schizocrinus nodosus* Hall

*Schizocrinus nodosus* Hall, Pal. New York, 1, 1847, p. 81, Pl. XXVII, figs. 1a-b.

This species has been listed from Paquette Rapids in the Rockland-Leray beds. No such form has been seen by the writer. As the genus is doubtful, it is probable that the identification is not valid.

## Genus, **Pycnocrinus** Miller

Genotype, *P. shafferi* Miller

*Pycnocrinus* is essentially the same as *Glyptocrinus*. The main difference is that there are no secondary radials within the cup. In some species the free arms divide again.

### *Pycnocrinus ornatus* (Billings)

*Glyptocrinus ornatus* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 260; Can. Org. Rem., dec. 4, 1859, p. 60, Pl. IX, figs. 2a, b; Wachsmuth and Springer, Mus. Comp. Zool., Mem. 20, 1897, p. 274, Pl. XX, figs. 6a, b.

No further description or illustration of the form is necessary. The ornamentation is very similar to that of *G. dyeri* (Meek) and *G. decadactylus* Hall, but the calyx is more rounded at the base than either of these species.

*Occurrence.* Cobourg beds, localities 4, 10; Hull beds, localities 46, 47.

*Type.* G.S.C., holotype, No. 1524, Cobourg beds, from an unspecified locality, Ottawa.

## Genus, **Periglyptocrinus** Wachsmuth and Springer

Genotype, *P. billingsi* Wachsmuth and Springer

*Periglyptocrinus* is essentially the same as *Glyptocrinus*, but differs in its development, in that the basals are longer, producing a more slender tapering base, and the arms have a well-developed biserial arrangement of the pinnules.

### *Periglyptocrinus billingsi* Wachsmuth and Springer

*Periglyptocrinus billingsi* Wachsmuth and Springer, Mus. Comp. Zool., Mem. 20, 1897, p. 277, Pl. XXI, figs. 1a, 1b.

This form has been clearly described and illustrated. It is easily separated from *P. priscus* (Billings) because of its larger size.

*Occurrence.* Hull beds, locality 46.

*Type.* G.S.C., cotypes, Nos. 1499a and 1499b, Hull beds, from cement quarries, Hull, Quebec.

---

[1] Wachsmuth and Springer: Acad. Nat. Sci., Phila., Proc. 1881, p. 394.

*Periglyptocrinus priscus* (Billings)

*Glyptocrinus priscus* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 257; Can. Org. Rem., dec. 4, 1859, p. 56, Pl. VII, figs. 1a-1f.

*Periglyptocrinus priscus* (Billings), Wachsmuth and Springer, Mus. Comp. Zool., Mem. 20, 1897, p. 278, Pl. XXI, fig. 2.

This species has been adequately described and illustrated. It is readily distinguished from *P. billingsi* Wachsmuth and Springer by its small size.

*Occurrence.* Rockland or Leray beds, locality 1.

*Type.* G.S.C., holotype, No. 1522, Leray or Rockland beds, Fourth Chûte of Bonnechère River, Renfrew county, Ontario.

## Flexibilia

### Genus, **Protaxocrinus** Springer

Genotype, *Taxocrinus ovalis* Angelin

Crown elongate; infrabasals small; posterior basal elongate; radianal as infer-radial directly under the right posterior radial; anal plates tending to be in contact with the right posterior rays without intervening brachials; elsewhere interbrachials few or wanting; lower part of interbrachial areas occupied by a plate or peristome, in some cases not appearing externally; arms dichotomous, diverging; column round, slightly enlarged near the calyx.

The genus is characterized by the insignificance of interbrachials, if present at all, with the consequent close-fitting, almost parallel brachials taking part in the calyx, though loosely knit.

*Protaxocrinus elegans* (Billings)

*Lecanocrinus elegans* Billings, Geol. Surv., Canada, Can. Org. Rem., dec. 4, 1859, p. 47, Pl. IV, fig. 4.

*Protaxocrinus elegans* (Billings), Springer, Smith. Instit., The Crinoidea Flexibilia, 1920, p. 346, Pl. 45, fig. 1.

The form has been well described and illustrated. It can readily be distinguished from *P. laevis* (Billings) by the subangular ridge on the radials and brachials within the calyx.

*Occurrence.* Cobourg beds, locality 4.

*Type.* G.S.C., holotype, No. 1433, Cobourg beds, from an unspecified locality, Ottawa.

*Protaxocrinus laevis* (Billings)

*Lecanocrinus laevis* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 278; Can. Org. Rem., dec. 4, 1859, p. 47, Pl. IV, fig. 3.

*Protaxocrinus laevis* (Billings), Springer, Geol. Surv., Canada, Mem. 15P, 1911, p. 11, Pl. III, figs. 10, 11, and 11a; Smith. Instit., The Crinoidea Flexibilia, 1920, p. 348, Pl. XLV, figs. 2, 5a, and 5b.

This species has been adequately illustrated. Billings distinguished this form from *P. elegans* by its short length, four instead of five joints in the secondary rays, and by having the upper part of the column round and smooth. Springer added that the joints in the secondary rays vary from four to five, and that the basal joints are smooth, not angular as in *P. elegans*. To this may be added that the interbrachials are arranged 1, 2, 1. Both radials and interbrachials are on the same plane in marked distinction from *P. elegans*. Because of this arrangement the "cup" of *P. laevis* has an appearance of being considerably larger proportionally than that of *P. elegans*.

*Occurrence.* Cobourg beds, localities 4, 38.

*Type.* G.S.C., holotype, No. 1442; paratype, No. 1442a; Cobourg beds, from an unspecified locality, Ottawa.

INADUNATA

Genus, **Hybocrinus** Billings

Genotype, *H. conicus* Billings

Calyx globular or pyriform, unsymmetrical, one side protruding; monoclinic; basals 5, pentagonal; radials 5, of which four are large and the right posterior one small; infer-anal plate in the same ring as the four large radials and almost as large, hexagonal, bearing the small right posterior radial on its right shoulder and the super-anal on its left; anal tube not extending far beyond the cup; arm facets small, round, less than width of a radial; arms simple, uniserial, non-pinnulate, made up of rather heavy quadrangular joints; ambulacral furrows on the arms, covered by small, alternating pieces, about five to each arm-joint; column round and small.

The genus is easily recognized by its unsymmetrical form, and by the position of the infer-anal plate.

*Hybocrinus conicus* Billings

*Hybocrinus conicus* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 274; Can. Org. Rem., dec. 4, 1859, p. 29, Pl. II, figs. 2a, 2b.

Nothing can be added to the description and the illustration. The form is large for the genus, and the long slender basals give the calyx the outline of an inverted cone, which distinguishes it from other species.

*Occurrence.* Cobourg beds, localities 4, 10, 23, 39.

*Type.* G.S.C., cotypes, Nos. 1418 and 1418a, Cobourg beds, from an unspecified locality, Ottawa.

*Hybocrinus tumidus* Billings

*Hybocrinus tumidus* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 275; Can. Org. Rem., dec. 4, 1857, p. 28, Pl. II, figs. 1a-1e; Springer, Mem. 15P, 1911, p. 19, Pl. V, fig. 5.

Nothing can be added to the description and illustration. An additional specimen indicates the horizon.

The species is considerably smaller than *H. conicus* and the plates more tumid.

*Occurrence.* Cobourg beds, localities 4, 20; Sherman Fall beds ?, locality 35; Hull beds, locality 37.

*Type.* G.S.C., cotypes, Nos. 1419b and 1419c, Cobourg beds, from an unspecified locality, Ottawa. Other cotypes missing.

Genus, **Heterocrinus** Hall

Genotype, *H. heterodactylus* Hall

Calyx subcylindrical, very small, monoclinic; basals small; radials very irregular, two compound, bisected transversely, the other three simple, but nearly as large as the two segments of the compound radials; the compound radial upon which the anal plate rests is designated super- and infer-radianal by Moore and Laudon (Geol. Soc. Amer., Spec. Paper 46, p. 27, 1943); anal tube delicate and straight, first anal plate resting on the shoulders of both posterior radials; arms ten, uniserial, long, cylindrical, irregularly divided, somewhat divergent, single joints alternately joined with pinnules from every second joint; stem pentagonal, axial; canal pentalobate, with lobes directed interradially.

The species differs from *Ectenocrinus* in that the anal plate rests against the left posterior radial rather than half upon it. But the calyx of both genera included here is small, and many specimens are poorly preserved, so that in many specimens the irregularly dividing arms are the only recognizable distinctive feature.

### *Heterocrinus tenuis* Billings

*Heterocrinus* tenuis Billings, Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 273; Can. Org. Rem., dec. 4, 1859, p. 50, Pl. IV, figs. 6a, 6b; Pl. X, figs. 1a-1c.

The form has been described and illustrated as well as possible from the rather poor material. The particular characteristics are the small size and the proportionately long basals, which give the calyx a very slender outline in contrast with the somewhat spreading arms. Billings refers the species to *Heterocrinus* with some doubt, because the specimens are half buried in the matrix. But it is like that genus, in so far as the plates can be seen, in size and in the irregular branching of the arms, but, according to Billings, differs from it in that "the column continues moniliform to the base of the cup". Specimens have been found, however, with a tendency to be pentagonal for a short distance below the cup.

The species differs from *H. heterodactylus* Hall mainly in its more slender and proportionately larger calyx.

*Occurrence.* Cobourg beds, localities 4, 9, 13, 38, 39, 52, 53; Sherman Fall beds, locality 44; Hull beds, localities, 34, 37.

*Type.* G.S.C., holotype, No. 1438, Cobourg beds, from an unspecified locality, Ottawa.

## Genus, **Ectenocrinus** Miller

Genotype, *Heterocrinus simplex* Hall

Calyx small, subcylindrical, moderately expanding; monocyclic; basals 5, unequal; radials irregular, 3; the right posterior, right anterior, and left anterior being compound, bisected transversely, the other two radials being simple but large. As in *Heterocrinus*, Moore and Laudon designate the posterior compound radial as super- and infer-radianal plates (op. cit.); anal plates three, above one another; arms uniserial, heterotomous, two main branches, straight, close, formed of a continuous series of wedge-shaped ossicles; stem round or sub-pentagonal, and expanded at the base of the calyx.

As mentioned above, the calyx differs from *Heterocrinus* in that the anal plate rests upon the left posterior radial rather than equally upon both left posterior radial and right posterior super-radial. It is also peculiar for its slender form, due to the close fitting arms, which bifurcate only at the top of the calyx, and to the flattened surface of the calyx plates and of the arm ossicles.

### *Ectenocrinus canadensis* (Billings)

Plate VI, figure 8

*Heterocrinus canadensis* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 273; Can. Org. Rem., dec. 4, 1859, p. 48, Pl. IV, figs. 5a-5d.

*H. grandis* Meek, Pal. Ohio, 1, 1873, p. 9, Pl. I, figs. 7a-7c; Miller, North Amer. Geol. Pal. 1889, p. 242.

Two of Billings' types are here refigured to show the plate arrangement more clearly. Billings' terminology of the orientation is reversed by modern usage, the anal plate being considered the posterior. The description then would be that the left posterior ray has three joints, the lower one, the radial, being simple but large. The arrangement of compound and simple radial

plates is typical of the genus. Both left and right posterior radials are truncated on the upper edge to receive the anal plate. When preserved, the ossicles of the free arms are wedge-shaped and alternate in position two by two.

The form is identical with *E. grandis* Meek as published and described. The writer has not seen the type. It may be identical with *E. simplex* Hall. If so, Hall's species has priority. *E. canadensis* Billings, however, differs from Hall's original description of *E. simplex* in having the stem round just beneath the calyx. It may be that this was a variable feature, for Meek later redescribes *E. simplex* as having a round column. Also, in descriptions of *E. simplex* no mention is made of the alternation of the arm ossicles by twos. This may be due to the state of preservation, as was the case in the original description of *E. canadensis*. If, however, *E. simplex* lacks this feature it would constitute a specific difference.

*Occurrence.* Cobourg beds, localities 4, 9, 20, 30, 38, 39, 57, 58; Sherman Fall beds, locality 54; Hull beds, localities 37, 44, 47.

*Type.* G.S.C., cotypes, Nos. 1441, 1441b, and 1441h, Cobourg beds, from an unspecified locality, Ottawa.

## Genus, **Iocrinus** Hall

Genotype, *Actinocrinus subcrassus* (Meek and Worthen)

In form an inverted pyramid with five sides deeply concave; monoclinic; basals small, pentagonal; radials large, strong, all of the same height, the right posterior compound, the lower part the larger super-radial supporting an arm on its right side and a series of anal plates on its left; brachials three to four in each ray, the upper one supporting the free arms; anal plates forming a tube of complicated structure, the first anal plate entirely above the radials; arms dichotomous, branching frequently, ossicles projecting and giving an imbricating appearance; column pentagonal.

The genus differs from *Heterocrinus* and *Ectenocrinus* in being more broadly expanding, and in being symmetrical to the top of the radials.

### *Iocrinus similis* (Billings)

Plate V, figure 3

*Dendrocrinus similis* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 267; Can. Org. Rem., dec. 4, 1859, p. 40.

Billings' original description states "cup, small, conical and subpentagonal" and then continues with a discussion of the arms. There is no illustration, but fortunately the type is available. Though poorly preserved the plates are sufficiently distinct to show that it is an *Iocrinus*.

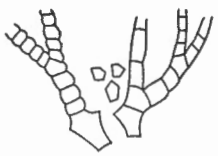


Figure 2. *Iocrinus similis* (Billings), showing the arrangement of the plates.

*Emended Description.* Calyx small, pentagonal; monoclinic; basals missing, but the space shows them to have been comparatively small and pentagonal; radials long, strong, the two visible ones pentagonal, wider above than below, somewhat rounded on the central axis and concave at the sutures; right posterior radial dividing transversely, its super-radial bearing an arm on its right upper facet and the basal plate of the tube on its left; anal plate separated

from the left posterior radial by a number of small indistinct plates of the anal tube; most of the irregular plates of the tube are obliterated, but the central prominent line of narrow cylindrical plates is distinct for a short distance; free arms dividing at the fourth plate above the left posterior radial, and at the third plate above the right posterior super-radial; arms long, slender, uniserial, as far as can be seen (apparent pinnules in the illustration are tool marks), irregularly divided, and composed of cylindrical ossicles.

*I. similis* Billings lacks the horizontally marked plates of the tubes of *I. subcrassus* and *I. trentonensis*. Its tube is more like that of *I. crassus*, but it can be distinguished from that species by its smaller size, more slender calyx, and more slender arms.

*Occurrence.* Cobourg beds, localities 4, 29, 39.

*Type.* G.S.C., holotype, No. 1428, Cobourg beds, from an unspecified locality, Ottawa.

### *Iocrinus subcrassus* Meek and Worthen

*Actinocrinus subcrassus* Meek and Worthen, Geol. Surv., Illinois, 3, 1868, p. 325, Pl. IV, figs. 5a-5d.

*Iocrinus subcrassus* M. and W., Wachsmuth and Springer, Proc. Acad. Nat. Sci., Phila., 1879, p. 295.

Several specimens of the species have been found.

In size and robustness the species lies betwen *I. trentonensis* Walcott, from the Trenton, and *I. crassus* (Meek and Worthen), from the Richmond. It can be readily distinguished from *I. crassus* by the horizontal plates of the anal tube, and from *I. trentonensis* by its much greater size.

*Occurrence.* Cobourg beds, locality 4; Hull beds, localities 34, 47.

### *Iocrinus* cf. *subcrassus* Meek and Worthen

Plate VI, figure 7

The plates, arms, and upper part of the tube of the specimen correspond with *Iocrinus subcrassus*. The base of the tube and the right posterior radial plate are crushed. Between the left posterior brachial and the one anterior to it are a few irregular plates, one comparatively large, the rest small, each plate bearing a prominent tubercle. The plates may be a part of the base of the anal tube or part of the tegmen. The preservation is too poor to be definite, but such plates have not been illustrated in other specimens.

*Occurrence.* Cobourg beds, localities 4, 29.

*Type.* G.S.C., plesiotype, No. 9068, Cobourg beds, Rideau Hall grounds, Ottawa.

## Genus, **Cremacrinus** Ulrich

Genotype, *C. punctatus* Ulrich

Calyx asymmetrical, curved back on the column; monoclinic; basals 4, anchylosed in some species, joined by suture in others; radials 4, left anterior, right posterior, and right anterior compound, the right posterior and the right anterior being at opposite sides each on its own infer-radial, so that instead of being adjacent they are separated from one another by the upper part of their respective infer-radials; simple, stout tube with lowest plate resting on the right posterior super-radials; three primary arms, one compound, bearing long, tapering, rather coarse pinnules; column round.

*Cremacrinus* is readily distinguished from other Ordovician Inadunata by its pendant habit, its asymmetry, and the number of arms.

### *Cremacrinus articulosus* (Billings)

Plate VI, figure 5

*Heterocrinus articulosus* Billings, Geol. Surv., Canada, Can. Org. Rem., dec. 4, 1859, p. 51, Pl. IV, fig. 8.

The type specimen is here refigured to show the shape of the individual plates. Nothing can be added to the description, except to state that, when an enlarged plate in the arms divides, the basal plate of each new branch is also enlarged, the second plate of the branch being reduced to normal size.

*Occurrence.* Cobourg beds, locality 4.

*Type.* G.S.C., holotype, No. 1445, Cobourg beds, from an unspecified locality, Ottawa.

### *Cremacrinus billingsiana* Ringueberg

*Castocrinus billingsiana* Ringueberg, New York Acad. Nat. Sci. Amer. 4, 1889, p. 394, Pl. X, fig. 3.

This species was described from a species of W. R. Billings. The type was not in his collection, nor has any other specimen been found.

The author of the species separates it from other species of the genus by its anchylosed base.

*Occurrence.* Cobourg beds, locality 4.

### *Cremacrinus furcillatus* (W. R. Billings)

*Calceocrinus furcillatus* W. R. Billings, Ottawa Nat. 1, 1887, p. 51, fig.
*Castrocrinus furcillatus* (W. R. Billings), Ringueberg, New York Acad. Sci. 4, 1889, p. 393, Pl. X, fig. 1.

The type specimen as described by W. R. Billings was not found in his collection. The genus *Castocrinus* has been considered synonymous with *Cremacrinus* so that this species is here placed under the latter genus.

*Occurrence.* Cobourg beds, locality 10.

### *Cremacrinus inaequalis* (Billings)

Plate V, figure 4

*Heterocrinus inaequalis* Billings, Geol. Surv., Canada, Can. Org. Rem., dec. 4, 1859 p. 51, Pl. IV, fig. 7a.
*Calceocrinus inequalis* (Billings), Wachsmuth and Springer, Proc. Acad. Nat. Sci. Phila., 1886, pp. 136, 205.
*Cremacrinus inaequalis* (Billings), Ulrich, 14th Ann. Rept. Geol. Nat. Hist. Surv., Minnesota, 1886, pp. 111, 113.
*Castrocrinus inaequalis* (Billings), Ringueberg, Ann. New York Acad. Sci. 4, 1889, p. 395, Pl. X, fig. 5.

The type specimen of the species is here re-illustrated. The species, somewhat doubtfully referred by Billings to *Heterocrinus*, has been assigned to one genus after another. A crucial part of the specimen is buried in a hard matrix. The basals, radials, and super-radials are visible, and the number of arms are of the *Cremacrinus* type. The minute plates between the basals and radials of *Cremacrinus*, as described by Ulrich, are not present, but there is a space where they might have been. Ringueberg refers the genus to *Castrocrinus* stating that "the consolidated basal piece (is) composed of two anterior and two lateral basals".

*Occurrence.* Cobourg beds, locality 4.

*Type.* G.S.C., holotype, No. 1444, Cobourg beds, from an unspecified locality, Ottawa.

## Genus, **Cupulocrinus** d'Orbigny

Genotype, *Scyphocrinus heterocostalis* Hall

Dicyclic; infrabasals 5, wider than high; basals 5, large, four hexagonal, fifth heptagonal and supporting the base of anal plate and on either side of it the left and right posterior radials; radials smaller than basals; facets wide, shallow, nearly straight; anal plate small, in line with but lower than radials, truncated above; second anal plate above left posterior radial, but partly supported on right by right radial and first right brachial, or by the infer- and super-radianal as designated by Moore and Laudon (op. cit., p. 53); anal tube prominent, tapering, large, smooth plates, dorsally rounded; loose, small, irregular interbrachials occasionally present; arms branching, uniserial.

The genus is most easily confused with *Dendrocrinus*, but differs in having wide brachial facets and a narrower anal tube, and the right posterior radial is not compound as in that genus.

### *Cupulocrinus conjugans* (Billings)

Plate VI, figure 6

*Dendrocrinus conjugans* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 268; Can. Org. Rem., dec. 4, 1859, p. 41, Pl. IV, figs. 1a-b, 2a-b.

The holotype is refigured to show the plate arrangement.

*C. conjugans* differs from *C. humilis* and *C. jewetti* in its slender arms, in having the anal tube relatively stronger than the arms, and in its relatively wider interbrachial spaces.

*Occurrence.* Cobourg beds, locality 4.

*Type.* G.S.C., cotypes, Nos. 1429 and 1429a, Cobourg beds, from an unspecified locality, Ottawa.

### *Cupulocrinus humilis* (Billings)

*Dendrocrinus humilis* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 270; Can. Org. Rem., dec. 4, 1859, p. 39, Pl. III, fig. 3.

The form has been well described and illustrated. Unfortunately Billings' type has been lost.

*C. humilis* differs from *C. jewetti* in having smooth plates flush with one another without depressed sutures, in having the anal tube evenly rounded without keel, and in having the stem enlarged at the base of the calyx. The species is distinguished from *C. conjugans* by its broader arms and consequent narrow interbrachial space.

*Occurrence.* Cobourg beds, locality 4; Sherman Fall beds, locality 54.

*Type.* Holotype missing. A plesiotype comes from Kirkfield, Ontario.

## Genus, **Dendrocrinus** Hall

Genotype, *D. longidactylus* Hall

Elongate, slender, obconical, unsymmetrical; dicyclic; infrabasals, five, small; basals 5, the largest plates in the calyx, four hexagonal, equal, the fifth truncate above; radials 5, four simple, the right posterior resting upon a radianal plate; radials hexagonal, with semicircular arm facets about one-third width of plate, and occupying the upper angle; anal plate in line with the radials, resting on the truncated basal radial, and against the radianal and right posterior radial; tube with wide, long, hexagonal plates; brachials 2 to 5; arms narrow, long, branching, ambulacral furrow deep; pinnulæ wanting; column pentagonal or, exceptionally, round.

Superficially it resembles *Heterocrinus* because of its slender form, but differs radically in being dicyclic, in its large basal plates, in having more regular radial plates, of which only one is compound instead of three, and the first anal plate rests upon the basal not on the two adjacent radial plates. For other differences see under *Cupulocrinus*.

### *Dendrocrinus acutidactylus* Billings

*Dendrocrinus acutidactylus* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 266; Can. Org. Rem., dec. 4, 1859, p. 37, Pl. III, figs. 2a-2b.

The type of this species comes from Montreal, but the species occurs in the Ottawa-St. Lawrence area, and is characterized by its small size and extremely slender arms.

*Occurrence.* Cobourg or Hull beds, locality 4 or 34.

### *Dendrocrinus gregarius* Billings

Plate VI, figure 4

*Dendrocrinus gregarius* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 265; Can. Org. Rem., dec. 4, 1859, p. 36, Pl. III, figs. 1a-1c.

Nothing is added to the description.

The species is to be distinguished from the *D. proboscidiatus* by the lack of the transverse ridges on the plates of the proboscis. One of the cotypes is refigured to show more clearly the basal plates of the proboscis.

*Occurrence.* Cobourg beds, locality 4.

*Type.* G.S.C., cotypes, Nos. 1427b and 1427c, Cobourg beds, from an unspecified locality, Ottawa.

### *Dendrocrinus proboscidiatus* Billings

*Dendrocrinus proboscidiatus* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 267; Can. Org. Rem., dec. 4, 1859, p. 38, Pl. III, figs. 3a-3c; W. R. Billings, Ottawa Nat. 1, 1887, p. 53, pl. fig.

The species has been described and illustrated. The holotype came from Montreal, but the species has been found at Ottawa.

It is characterized by the proboscis, which is enormously large in proportion to the size of the calyx and has the transverse ridges on its plates.

*Occurrence.* Cobourg beds, locality 10.

*Type.* G.S.C., holotype, No. 1431, from Montreal.

### *Dendrocrinus rusticus* Billings

*Dendrocrinus rusticus* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 270; Can. Org. Rem., dec. 4, 1859, p. 41, Pl. III, figs. 7a, 7b.

The type of this species is lost, and no other specimen has been found.

*Occurrence.* Cobourg beds, locality 4.

## Genus, **Ottawacrinus** W. R. Billings

Genotype, *O. typus* W. R. Billings

Calyx obconical; dicyclic; infrabasals 5, pentagonal; basals 5, one pentagonal, two hexagonal, two heptagonal; radials 4, simple, right posterior compound; radianal plate large, almost under right posterior radial, followed by small plates not in longitudinal rows; lowest brachial filling the upper facet of radials; interbrachials sometimes present; arms heterotomous, biserial; column, round.

The genus differs from *Dendrocrinus* in having large radial facets and in lacking the somewhat regular longitudinal arrangement of the plates of the anal sac. It differs from *Cupulocrinus* in the irregular basals, and in lacking the prominent regular anal tube rounded on the back.

### *Ottawacrinus typus* W. R. Billings

*Ottawacrinus typus* W. R. Billings, Ottawa Nat. 1, 1887, p. 49, pl. fig.; Miller, North Amer. Geol. Pal. 1889, p. 265, fig. 378; Springer, Geol. Surv., Canada, Mem. 15P, 1911, p. 37, Pl. IV, figs. 5-7; Bather, Geol. Surv., Canada, Mus. Bull. 1, 1913, p. 2, Pl. I.

This species has been adequately described and illustrated. Unfortunately the holotype was not in the W. R. Billings collection when purchased by the Geological Survey.

*Occurrence.* Cobourg beds, locality 10; Hull beds, locality 34.

## Genus, **Carabocrinus** Billings

Genotype, *C. radiatus* Billings

Globular; dicyclic; infrabasals 5, of which four are pentagonal, the fifth irregular and much broader than high; basals 5, hexagonal; radials 5, upper facet having deep small arm grooves occupying about one-third of the margin; anal plate large, in line with radials, supported on the upper right facet of the posterior basal and upon the left facet of the upper section of a compound infra-anal plate that also supports the right posterior radial. The inferior part of the infra-anal plate with the posterior basal rests upon the long, irregular infrabasal; arms narrow, branching; surface ornamented by radiating ridges.

The genus is distinguished from others by its anal and compound infra-anal plates, by the small round arms, and by its ornamentation.

### *Carabocrinus radiatus* Billings

Plate V, figure 5

*Carabocrinus radiatus* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 276; Can. Org. Rem., dec. 4, 1859, p. 31, Pl. II, figs. 3a-3c; Miller, North Amer. Geol. Pal. 1889, p. 230, fig. 261; Grabau and Shimer, North Amer. Index Fossils, 2, 1910, p. 504, fig. 1817.

Billings' description and illustrations are clear for the lower part of the calyx. But among the cotypes are two small specimens with the arms broken away, thereby revealing the upper surface, with five irregularly radiating ambulacral grooves, the mouth, the anal opening, and three interambulacral plates at the base of the arms. The covering plates of the ambulacral canal are quadrate, larger and opposite where bordering the elongated oral orifice, smaller and alternating along the grooves between the mouth and the base of the free arms.

At the outer edge of the upper surface of the calyx three small plates separate the ambulacral grooves from one another and from the arms, around the base of which they are grouped. The plates are crossed by parallel striæ, the long central one being directed towards the arm centre. The anal opening appears just left of the centre, situated in a fourth plate that shoves aside the left and centre striated plates of the sector in which it lies.

These features have not been preserved on other species of *Carabocrinus*, but better specimens might indicate that they are of generic value.

*C. radiatus* Billings is distinguished from *C. vancortlandti* by its compact spherical form.

*Occurrence.* Cobourg beds, localities 4, 20, 24, 38; Hull beds, localities 34, 37, 40.

*Type.* G.S.C., cotypes, Nos. 1425, 1425b, 1425d, and 1425e, from unspecified localities in Ottawa, Ontario, and Hull, Quebec.

### *Carabocrinus vancortlandti* Billings

*Carabocrinus vancortlandti* Billings, Geol. Surv., Canada, Can. Org. Rem., dec. 4, 1859, p. 32, Pl. II, fig. 4; Weller, Chicago Acad. Sci. Nat. Hist., Bull. 4, 1900, p. 28, fig. 9.

Nothing can be added to Billings' description and illustration. It is distinguished from *C. radiatus* by its larger, more oval form.

*Occurrence.* Cobourg beds ?, locality 2. The holotype was probably found in a boulder, though it is not so stated. The only Ottawa limestone exposed in McNab township is in the Black River-Leray beds, which are not usually a crinoid horizon. The direction of the glacial striæ shows that boulders from the Upper Trenton at Clear Lake could have been carried in this direction.

*Type.* G.S.C., holotype, No. 1424.

## Genus, **Porocrinus** Billings

Genotype, *P. conicus* Billings

Calyx conical; dicyclic; infrabasals 5, pentagonal; basals 5, three hexagonal, two heptagonal; radials 5; infra-anal plate small, supported by two upper edges of the two heptagonal basals, and in turn partly supporting right posterior radial and anal plate; anal plate in line with radials, and resting on truncated face of one heptagonal basal and on infra-basal; anus on a slight protuberance; deeply sunken pore-rhombs lying between the ridges and at the angle of junction of every three plates, the ducts being oblique to each plate; arms 5, simple, weak.

The genus is sometimes classed as a cystid. The rhombs differ from known cystids in their sunken position at the angles of the plates, and in their great number. If considered a crinoid, the genus is easily distinguished by the pore-rhombs.

### *Porocrinus conicus* Billings

*Porocrinus conicus* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 279; Can. Org. Rem., dec. 4, p. 34, Pl. II, figs. 5a-5d; Miller, North Amer. Geol. Pal. 1889, p. 273, fig. 400; Zittel, Textbook Pal., 1913, p. 217, fig. 314a.

The species has been well described and illustrated. It can be distinguished from *P. smithi* and other species by its smooth plates.

*Occurrence.* Cobourg beds, locality 4; Hull beds, locality 37.

*Type.* G.S.C., cotypes, Nos. 1423, 1423a, 1423b, 1423c, and 1423d, Cobourg beds, from an unspecified locality, Ottawa.

## Genus, **Palaeocrinus** Billings

Genotype, *P. striatus* Billings

Calyx oval or pyriform; dicyclic; infrabasals 5, pentagonal; basals 5, four hexagonal, one heptagonal; radials 5, arm facets semicircular and occupying about one-quarter the width of radial; anal plate in line with radials, resting on truncated heptagonal basal and a small radianal plate; anal tube composed of three to five rows of plates; arms branching, slender, sharp on the back; five ambulacral grooves across the top of the calyx; column round or pentagonal.

The calyx resembles *Dendrocrinus*, but the basal plates are relatively smaller and the arm facets and arms are smaller, and sharper; the greatest difference, however, is in the smaller anal tube.

*Palaeocrinus angulatus* (Billings)

Plate VI, figure 1

*Dendrocrinus angulatus* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 269.
*Palaeocrinus angulatus* Billings, Can. Org. Rem., dec. 4, 1859, p. 45, Pl. III, figs. 6a, 6b.

*Emended Description.* Cup small, not typically conical as described by Billings but slightly constricted above the middle of the radial plates; infrabasals, basals, radials, and anal plate typical of the genus; basals crossed by six ornamental ridges, sharply defined and intersecting each side; ridges from adjacent plates cutting the infra-basals unite, forming a beautiful five-pronged star radiating from the column; radials and anal plate with four ridges, the arms and the tube occupying the position of a fifth ridge; arms slender, sharp on the back, divergent after the second division, the left posterior and left anterior arms having three joints; the other three having four joints in the first section.

The species is distinguished by the ornamental ridges on the calyx plates.

*Occurrence.* Cobourg beds, locality 4.

*Type.* G.S.C., holotype, No. 1435, Cobourg beds, from an unspecified locality, Ottawa.

*Palaeocrinus pulchellus* Billings

Plate VI, figure 3

*Palaeocrinus pulchellus* Billings, Geol. Surv., Canada, Can. Org. Rem., dec. 4, 1859, p. 46.

*Emended Description.* Cup conical, flaring, without the constriction evident in *P. angulatus*. The type, and only specimen, is considerably crushed, and it is difficult to determine the outline and ornamentation of the plates. Ridges are evident but they appear broader, less definite, and perhaps fewer than in *P. angulatus;* arms sharp on back, slender, dividing at least three times, abruptly divergent, giving them an angular appearance; three joints in one, four joints in the other of the two arms preserved; column round in section.

This form can be distinguished from *P. angulatus* by its more conical shape, less definite ridges, and round column.

*Occurrence.* Cobourg beds, locality 4.

*Type.* G.S.C., holotype, No. 1434, Cobourg beds, from an unspecified locality, Ottawa.

*Palaeocrinus rhombiferus* Billings

Plate VI, figure 2

*Palaeocrinus rhombiferus* Billings, Geol. Surv., Canada, Can. Org. Rem., dec. 4, 1859, p. 45.

*Emended Description.* Cup conical, not so widely flaring as in *P. pulchellus,* straight above the middle of the radials, not constricted as in *P. angulatus,* infrabasals small; basals, those preserved, pentagonal, each plate having three ridges crossing the upper two and the lower sides, enclosing rhomboid surfaces around the base; radial plates carrying four ridges, two from the adjacent basals and one each from the adjacent radials; all ridges broad, not sharply defined; anal plate not shown; arms sharp, slender, with two divisions only, less divergent than in the other two species; above the second division the one arm preserved is slender, long, and tapering; column not preserved.

The species differs from both the preceding species in the form of the calyx and the slender arms. Billings distinguished it from *P. angulatus* by the absence

of horizontal ridges and consequent rhomboid surfaces. This is only true around the base, the radial plates having horizontal ridges break the rhomboid pattern on the upper half.

*Occurrence.* Cobourg beds, locality 4.

*Type.* G.S.C., holotype, No. 1436, Cobourg beds, from an unspecified locality, Ottawa.

### Genus, **Euspirocrinus** Angelin

Genotype, *E. spiralis* Angelin

Calyx subcylindrical, asymmetrical; infrabasals 5, subequal; basals 5, four hexagonal, the fifth heptagonal; radials large, sublunar; anal area comparatively wide, two anal plates, one slightly lower than the other, the infra-anal resting upon the posterior and right posterior basal, the upper anal plate projecting beyond the radials and resting upon the truncated upper edge of the posterior basal, and lying between the infra-anal on the right, and the left posterior radial on the left, but separated from the right posterior radial by the next higher plate of the tube; anal tube, slender, with a few large alternating plates, sunk into the cup between the radials and brachials; arms dividing and having a tendency to coil inwards; arm plates variable in number, rather wide and short.

The genus can be readily distinguished from others by its slender tube with alternating plates.

### *Euspirocrinus obconicus* W. R. Billings

*Euspirocrinus obconicus* W. R. Billings, Ottawa Field Nat. Club, Trans. 2, 1885, p. 248, pl. fig.; Miller, North Amer. Geol. Pal. 1889, p. 246, figs. 306, 307.

This specimen has been clearly described and well illustrated, and is unlike any other.

*Occurrence.* Cobourg beds, locality 10; Sherman Fall or Hull beds, locality 42.

*Type.* G.S.C., holotype, No. 1566, Cobourg beds, Booth street, Ottawa.

## ASTEROIDEA

### Genus, **Hudsonaster** Sturtz

*Condensed from Schuchert.* Disk small, 5 short, rapidly tapering rays. Abactinal side—3 columns of large thiek plates, bordered by 2 columns of inframarginal plates, which are also visible actinally; abactinal disk having 1, small, tumid plate, surrounded by a circle of accessory plates and one space, possibly an anal opening; a second outer circle of 10 large plates, five radial and five interradial in position; also 5 small, isolated plates inserted between the interradials at the base of the radials; madreporite abactinal, resting on one interradial plate, between two radials; no accessory plates. Actinal side—infrabasals well developed, adjoining 5 isolated, conspicuous, axillary plates; adumbulacral plates numerous, one to two to each infrabasal; oral aperture 5 pairs of pointed plates in an adambulacral position; ambulacral grooves narrow and regularly tapering; covering plates rectangular, opposite or slightly alternate to the umbulacrals.

*Hudsonaster* differs from *Palaeaster* and *Petaster* in that it lacks all accessory plates.

### *Hudsonaster matutinus* (Hall)

*Asterias matutina* Hall, Pal. New York, 1, 1847, pp. 91, 318.

*Petraster rigidus* (part) Billings, Geol. Surv., Canada, Can. Org. Rem., dec. 3, 1858, Pl. IX, fig. 3b (not fig. 3a).

*Hudsonaster matutinus* (Hall) Schuchert, in Frech, Foss. Cat. 1, Anim., pt. 3, 1914, p. 21; U.S. Nat. Mus. Bull. 88, 1915, p. 57.

This species has been adequately described and figured. It is larger than *H. narrawayi,* the adambulacrals are deeper, and there are more plates to the column.

*Occurrence.* Cobourg beds, localities 30, 39.

*Type.* G.S.C., plesiotype, No. 1402, Cobourg beds, Governor Bay, Ottawa.

### *Hudsonaster narrawayi* (Hudson)

*Protopalaeaster narrawayi* Hudson, Ottawa Nat. 26, 1912, p. 25, Pls I-III; Raymond, Ottawa Nat. 26, 1912, p. 105, pl. figs. 204; Hudson, New York State Mus. Bull. 164, 1913, p. 130, Pl. V; Ottawa Nat. 27, 1913, pp. 77-84, 2 pls.

*Hudsonaster narrawayi* Hudson, Schuchert, in Frech, Foss. Can. 1, Anim., pt. 3, 1914, p. 22; U.S. Nat. Mus. Bull. 88, 1915, p. 59, Pl. I, fig 1.

This species has been thoroughly described and illustrated. As mentioned above, the species is smaller than *H. matutinus* (Hall) and has fewer plates in each ray.

*Occurrence.* Hull beds, locality 37; Rockland or Leray beds, locality 3.

*Type.* In the Royal Ontario Museum, Toronto.

## Genus, **Promopalaeaster** Schuchert

Genotype, *Palaeaster granulosus* Meek

*Condensed from Schuchert.* Disk, large, with distinct angular interbrachial arcs and having numerous, small, accessory plates; rays 5, slender to stout, rather long, tapering. Abactinal side—numerous columns of small, tumid, closely adjoining or reticulate, spinose plates; medial radial and two lateral plates usually conspicuous; supramarginals continuing over the disk and uniting in the axillary area; accessory plates numerous, in some cases diagonally arranged next median column; madreporite conspicuous, radially striate, near disk margin; inframarginals small, with blunt spines, increasing in number towards the disk, forming small interbrachial arcs; interbrachials on both sides, of medium size, arranged in pairs with interbrachial marginals. Actinal side—adambulacrals, proximally increasing in size, each plate having a narrow extension attached distally but free proximally; furrows wide, tapering; ambulacrals, two columns of opposite or slightly alternating plates, distally as wide as long, proximally increasing width to four times length, carinated; carinæ distally regular, but forked towards mouth and laterally uniting with the adambulacral extension; orals the ends of the adambulacrals, with one small quadrangular ossicle situated between the modified proximal end plate of the ambulacrals; podial openings distally, one at the outer margin of each ambulacral plate, placed between sutures and beneath adambulacrals, proximally increasing to four openings, every other podial opening placed progressively inward.

A number of species of the genus were formerly assigned to the genus *Palaeaster,* but *Promopalaeaster* differs from that genus in size, in its numerous accessory plates, and in the interbrachial arcs and interbrachial marginal plates. Schuchert considers *Promopalaeaster* to be a direct development of *Mesopalaeaster,* which is a descendant of *Hudsonaster.*

*Promopalaeaster* differs from *Hudsonaster* in having interbrachials, and from *Mesopalaeaster,* from which it is derived, in its larger size and more numerous accessory plates.

### *Promopalaeaster wilsoni* (Raymond)

*Palaeaster ? wilsoni* Raymond, Ottawa Nat. 26, 1912, p. 78, Pl. V, figs. 1-4.
*Promopalaeaster wilsoni* (Raymond), Schuchert, in Frech, Foss. Cat. I, Anim., pt. 3, 1914, p. 34; U.S. Nat. Mus. Bull. 88, 1915, p. 106, Pl. XIII, figs. 1, 2.

This species has been adequately described and illustrated.

*Promopalaeaster wilsoni* is nearest *P. magnificus* (Miller) of the Richmond formation. It differs in having stouter rays, in lacking the regular oblique arrangement of the accessory plates of the abactinal face, and in being less spinose.

*P. prenuntius* is the species nearest to *P. wilsoni* stratigraphically, but it can be readily distinguished, as it is considerably smaller and more spinose.

*Occurrence.* Rockland-Leray beds, locality 3.

*Type.* G.S.C., holotype, No. 8150, Rockland-Leray beds, City View, southwest of Ottawa.

### *Promopalaeaster* species undetermined

The specimen is too poor and broken to be described and made a holotype. It is mentioned here because fossil starfish are rare in these rocks, and it is another record of the genus *Promopalaeaster.*

The disk measures 8 mm. in diameter, and the base of one ray is 4 mm. wide; the accessory plates of the abactinal side are arranged in diagonal rows as in *P. magnificus* (Miller).

*Occurrence.* Hull beds, locality 37.

## Genus, **Petraster** Billings

Genotype, *Petraster* (*palasterina*) *rigidus* Billings

*Condensed from Schuchert.* Disk pentagonal; interbrachial arches rather large; 5 rays, short and slender or stout and rapidly tapering. Abactinal side—one medial, two marginal, and one inframarginal column of plates in outer part of ray, proximally having accessory plates between median and marginal column; madreporite abactinal; inframarginals common to abactinal and actinal sides. Actinal side—adambulacrals and inframarginals adjacent distally, separated proximally by small, accessory, interbrachial plates; a pair of large triangular plates at the base of each ambulacral column forming the orals; ambulacrals slightly alternate; groove narrow, tapering; podial openings in outer proximal corner of plate.

*Petraster* differs from *Palasterina* in having prominent, closely adjoining, short and wide infrabasals; in the absence of an irregular ring of prominent basal radials and supramarginals on the abactinal side; in that the interbrachials never reach the outer ends of the rays on the abactinal side; and in being less spinose. The genus is readily distinguished from *Hudsonaster* by the presence of accessory plates.

### *Petraster rigidus* Billings

*Palaesterina rigidus* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 291.
*Petraster rigidus* Billings, Geol. Surv., Canada, Can. Org. Rem., dec. 3, 1858, p. 80, Pl. IX, fig. 3a (not fig. 3b); Schuchert, in Frech, Foss. Cat. I, Anim, 1914, p. 32; U.S. Nat. Mus. Bull. 88, 1915, p. 141, Pl. XXVII, fig. 5.

This species has been well described and figured.

Only two other species of *Petraster* have been cited from the Ordovician, both considerably higher stratigraphically. *P. rigidus* has a single row of interbrachials, several of which extend up into the lower part of each ray diminishing

in size, whereas *P. speciosus*, from the Maysville and Richmond, has a broad disk with numerous interbrachials, and in *P. americanus* from the Maysville the interbrachials are confined to the disk.

*Occurrence.* Cobourg beds, locality 30.

*Type.* G.S.C., holotype, No. 1401a, Cobourg beds, Rideau Hall grounds, Ottawa.

### Genus, **Stenaster** Billings

Genotype, *S. salteri* Billings

*Emended Description.* Disk small, without interbrachial arcs; rays five, short, stout, petaloid. Abactinal side—lacking preservable plates; madreporite unknown. Actinal side—adambulacral plates few, never more than seventeen in a column, subquadrangular, thick, larger in the middle diminishing at both ends; ambulacrals excavated for the podial openings with a T-shaped rim, the stem of which is directed towards the adambulacrals; covering plates above the ambulacrals perforated for the podia; oral plates a pair of triangular proximal ambulacrals; spines unknown.

The genus differ from *Urasterella* in its petaloid form, fewer ambulacrals and adambulacrals, and absence of spines; from *Palaeaster*, with which it was originally confused, it differs in the absence of supramarginals.

### *Stenaster salteri* Billings

Plate VI, figure 9

*Stenaster salteri* Billings, Geol. Surv., Canada, Can. Org. Rem., dec. 3, 1858, p. 78, Pl. X, figs. 1a, 1b; Schuchert, U.S. Nat. Mus. Bull. 88, 1915, p. 165, Pl. XXXII, fig. 1.

One addition is here made to the description and illustrations of this species. Each of the ambulacral plates preserved shows a low tubercle. The specimen illustrated is poor, but this feature is clear on one ray.

*Occurrence.* Cobourg beds, localities 4, 23, 25, 30, 39.

*Types.* G.S.C., holotype, No. 1398, not from this region, but from Belleville, Ontario; plesiotype, No. 9069, Cobourg beds, from Governor Bay, Ottawa.

### Genus, **Urasterella** McCoy

Genotype, *Uraster ruthveni* Forbes

*Condensed from Schuchert.* Disk small, without interbrachial arcs, formed of a central plate surrounded by a first ring of 5 plates, which in some instances are radial bases, and a second ring with 15 plates, five the secondary radials and ten the basal supramarginals, in cases a few accessories between the central plate and the first ring; rays 5, very long and slender, stouter and more tapering when young. Abactinal side—numerous, small, stellate plates, lateral ones with long, blunt, stout, non-articulate rods; medial column conspicuous or suppressed when adjoining supramarginals; number of columns varying up to thirteen at base of a ray; growing tips without accessory plates; inframarginals distally pass to actinal side, proximally not distinguishable from accessory plates; madreporite medium size, convex, depressed, and granulostriate. Actinal side—adambulacrals numerous, coin-shaped, inframarginal position, pustulose and spinose; marginal spines slender, flat, and longitudinally grooved; orals of small triangular end plates of adambulacral columns; ambulacral plates opposite or slightly alternate, wedge- or club-shaped, each plate in column overlapping adjoining plate and laterally excavated on the proximal edge for the podial opening between the plates; medial columns loosely jointed.

*Urasterella* can be distinguished from other Palæozoic Asteroidea by its long flexible rays, the absence of inframarginal plates, and its distinct interbrachial plates. It differs from *Stenaster*, in particular, in the numerous, thin, coin-shaped adambulacrals, and wholly different ambulacrals.

### *Urasterella pulchella* (Billings)

*Palaeaster pulchellus* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 292.
*Stenaster pulchellus* Billings, Can. Org. Rem., dec. 3, 1858, p. 79, Pl. X, fig. 2.
*Urasterella pulchella* (Billings) Raymond, Ottawa Nat. 26, 1912, p. 106, fig. 1; Schuchert, U.S., Nat. Mus. Bull. 88, 1915, p. 178, Pl. XXVIII, figs. 3, 4; Pl. XXX, fig. 5; Hudson, 69th Report New York State Mus., p. 124, Pls. IX and X, 1915.

This form has been described and well illustrated.

Of the three other Ordovician species of *Urasterella* found in North America, *U. pulchella* is stratigraphically nearest to *U. ulrichi* of Black River age. Biologically it is closer to *U. grandis* from the Richmond, of which Schuchert considers it to be the ancestor. From both of these species *U. pulchella* can be distinguished by its smaller size, more slender rays, and its fewer columns of plates. From the third species *U. huxleyi*, from a Chazy horizon, it is distinguished by its less convex and more sharply tapering rays and by the fewer number of plates.

*Occurrence.* Cobourg beds, locality 4; Hull beds, localities 34, 37.

*Type.* G.S.C., holotype, No. 1397a, Cobourg beds, from an unspecified locality, Ottawa.

## Genus, **Schuchertia** Gregory

Genotype, *Palasterina stellata* Billings

*Condensed from Schuchert.* Outline pentagonal; disk large, with well-developed brachial arches; rays 5, short and slender. Abactinal side—numerous, small, non-stellate plates arranged in quincunx or columns; no radial, inframarginal, supramarginal, or other columns recognized; madreporite not distinguishable. Actinal side—furrows very narrow; adambulacrals present; inframarginals present in proximal region; interbrachial areas with small accessory plates, continuous with those of the abactinal side; ambulacral plates apparently slightly alternating.

The genus differs from *Petraster* in having no defined columns of plates on the abactinal side, and on the actinal side incomplete columns of inframarginals adjoining the adambulacrals, rather than the distinct column of ray plates and prominent inframarginals of *Petraster*.

### *Schuchertia stellata* (Billings)

*Palasterina stellata* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 290; Can. Org. Rem., dec. 3, 1858, p. 76, Pl. IX, figs. 1a, 1b.
*Schuchertia stellata* Billings, Gregory, Geol. Mag., dec. 4, vol. 6, 1889, p. 351; Schuchert, U.S. Nat. Mus. Bull. 88, 1915, p. 196, Pl. XXXII, fig 2; Pl. XXXIII, fig. 1.

This species has been adequately described and illustrated.

*S. laxata*, from the Richmond, is the only other species cited from the Ordovician. *S. stellata* differs from it in its smaller size, the disk, with its larger ossicles, constituting a greater proportion of the whole.

*Occurrence.* Cobourg beds, localities 4, 30.

*Type.* G.S.C., holotype, No. 1399, Cobourg beds, from an unspecified locality, Ottawa; plesiotype, No. 8148, Cobourg beds, from Governor Bay, Ottawa.

## Genus, **Taeniaster** Billings

Genotype, *Palaeocoma spinosa* Billings

Disk small, with concave margins between the rays. Actinal side—having many spines; adambulacrals narrow, sometimes curved, bearing spines; furrows wide; ambulacrals L- or crescent-shaped, opposite or alternate; orals a star-shaped group of slender plates forming a sharp angle and composed of a plate from each of two adjacent rays to which is attached a V-shaped jaw plate.

The genus can be recognized by the Ophiurid-like disk, and the peculiar shape of the ambulacral plates.

### *Taeniaster spinosus* Billings

*Palaeocoma spinosa* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-56 (1857), p. 292.
*Taeniaster spinosus* Billings, Can. Org. Rem., dec. 3, 1858, p. 81, Pl. X, figs. 3a-3d; Schuchert, U.S. Nat. Mus. Bull. 88, 1915, p. 219, Pl. XXXVI, fig. 1, text fig. 17.

This species has been adequately described and illustrated.

*T. spinosus* is distinguished from the following species by its smaller size and its L-shaped ambulacrals.

*Occurrence.* Cobourg beds, localities 23, 26.

*Type.* The type specimens come from Montmorency Falls, Quebec; G.S.C., cotypes, Nos. 1404, 1404b.

### *Taeniaster cylindricus* (Billings)

*Palaeocoma cylindrica* Billings, Geol. Surv., Canada, Rept. of Prog. 1853-1856 (1857), p. 292.
*Taeniaster cylindricus* Billings, Can. Org. Rem., dec. 3, 1858, p. 81, Pl. X, figs. 4a-4b; Schuchert, U.S. Nat. Mus. Bull. 88, 1915, p. 220, Pl. XXXVI figs. 2, 3, text fig. 18.

This species has been well and adequately described.

*T. cylindricus* is distinguished from the preceding species by its curved ambulacrals and fewer spines.

*Occurrence.* Cobourg beds, locality 4.

*Type.* G.S.C., Cotypes, No. 1405a (2 specimens on one slab), Cobourg beds, from an unspecified locality, Ottawa.

51687—5

## Plate I

(Except where otherwise stated all figures are natural size)

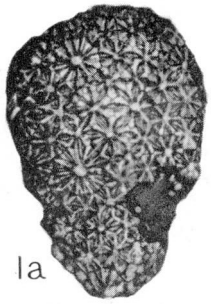
Figure 1. *Amygdalocystites florealis* Billings. 1a, a specimen with well-preserved plates; 1b, the same x 4, showing the "striæ" within the depression, and the wedge-shaped termini of the rays. Plesiotype, G.S.C. No. 9062. (Page 9.)

Figure 2. *Amygdalocystites florealis* Billings. Another specimen. 2a, a small piece, showing the ornamentation; 2b, the same, x 2, showing that the striæ are part of the water vascular system; 2c, the same, x 2, showing part of the water vascular system perpendicular to the surface. Plesiotype, G.S.C. No. 9062a. (Page 9.)

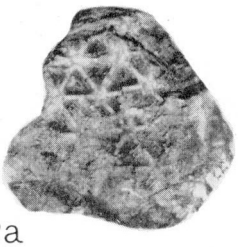
Figure 3. *Amygdalocystites? radiatus* Billings. 3a, underside of a specimen; 3b, five plates taken from the same, x 4; 3c, upper side of the identical five plates, x 4. Plesiotype, G.S.C. No. 9063. (Page 10.)

Figure 4. *Amygdalocystites? radiatus* Billings. Worn top, x 4, showing the marginal and second line of pores. Billings' paratype, G.S.C. No. 1394a. (Page 10.)

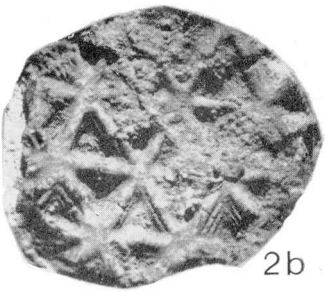
PLATE I



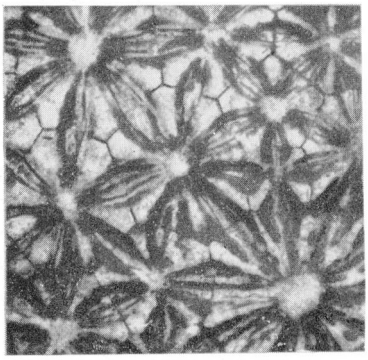
1a



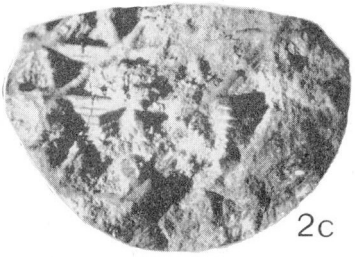
2a



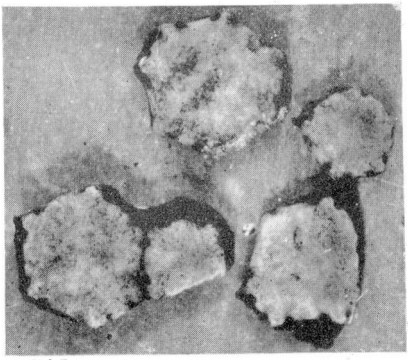
2b



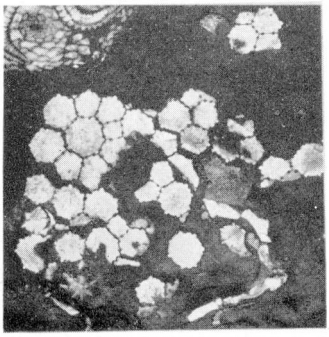
1b



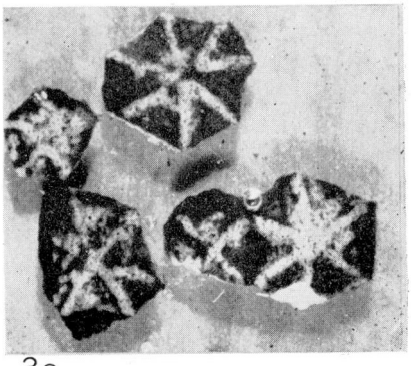
2c



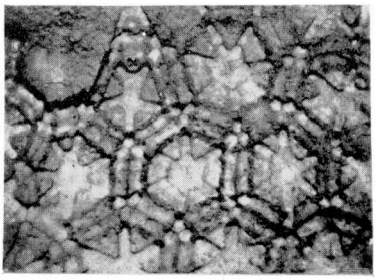
3b



3a



3c



4

51687—5½

## Plate II

Figure 1. *Ateleocystites huxleyi* Billings. 1a, showing the striated plate at the top, which was thought to have been pinnules; 1b, the same, x 2. Holotype, G.S.C. No. 1392. (Page 7.)

Figure 2. *Ateleocystites huxleyi* Billings, showing the three upper oral ? plates, and the irregular, free markings thought to be the true pinnules. Paratype, G.S.C. No. 1392a, x 2. (Page 7.)

Figure 3. *Ateleocystites huxleyi* Billings, showing that only half of the transverse lines of the two marginal plates extend across the two inner plates. Paratype, G.S.C. No. 1392b, x 2. (Page 7.)

Figure 4. *Ateleocystites huxleyi* Billings, showing the convex side with its small irregular plates, the reverse side of the two outer basal marginal plates, and a suggestion of striation on the second tier of marginal plates. Paratype, G.S.C. No. 1392d. x 2. (Page 7.)

Figure 5. *Pleurocystites squamosus* Billings. 5a, a specimen from Billings' type material, x 2; 5b, the same, x 3½, showing the plate arrangement in the arms. Plesiotype, G.S.C. No. 1381c. (Page 12.)

Figure 6. *Pleurocystites squamosus* Billings. Another specimen, x 2, from the posterior side, showing the slit in the upper middle plates with the two pores below it, and the small, numerous, irregularly arranged plates. Plesiotype, G.S.C. No. 9064. (Page 12.)

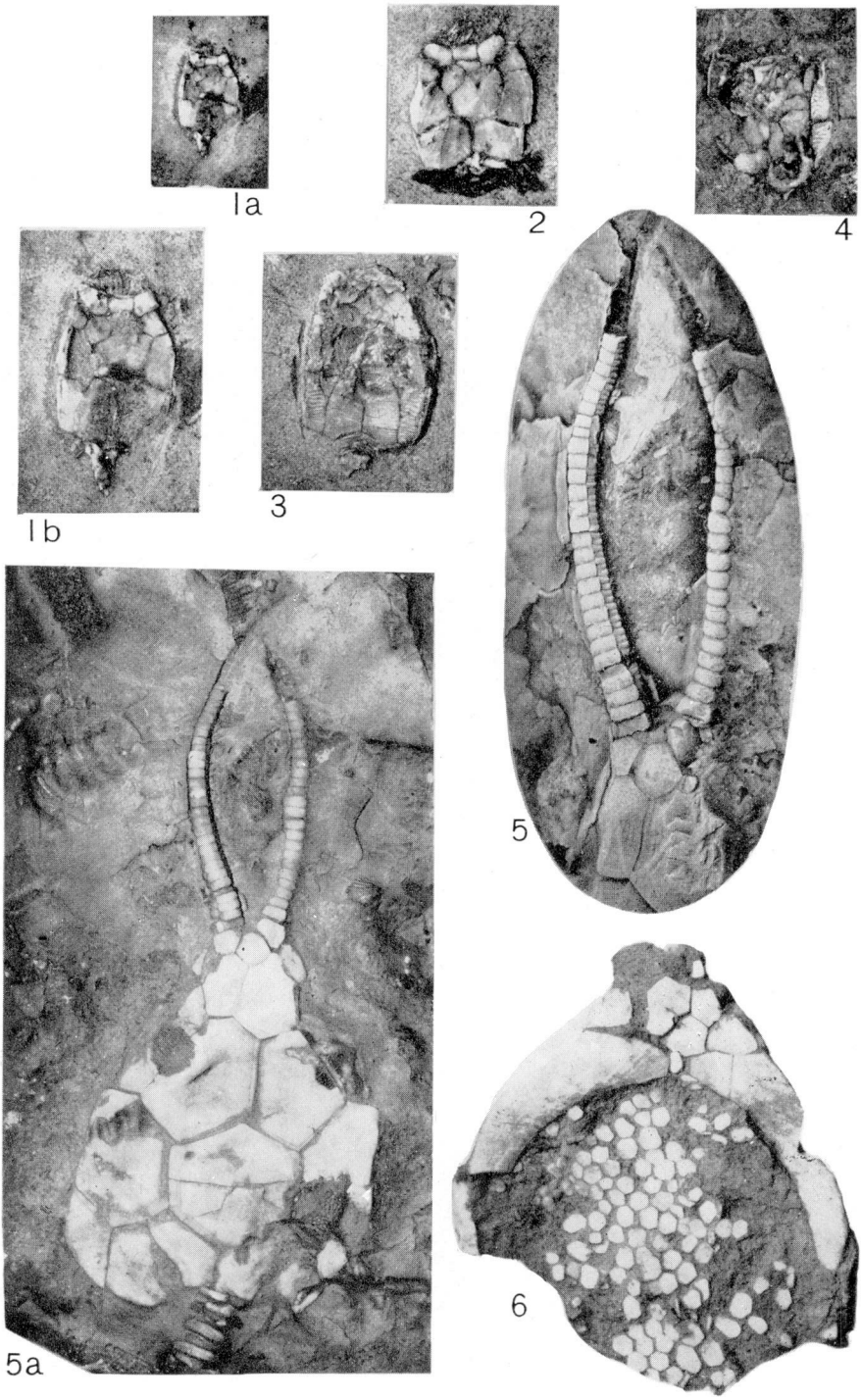

1a
2
4
1b
3
5
5a
6

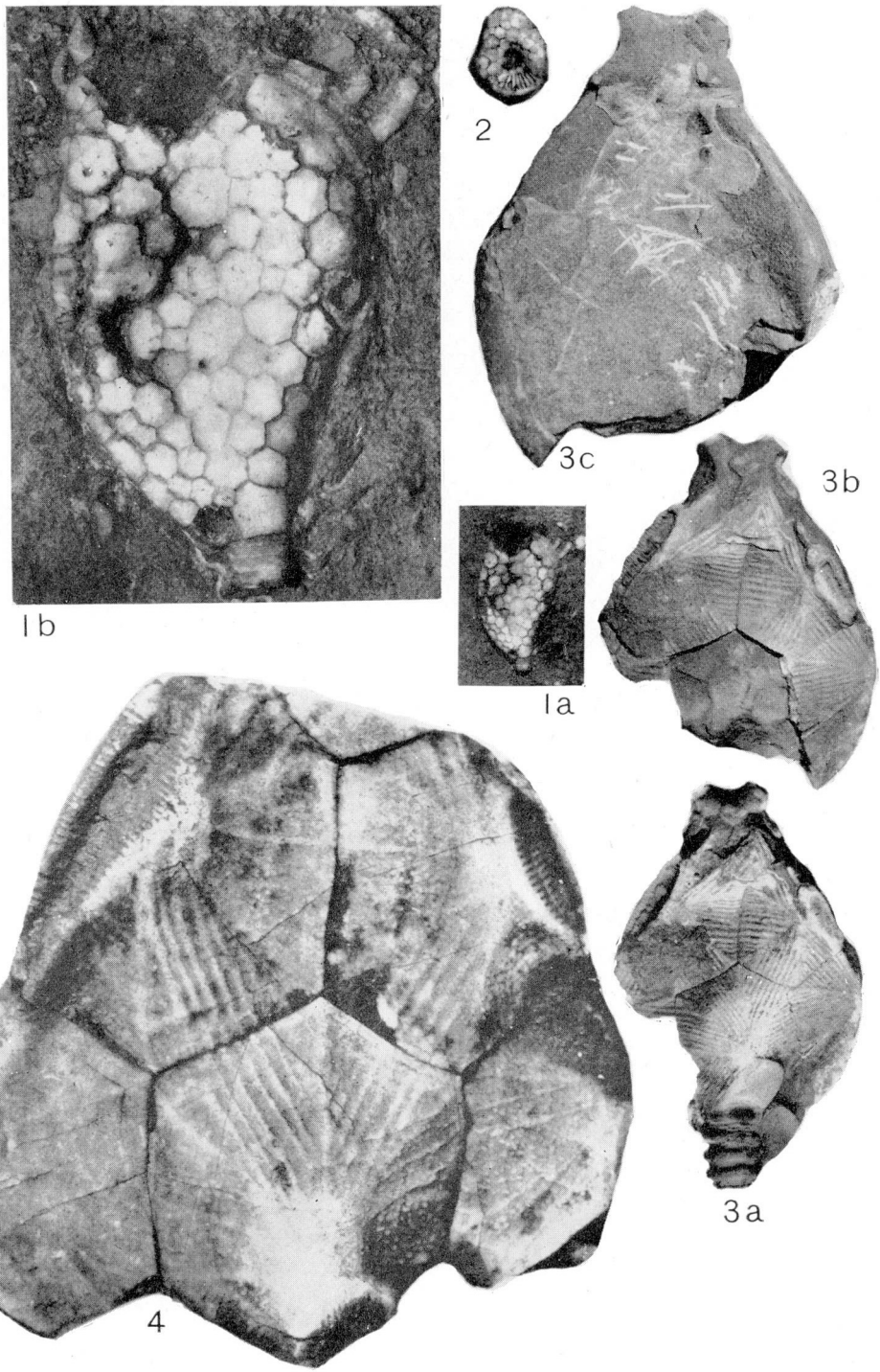
PLATE III

Figure 1. *Ottawacystites laevis* (W. R. Billings). 1a, showing 3 of the 4 arms, the irregularity of the plates, and the pores at the sutures; 1b, the same, x 4. Holotype, G.S.C. No. 1395. (Page 14.)

Figure 2. *Lichenocrinus ottawaensis* n.sp., showing the coils in the interior, x 1½. Holotype in the private collection of W. Sinclair. (Page 17.)

Figure 3. *Pleurocystites elegans* Billings. 3a, a specimen from Lemieux Island, x 1¾, showing the position of the pore-rhombs and the striation; 3b, the same, x 2, with a piece removed showing the inside of the posterior plates; 3c, the same showing wide, raised, marginal plates, x 2½. Plesiotype, G.S.C. No. 9065. (Page 13.)

Figure 4. *Pleurocystites filitextus* Billings, showing the radiating striæ, the roughened surface, and the elongated pore-rhombs, x 4. Holotype, G.S.C. No. 1400. (Page 13.)


1b
2
3c
3b
1a
3a
4

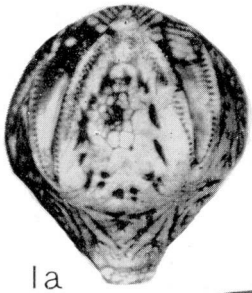
## Plate IV

Figure 1. *Astrocystites ottawaensis* Whiteaves. 1a, showing the small plates surrounding the anus; 1b, showing the upper surface with the deltoid-like plates. Holotype, G.S.C. No. 752, x 2. (Page 23.)

Figure 2. *Lepidoconia lorifrons* (Raymond). 2a, holotype; 2b, the same, x 4, showing the marginal plates, the twist of the central ambulacral groove, and the pore system. G.S.C. No. 1414. (Page 21.)

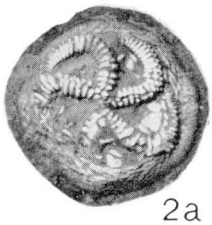
Figure 3. *Cyclocystoides billingsi* n.sp., showing the marginal and radiating ridges, and a small section of the reticulate surface to the right of the break in the circumference. Holotype, G.S.C. No. 9066. (Page 18.)

Figure 4. *Pleurocystites robustus* Billings, showing the pattern of the striation, x 3½. Holotype, G.S.C. No. 1384. (Page 13.)

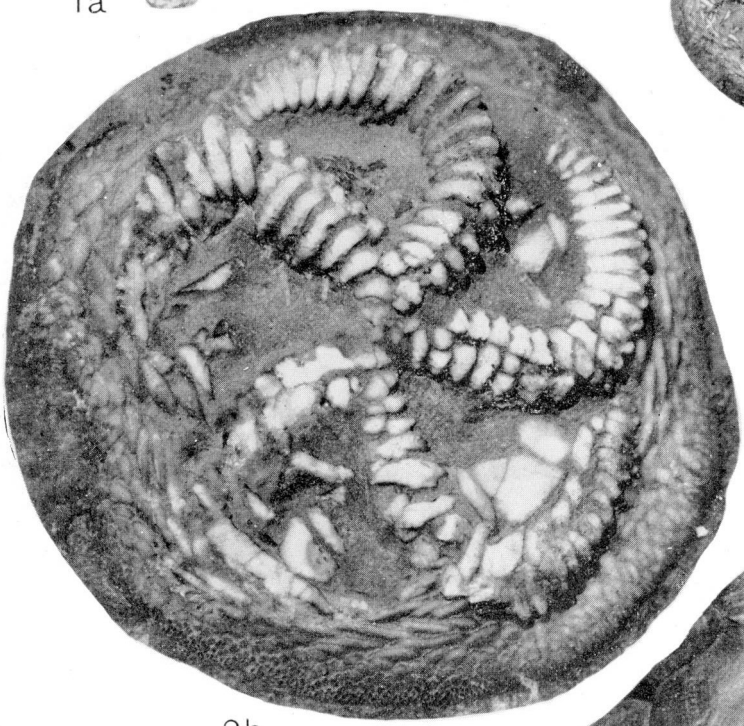


1a

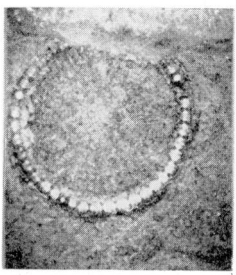
1b



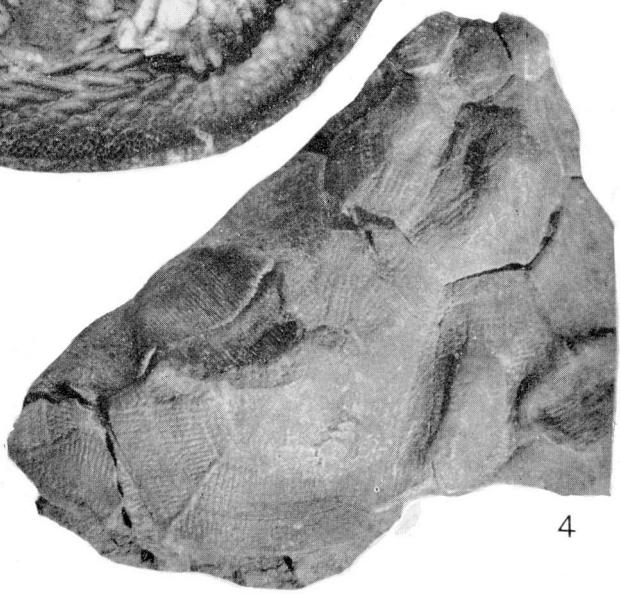
2a



2b



3



4

## Plate V

Figure 1. *Archaeocrinus ottawaensis* n.sp., showing the globular calyx. Holotype, G.S.C. No. 9067. (Page 26.)

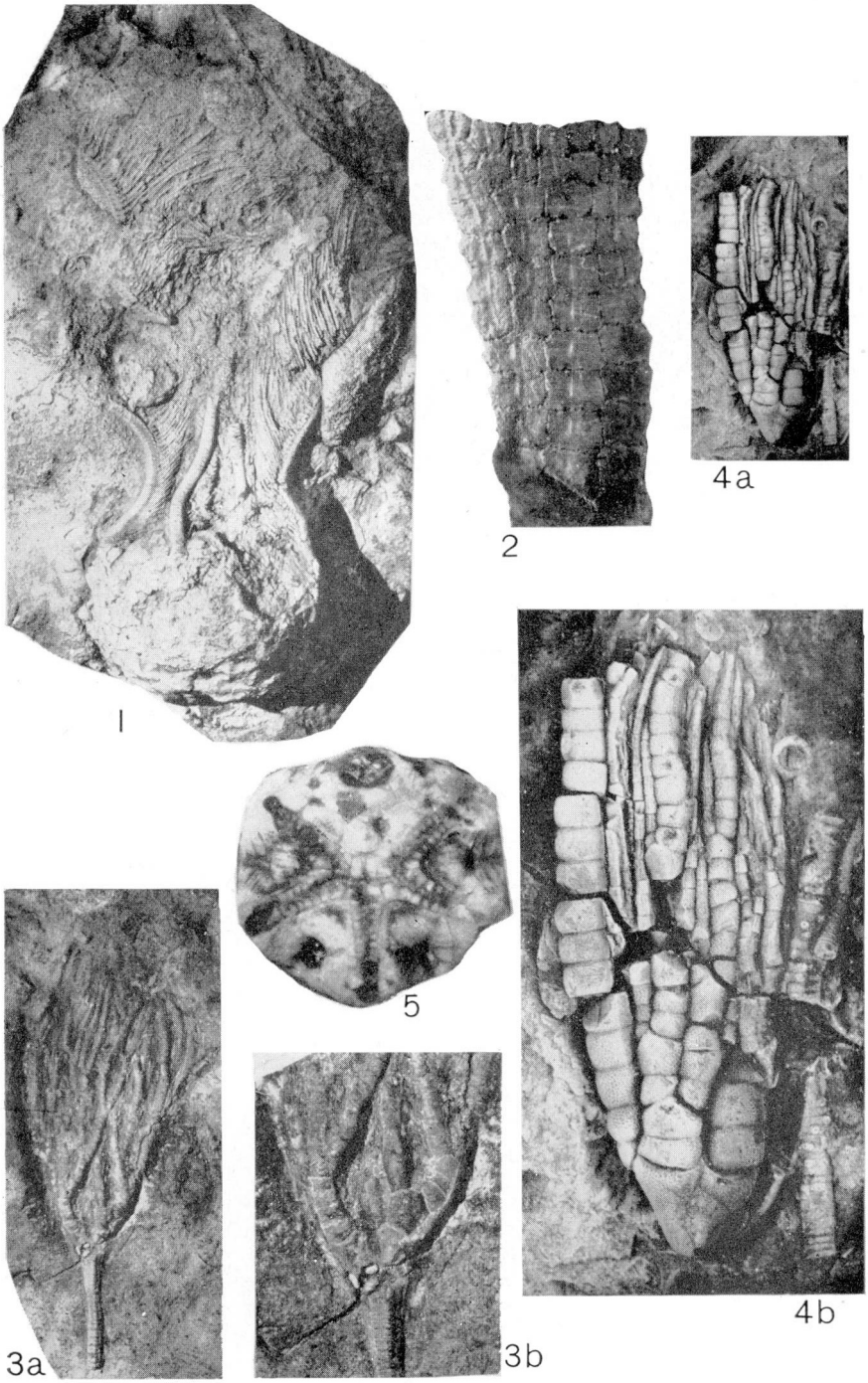
Figure 2. *Cleiocrinus regius* Billings. Small area showing the pores between the plates, x 3. Holotype, G.S.C. No. 1443a. (Page 23.)

Figure 3. *Iocrinus similis* (Billings). 3a, a re-illustration of the imperfect holotype; 3b, the same, x 2, showing the position of the basal, and plate. G.S.C. No. 1428. (Page 33.)

Figure 4. *Cremacrinus inaequalis* Billings. 4a, the holotype, showing the bend of the stem at the base of the calyx; 4b, the same, x 2, showing the basal plates and the peculiar granulate surface. Holotype, G.S.C. No. 1444. (Page 35.)

Figure 5. *Carabocrinus radiatus* Billings, showing the three small striated plates between each ambulacral groove, x 3. Cotype, G.S.C. No. 1425e. (Page 38.)

PLATE V



## Plate VI

Figure 1. *Palaeocrinus angulatus* Billings. 1a, the holotype, showing the ridges, x 1½; 1b, showing the pattern as seen from the base. G.S.C. No. 1435. (Page 40.)

Figure 2. *Palaeocrinus rhombiferus* Billings, to show the rhomboid markings. Holotype, G.S.C. No. 1436, x 1½. (Page 40.)

Figure 3. *Palaeocrinus pulchellus* Billings, showing the angular divergence of the arms. Holotype, G.S.C. No. 1434, x 2. (Page 40.)

Figure 4. *Dendrocrinus gregarius* Billings. 4a, one of the cotypes; 4b, the same, x 2, showing the basal plates of the anal tube. G.S.C. No. 1427e. (Page 37.)

Figure 5. *Cremacrinus articulosus* (Billings). A re-illustration of the holotype to show the plate arrangement and the ossicles swollen at the point of division. G.S.C. No. 1445. (Page 35.)

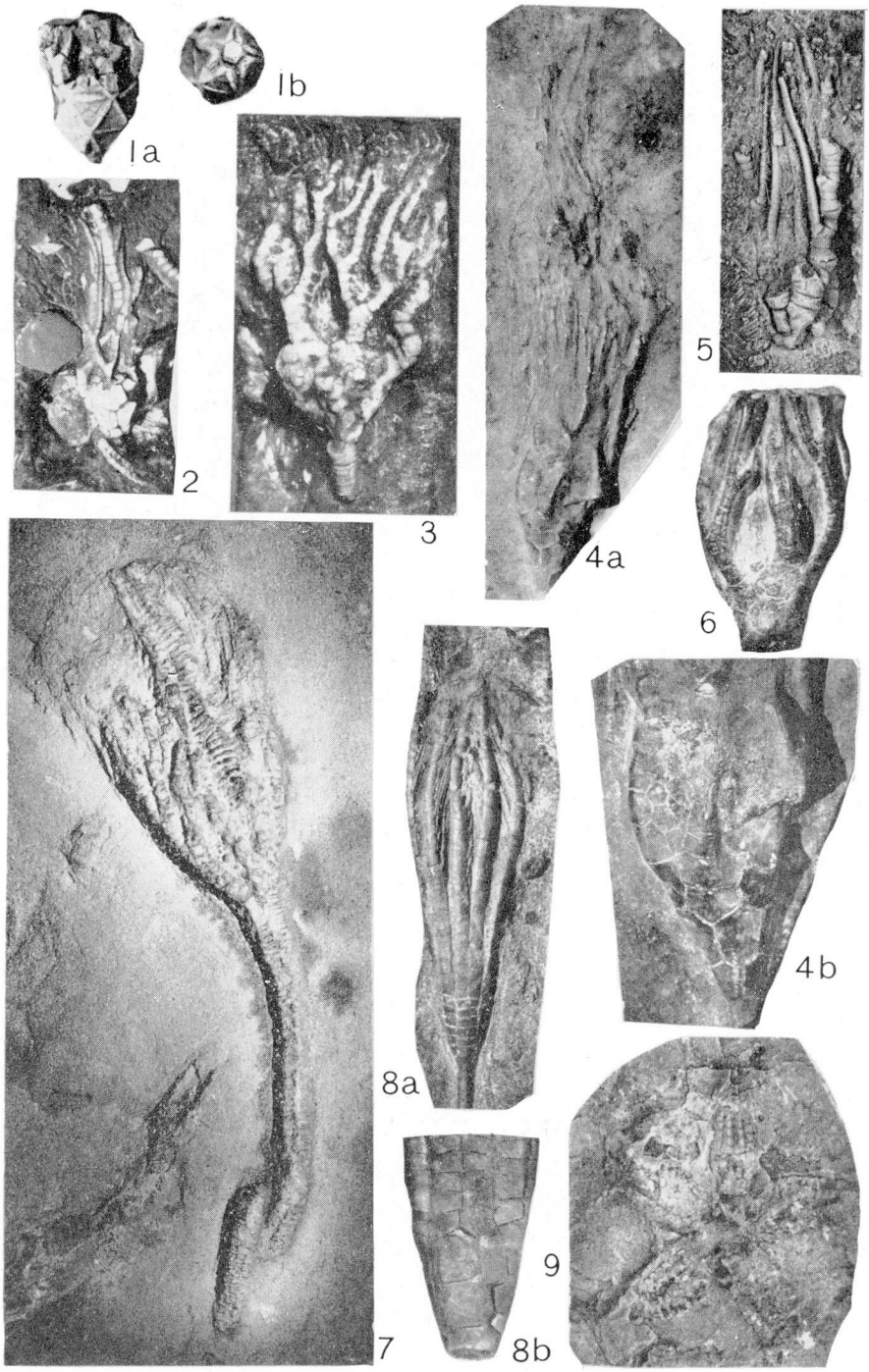
Figure 6. *Cupulocrinus conjugans* (Billings). A re-illustration of the holotype to show the plate arrangement. G.S.C. No. 1429, x 1½. (Page 36.)

Figure 7. *Iocrinus subcrassus* Meek and Worthen, showing the large prominent anal tube and the tubercled plates between the left posterior and left anterior brachials. G.S.C. No. 9068. (Page 34.)

Figure 8. *Ectenocrinus canadensis* (Billings). 8a, one of Billings' cotypes, G.S.C. No. 1441; 8b, another cotype, x 2, showing the anal plate resting upon both left and right posterior radials, G.S.C. No. 1441b. (Page 32.)

Figure 9. *Stenaster stellata* Billings, showing the small low tubercles. Plesiotype, G.S.C. No. 9069. (Page 44.)

PLATE VI



# INDEX TO FOSSILS