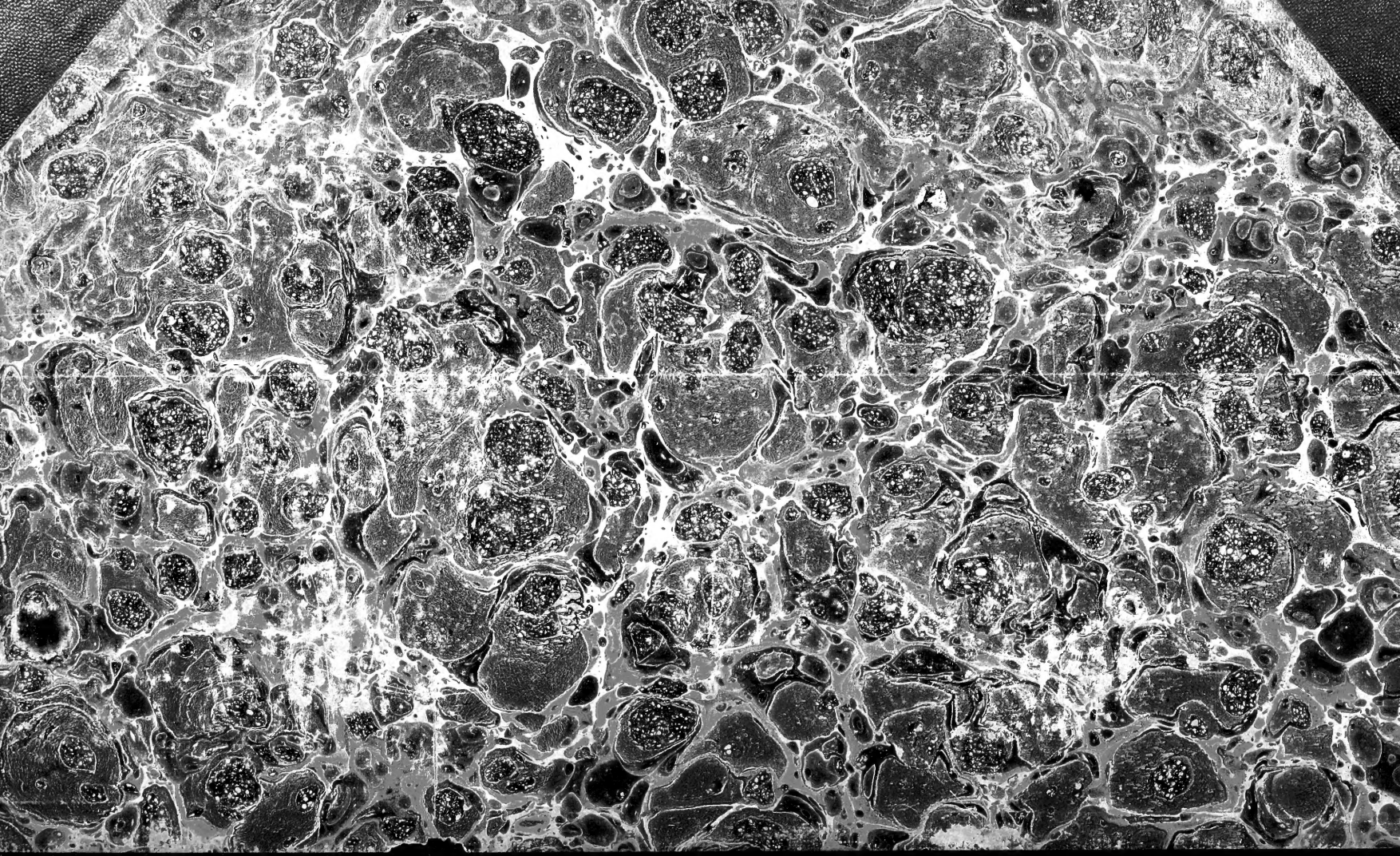

GEOLOGICAL SURVEY OF CANADA.

SIR W. E. LOGAN, F.R.S., DIRECTOR.

FIGURES AND DESCRIPTIONS

OF

CANADIAN ORGANIC REMAINS.

DECADE III.

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CONTENTS.

PREFACE.

One of the subjects comprehended in the recommendation of the Select Committee appointed by the House of Assembly, on the Geological Survey, in 1854, was the publication of figures and descriptions illustrative of such new organic forms as might be obtained in the progress of the investigation. In compliance with this recommendation, it was determined that the publication should be made in parts or decades, after the mode adopted by the Geological Survey of the United Kingdom, each part to consist of about ten plates, with appropriate descriptive text, and to comprehend one or more genera or groups of allied fossils, or the description of several species, for the illustration of some special point in geology.

The first part or decade was confided for description, in 1855, to Mr. J. W. Salter, one of the Palæontologists of the Geological Survey of the United Kingdom. This comprehends different genera and species from one locality. Of these several are new, while others are more perfect forms of species already partially described; and the general object is to exhibit a commingling of forms heretofore supposed to belong to distinct epochs. The plates of this decade are the work of Mr. W. Sowerby, from drawings by Mr. R. C. Bone. The engravings are on steel; nine of the plates are finished, and it is expected the tenth will be completed in a short time.

The second decade was undertaken also in 1855, by Mr. James Hall of Albany, so justly celebrated for his works on the Palæontology of New York. It will comprehend the description of a large number of remarkable new forms of *Graptolithus* and allied genera from the Hudson River group. The drawings are by

Mr. F. B. Meek. Six plates have been engraved on steel by Mr. J. E. Gavit, and ten more plates are in the engraver's hands. The number of species will probably be twenty-four, of which Mr. Hall has already given a description in the Report of Progress for the year 1857.

On the appointment of Mr. E. Billings as Palæontologist of the Survey, in 1856, his first duty was to effect an arrangement of the Museum. This being accomplished, he devoted his attention to a third decade. This comprehends all the Cystideæ and Star-fishes, as well as all the Entomostraca, of the collection. With the view of obtaining the plates necessary for the illustration of these, Mr. Billings, in the month of February last, carried his fossils to London. Finding that considerable delay was likely to attend the publication of the decade should he illustrate it by engravings on steel, he determined to have recourse to lithography. Although minute detail cannot be so finely given by this mode, nor so large an edition be obtained, it is yet perfectly suitable for all practical purposes. It is occasionally used for the fossils of the British Survey, and very generally for the illustration of the best palæontological works on the continent of Europe. The twelve plates which illustrate the third decade are the work of several well-known artists, who have all their respective merits. One of the plates is by Mr. R. C. Bone, two of them by Mr. J. Dinkle, four by Mr. Tuffen West, three by Mr. H. S. Smith, one by Mr. W. Sowerby, and one by Mr. G. West. Of the descriptive part, the Cystideæ and Star-fishes are by Mr. E. Billings; the genus Cyclocystoides by Mr. Salter and Mr. Billings; and the Entomostraca by Mr. T. R. Jones, assistant-secretary of the Geological Society of London, who is considered the best authority on this particular family of animals, and had previously described a large number of the Canadian species.

While Mr. Billings was attending to the progress of his decade in London, it appeared doubtful which of the three that were in hand would be first ready for publication. He, in consequence, caused to be registered on the plates, as the number of the decade, the figure which indicates the order in which it was commenced.

It therefore appears as the third decade, but being the first ready, and the subject quite distinct from those of the other two, no hesitation is experienced in placing it first before the public.

Mr. H. S. Smith, who, as already stated, supplied three of the plates, has been induced to come out to Canada with the design of devoting his attention to the representation of the fossils of the Provincial collection; and it will therefore in future be unnecessary to go out of the country for the illustration of them, unless it be to procure the aid of the best authority on some special subject.

Of the third decade an edition of 2000 copies is issued. Of these 500 copies are reserved for the members of the Legislature; and it is intended to fix upon the remainder a moderate price, and dispose of them to the public through some respectable bookseller. By this means it is hoped that they will fall into the hands of those who will really appreciate them. The same course will be pursued in respect to the first and second decades, when they are ready.

A fourth decade is now in hand which will illustrate the Crinoids of the collection.

W. E. LOGAN.

Montreal, 30th June, 1858.

CANADIAN ORGANIC REMAINS.

On the CYSTIDEÆ *of the Lower Silurian Rocks of Canada.* By E. BILLINGS, F.G.S.

SECTION I.

GEOLOGICAL POSITION, STRUCTURE AND CLASSIFICATION.

I. *Introductory Observations.*

As several elaborate and beautifully illustrated memoirs upon the structure and affinities of the Cystideæ have appeared during the last few years, it would be superfluous, on the present occasion, to enter upon a re-examination of the subject, were this decade designed to circulate only among scientific men, for whom it would be sufficient to give nothing more than the most concise technical descriptions of the species. But being intended also for the use of the students of Canadian geology—whose number is rapidly increasing throughout the Province—it appears necessary to commence with a general summary of what has been ascertained up to the present time concerning the zoological characters and distribution in time and space of this somewhat extraordinary group of extinct organisms. By this course it is hoped that, while the foreign geologist will receive all the intimation he desires of what we are doing, the growth of science in our own country will also be promoted.

The Cystideæ were a race of small marine animals, which flourished vigorously during the Silurian period, but totally disappeared before the commencement of the Carboniferous era. They were closely allied to that interesting family, the lily encrinites, or Crinoids, and, like them, entirely covered, as with a coat of mail, by a dermal or external skeleton of thin calcareous plates, which were sometimes richly ornamented with radiating ridges or striæ. Attached to the lower extremity of the body was a short flexible stalk, usually called the column, that served to anchor the animal

securely to one spot on the bottom of the ocean throughout life; and at the opposite, or upper end, a set of arms, which, in addition to their other functions, may have assisted in the collection of food by exciting currents of water towards the mouth. This latter organ was a circular or oval aperture, situated in the side, below or near the summit, and in some species must have been also the passage through which such matter as could not be digested was thrown out. The young were developed from eggs, which were, there is good reason to believe, generated in the grooves of the arms or pinnulæ, where, as has been ascertained by actual observation, the organs of reproduction are situated in the Crinoids that exist in some of the seas of the present time.

Concerning the food, habits, or other particulars of the natural history of the Cystideæ, we can never hope to acquire any great amount of information, as the race wholly perished many ages ago, and the only evidences we have of its existence are, with few exceptions, very imperfect skeletons, which exhibit nothing except the structure of the external hard parts. It is only probable that their nourishment was derived from minute particles of animal or vegetable matter diffused through the waters in which they lived. The structure and position of the mouth are such, that they could not have been highly carnivorous, while their nearly sedentary condition would altogether preclude the capture of any prey except such as might float by chance within their reach. Animals rooted to the ground like a plant would fare ill were they organized to support life by the predacious mode only.

The fossil remains of the Cystideæ consist for the greater part of mere fragments of the plates and columns; but these, in certain localities, occur in such prodigious abundance, that they constitute the principal portion of strata of rock several feet in thickness. Of many of the species specimens of the bodies are exceedingly rare, and when these are discovered they are usually more or less crushed and distorted. While the fossil Corals, Brachiopods and Gasteropods may be collected in hundreds, few cabinets can boast of half-a-dozen good Cystideans, even in those countries where whole formations of rock are composed of the exuviæ of the race.

With respect to their distribution in time, they have been discovered in Bohemia, by M. Barrande, in beds which lie in the very bottom of the oldest rocks containing traces of animal life; and therefore, according to the present state of our knowledge of the primeval fauna, they were among the first living things that made

their appearance upon the surface of this planet. The Lower Silurian formation, in the several countries where it has been most studied, has at its base a great thickness of stratified rocks which are altogether without fossils—at least none have been discovered in them up to the present time. Then follows in conformable succession a series in which organic remains do occur, but not in any great abundance. This is the lower half of the fossiliferous portion of the Lower Silurian. In Great Britain these strata are the Lingula Flags of Sir Roderick Murchison; in Bohemia the Primordial Zone of Barrande; and in Norway and Sweden the Alum Slates, or Regions A and B, of M. Angelin, the leading palæontologist of that country. In America they have not been distinctly recognized, although it is doubtfully anticipated that the Potsdam sandstone and the lowest sandstones of the western states may be of the same age. It is more probable that some of the ancient schists in the eastern states, where a large trilobite of the genus *Paradoxides* has been found, are of the age of this "primordial zone of life." In whatever way this point may be decided hereafter, it is only in Bohemia that Cystideæ have been found so low down in the geological series. Four species have there been discovered, together with twenty-seven species of Trilobites, one Brachiopod (*Orthis Romingeri*, Barrande), and one Pteropod (*Pugiunculus primus*, Barrande), but no Crinoids.

In Scandinavia the Primordial Zone has not yet yielded traces of either Crinoids or Cystideæ, but seventy-one species of trilobites, and eight Brachiopods of the genera *Lingula*, *Orbicula*, *Orthis* and *Atrypa*, have been discovered, with one or two graptolites and a small orthoceratite, near the top.*

In England the Lingula Flags, which are regarded as the equivalents of the Bohemian and Scandinavian deposits, have furnished a very similar fauna of trilobites and rare mollusca, with one or two graptolites; but up to this date only a fragment of a crinoidal column and no Cystideans. It is also to be observed, that in none of these countries have any corals been detected in these lowest fossiliferous strata.

In the upper half of the Lower Silurian, organic remains become exceedingly abundant, and it is in this part of the geological series that the Cystideæ attain their greatest development, both in the numbers of the species and of the individuals. This deposit is

* Parallèle entre les Dépôts Siluriens de Bohême et de Scandinavie; par M. Barrande page 39 et seq.

represented in England by the Llandeilo and Bala or Caradoc groups of Murchison; in Bohemia by the stage D, containing the "second fauna" of Barrande; in Scandinavia and Russia by the Regions BC, C and D of Angelin, and the "Pleta" or Orthoceratite limestone; and in Canada by all the groups from the base of the Calciferous Sandrock up to the top of the Hudson River group.

While these rocks were slowly being deposited, the Cystideæ literally covered the bottom of the ocean in dense swarms in certain localities which were favorable to their existence, one generation growing upon the remains of another, until thick beds were formed. In Russia, Norway and Sweden, Sir Roderick Murchison* discovered them in the Pleta limestone, which appears to be of the age of the Chazy, Birdseye, Black River and Trenton limestones, packed together like "bunches of enormous grapes;" and in Bohemia M. Barrande has found them equally abundant. He says that the Crinoids and Star-fishes have left only insignificant traces, but the Cystideæ form entire beds of from one to two yards in thickness.†

In Canada they make their appearance rarely in the Calciferous Sandrock, but in the Chazy and Trenton their remains are more common, consisting however mostly of the detached plates packed together in thick strata. They are not very generally distributed, but confined to certain localities. Throughout extensive regions occupied by these formations scarcely a vestige of a Cystidean is to be found; but in other places, such as the neighbourhoods of the cities of Montreal and Ottawa, they are exceedingly plentiful. Everywhere however good specimens are rare.

M. Barrande, in comparing the European rocks of this age, observes, that in Bohemia the Cystidean zone occurs about the centre of his stage of Quartzites D, which would be also the equivalent of Angelin's group C. In England the corresponding level would be about the Bala limestone, where the principal masses of Cystideæ are found. The abundance of their remains in the Chazy and Trenton of Canada confirms the views of M. Barrande, and at the same time tends to shew that these two American formations should be paralleled with the Bala rather than with the Llandeilo. This question however cannot be decided without more perfect lists of fossils than can be at present procured.

The number of species of Cystideæ that occur in this zone are as follows, so far as I can ascertain, in these countries respectively:—

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* Geology of Russia and the Ural Mountains; by Sir R. I. Murchison, page 38.

† Système Silurien du centre de la Bohême; par M. Joachim Barrande, page 66.

Scandinavia and Russia*	20
Great Britain†	13
Bohemia, about	8
Canada	21
New York	1
	63

In consequence of the imperfection of the specimens and some confusion in the descriptions of different authors, the above numbers may not be exactly correct; but from what I have seen it appears to me that there are more than sixty species, described and undescribed, belonging to this period.

In the Upper Silurian there are in Great Britain nine species, and in Canada and New York about the same number, but none in either Bohemia or Scandinavia have yet been made public.

According to the present state of our knowledge, then, in the lower half of the Lower Silurian there are four species, in the upper half sixty-three, and in the Upper Silurian eighteen.

Very little dependance however can be placed upon numerical comparisons, such as the above, in dealing with questions relating to the Cystideæ or Crinoideæ, for the reason that new discoveries are every year being made which very materially change the aspect of these computations. For instance, six years ago only eleven Crinoids, one Cystidean, and one Star-fish, were known in the Lower Silurian of New York and Canada, but in the collection of the Geological Survey of Canada there are now twenty-one species of Cystideans, about fifty Crinoids, and ten Star-fishes, or in all eighty-one species of Echinodermata from this formation instead of thirteen.

In the Devonian formation several forms resembling Cystideæ have been referred to that group of organisms; but it remains still to be shewn that they are true Cystideans. The weight of the evidence tends to shew that the race was ushered in with the first living inhabitants of the deep—attained its greatest development in the latter portion of the Lower Silurian era, and died out about the time of the commencement of the Devonian. Of its associates in the Primordial Zone, the Brachiopoda, Pteropoda and Bryozoa remain to the present day. The trilobites held their possession of

* Bronn's Index Palæontologicus. Zweite Abtheilung, p. 181.

† On the British Cystideæ, by Prof. E. Forbes. Memoirs of the Geological Survey of Great Britain, vol. ii. part 2, p. 483 et seq.

existence until the Carboniferous period, and the graptolites disappeared early in the Upper Silurian. With the exception then of the graptolites, the Cystideæ were the first race that became extinct.

II. *The General Form and External Skeleton of the Cystideæ.*

In form the Cystideæ were either globular, oval, pyriform, conical, or sub-cylindrical, and their dimensions seldom more than one inch and a-half or two inches in length and breadth. They were protected by an external skeleton composed of flat polygonal calcareous plates, which were so accurately fitted together that they enclosed, with the exception of the arms and column, the whole of the animal almost as completely as an egg is contained in its shell. In some of the species the plates were neither limited as to their number, nor arranged according to any definite order, and in these, as the body increased in size, the corresponding enlargement of the skeleton was effected both by the growth of the older plates and the introduction of new ones between them. In many species the number of the plates and plan of arrangement remained constant throughout the life of the animal, the shell being enlarged by the continual growth of the original plates and without the addition of new ones. In others, such as the species of the genus *Pleurocystites*, both of these modes of increase prevailed, the dorsal side having the number and arrangement definite and the ventral indefinite. The growth of the individual plates appears to have been by the assimilation of fresh particles of matter throughout the whole mass, instead of by additions to the edges.

III. *The Mouth, Ambulacral Orifice and Anus.*

In the Cystideæ we find two and in some species three principal apertures through which the more important functions of the animal economy were exercised. These are :—

1. *The mouth*,—A large orifice situated on one side, usually about the middle of the body, but sometimes near either the base or the apex. In many species it was provided with a valvular apparatus, by which it was opened or closed; in others no such provision existed, or at least it has not been preserved in the fossil state. It is quite probable that in most of the species this orifice subserved the double function of a buccal and an anal aperture.

2. *The ambulacral orifice*.—This opening is always situated in or near the centre of the upper part of the body, and in the central

point between the bases of the arms when these are present. Through it the vessels of the aquiferous system and of the organs of reproduction, which were situated in the grooves of the arms, communicated with the interior. There can be little doubt also that the nervous filaments, if the Cystideæ possessed any, gained access to the arms through this passage.

Concerning the functions of these two apertures much difference of opinion has existed amongst the best naturalists, some regarding the large opening in the side as an ovarian orifice, others believing it to be the mouth. Since the discovery recently made of the ambulacral orifices of the true Crinoideæ and also of the arms of the Cystideæ, it appears to be quite certain that the latter opinion is the correct one. I shall notice this subject more at length in the next section.

3. *The anus.*—In some species there is a third small aperture, which is always situated near the apex. It is usually minute and in certain genera has not yet been observed. This orifice is designated the anus by most authors, a view of its characters somewhat supported by the fact that we know of no other function that can be assigned to it. In the species which were not provided with this opening, the excrements were ejected through the mouth, as in those Star-fishes that have no anus.

IV. *The Arms, Ambulacral Grooves and Pinnulæ.*

The arms of the Cystideæ only differ from those of the true Crinoideæ in the position which their bases occupy in the skeleton, and in the general inferiority of their development. The structure of the arms is essentially the same in the two groups, but in none of the Cystideæ do we find them of a very high degree of perfection. I propose to arrange them in the following order :—

1. Cystideæ in which the body of the arm was not developed, but only the grooves and pinnulæ. The following species are examples:

Cryptocrinus cerasus (von Buch), which in the specimens I have observed, has fourteen small plates arranged in a circle around the ambulacral orifice. Each one of these exhibits upon its surface a small irregular scar, which marks the position of the attachment of a single pinnula. No grooves are visible, but it is quite evident that this species had no true arms.

In *Echino-encrinites angulosus* (Pander), there were five or six pinnulæ, with their corresponding grooves.

In the genus *Glyptosphærites* (Müller), represented by the species *Sphæronites Leuchtenbergii* (Volborth), very slightly impressed grooves radiate from the ambulacral orifice and ramify over the surface of the body. At the end of each branch the place of the attachment of a pinnula is seen. Upon the closest examination of good specimens I have been unable to detect any indication that these grooves were occupied by an arm that was bent backward upon the body as in the genera *Apiocystites* (Forbes), and *Callocystites* (Hall). It is also quite clear that the pinnulæ were not seated upon arms of this kind, but immediately upon the surface of the plate. The grooves are not excavated but impressed; they appear as if they had been formed by several fine threads lying on the surface, while the plates were too soft to sustain their weight. In this species the pinnulæ were distant from each other and scattered over the greater part of the body. In *C. cerasus* they formed a circle around and quite close to the orifice, and in *E. angulosus* they were also confined to the apex, but somewhat scattered. According to my views we have in these forms the lowest and most rudimentary condition of the radii yet seen in any Crinoideæ or Cystideæ. The ambulacral vessels issued from the interior through the orifice, and having nothing to support them, crept along the surface, sending out branches to those points where the pinnulæ arose. The main trunk of the arm, or that which bears the pinnulæ in the Crinoids, was totally absent: it was never developed. There is nothing but the grooves and the pinnulæ to indicate the existence of an ambulacral system.

2. Cystideæ in which the arms were developed, but bent backward and attached to the body. In these we perceive a structure one stage more perfect than in the several species just noticed. The arms of *Apiocystites pentrematoides* (Forbes), *Callocystites Jewettii* (Hall), and *Glyptocystites multiporus*, are all constructed upon the same type. They originate in the apex of the fossil, where their bases are all crowded together into a narrow space, in the centre of which is the ambulacral orifice. They are composed of double series of flat plates which alternate with each other, and have the usual grooves of the Crinoids along their centres. On each side of the groove is a row of pinnulæ. From the main groove smaller ones branch out to the base of each pinnula. The whole structure is exactly that of the arms of the true Crinoideæ, but not so perfectly developed. The arms of all the Crinoids have sufficient strength to stand erect, but in these Cystideæ it appears to have been otherwise, and consequently we find them not free and supporting themselves, but lying at full

length upon the surface of the body. In *Amygdalocystites florealis* and the two species of *Malocystites*, the arms are also recumbent, but their position is somewhat different. The grooves are not in the centre of the upper surface of the arms, but upon one side, and there is but one row of pinnulæ. These characters are not the results of a different structure, but are occasioned by the curious position of the arms, which do not rest with their backs in contact with the surface, but with one of their sides undermost.

3. *Cystideæ with free arms.*—The only species known is *Comarocystites punctatus* (Billings), which has not only the free arms but also the pinnulæ of a true Crinoid. It is probable that some of the small Cystideans described by Professor Forbes, in the "Memoirs of the Geological Survey of Great Britain," belong to this group. The four little prominences on the top of *Caryocystites munitus* appear to be the remains of arms which were free, and of a large size in proportion to the magnitude of the body. The genus *Pleurocystites* has two appendages which are more of the nature of pinnulæ than arms. They are composed of a double series of joints, and have the grooves bordered by small marginal plates. In this respect they exactly resemble the pinnulæ of *Pentacrinus caput-Medusæ* as figured by Miller. Although in the descriptions of the species I have called them arms, I am not at all satisfied that they are entitled to be so designated.

The distribution of the arms of the Cystideæ above given into three kinds, is not intended as a classification of the species into groups. On the contrary, we find that widely different genera, such as *Malocystites* and *Apiocystites*, have recumbent arms, and others equally far apart, such as *Echino-encrinites* and *Glyptosphærites*, with pinnulæ only, while *Comarocystites*, which agrees with the *Sphæronites* in the numerous plates of the body, has the arms free. Even in the same genus we have two of those degrees of development, for *Glyptocystites Logani* has only pinnulæ, but *G. multiporus* has both recumbent arms and pinnulæ. It is quite clear therefore that such characters are not often of more than mere specific importance in classification.

V. *The Calycine Pores or Pectinated Rhombs.*

Many of the Cystideæ were also provided with a peculiar system, consisting of pores which penetrated through the plates of the body, and probably served as media of communication between the interior and exterior, although the precise nature of their functions has not

yet been ascertained. The form and distribution of these pores vary greatly, but certain groups of species, closely related by other characters, have them arranged after a plan common to themselves, and not found in the species of other groups. Thus the genera *Prunocystites* (Forbes), *Pseudocrinites* (Forbes), *Apiocystites* (Forbes), and *Lepadocrinites* (Conrad), belong to a group characterized by a skeleton composed of a small number of plates, about twenty, which are arranged in four series. All these have three pectinated rhombs, one situated at the base and two near the apex. *Echino-encrinites* (Meyer) and *Glyptocystites* have the same number of plates, but the rhombs, although the same in general structure, are arranged in a manner somewhat different from the others: *Echino-encrinites* having two rhombs at the base and one in the upper part of the body, while *Glyptocystites* has from ten to thirteen rhombs; but two of these, in *G. multiporus* and also *G. Forbesi*, are situated at the base of the dorsal side, in a position exactly like that of the two basal rhombs of *Echino-encrinites*. In those genera with the skeleton composed of an indefinite number of plates, the pores are circular, and not clefts of considerable length, as in the others. It appears therefore that good characters for classifying the species of the Cystideæ into groups can be derived from the form and arrangement of these organs, and accordingly a classification upon this principle has been proposed by Professor J. Müller of Berlin. The outlines of his system will be given hereafter.

VI. *The Column.*

The stem, stalk or column of the Cystideæ is usually short and tapering from the body downwards. In other respects it is the same in structure as the columns of the ordinary Crinoideæ. The most remarkable form is the column of *Lepadocrinites gebhardii* (Conrad), from the Lower Helderberg rocks of the United States. It differs from all others known in having a large portion of the lower extremity composed of a single long spindle-shaped joint.

SECTION II.

ON THE AMBULACRAL ORIFICES OF THE CYSTIDEÆ AND CRINOIDEÆ.

If it were possible to procure a Cystidean with all the internal and external organs perfectly preserved, it might be easy to deter-

mine accurately the functions of the several orifices that have occasioned so much discussion among the eminent naturalists and palæontologists who have written upon the structure and affinities of these fossils. It is not however probable that a single specimen retaining even a vestige of the soft parts will ever be discovered, and we are compelled therefore to content ourselves with the next best method of conducting the investigation. The only course is to proceed by examining and comparing the offices of the ambulacral grooves and apertures of some of the existing species of Echinodermata which have been dissected by observers of good authority. In pursuance of this plan, I shall here notice briefly such points in the organization of the Star-fishes and recent Crinoids, as appear to have a direct bearing upon the subject.

I. *Ambulacra of the Star-fishes.*

The Star-fishes are not closely related to either the Crinoideæ or the Cystideæ in the structure of their skeletons, but they present the most perfect examples of Echinoderms with all the ambulacral vessels located in grooves upon the outside. The mouth is situated in the centre of the under-side of the body, and the ambulacra consist of a set of deep furrows which radiate therefrom to the outer extremities of the rays. They contain the following organs, all of which communicate with the interior by passing inward through the mouth.

1st. *The aquiferous canals*, consisting of a set of long tubular vessels extending the whole length of the furrows and entering the mouth. They are attached to, or originate in, another vessel, which forms a ring around the mouth, inside of the body. Connected with these vessels, and situated in the grooves, are two or four rows of suctorial feet, the whole constituting the most extraordinary system of locomotion known.

2d. *The nerves of the ambulacra.* These are also connected with a ring around the œsophagus, and pass out from the interior through the mouth. The main trunks lie along the bottoms of the ambulacral grooves, and send out branches to the suctorial feet.

3d. *The blood-vessels*, which also proceed from circular canals in the interior, and reach the ambulacra through the mouth.

The aquiferous canals and suctorial feet, with their nerves and blood-vessels, constitute the ambulacral system of the Star-fishes; and as all the organs are situated on the outside of the animal, and

communicate with the interior through the mouth, one of the functions of the aperture is that of an ambulacral orifice. In those species without an anus, the ova and excrements are extruded through the oral opening. In many which have an anus there are several sets of genital pores for the production of the eggs.

The following then are the apertures which in the Star-fish without an anus are all combined in one:—

1. The mouth.
2. The anus.
3. The ovarian apertures.
4. The ambulacral orifice.

In those with an anus and genital pores, the mouth has of course but two functions.

II. *Recent Crinoids.*

In the recent species of Crinoids, such as *Pentacrinus caput-Medusæ*, and the several species of the genus *Comatula*, the ambulacral grooves radiate from the mouth and are continued along the ventral sides of the arms to their extremities. At first there are five only, but these divide into ten before reaching the margin, in order to furnish a groove for each of the ten arms (see fig. 1). The grooves also send off slender branches to the pinnulæ, and they are all provided with suctorial feet, ambulacral canals, nerves and blood-vessels, as in the Star-fishes. The young however do not escape through the mouth, but the ova are developed beneath the soft skin in the grooves on the ventral side of the pinnulæ, and when the proper time arrives are set free. The vessels of the arms all enter through the mouth, and as there is always a distinct anus, it follows that this aperture has two functions.

1*st*. It is the mouth.

2*d*. It is the ambulacral orifice.

3*d*. It must also, to some extent, be regarded as an *ovarian aperture*, because in all animals there must exist a connection of some kind between the reproductive and nutritive systems. It has been demonstrated by Mr. J. V. Thompson of Cork (see Edinburgh New Philosophical Journal, 1836), that the ova, as above mentioned, are generated in the arms and pinnulæ outside of the body; and as there is no other aperture for that purpose, then it must follow that whatever may be the vessels by which a communication is effected between the ovaries and the interior, they can only pass through the mouth. For the same reason, the ambulacral orifices

of the palæozoic Crinoids (to be mentioned in the next paragraph) partake also of the nature of *ovarian* or *genital apertures*.

The structure of the Star-fishes and recent Crinoids only agrees in these respects: that both groups have the ambulacra outside of the body, and the ambulacral orifice and mouth combined in a single opening.

III. *The Palæozoic Crinoids.*

In at least a great many species of the palæozoic Crinoids we find an arrangement so different, that it almost justifies their separation into a division distinct from the recent forms. The structure of the arms is precisely the same, and there is not the least doubt that their functions were also to support the ambulacra and reproductive organs, as in *Pentacrinus* and *Comatula*. In the ventral surface however, or in the circular space surrounded by the arms, there is only one large opening, but no grooves radiating from it to those of the arms. To shew more clearly the difference between the recent and extinct species in this respect, I have constructed the following diagrams :—

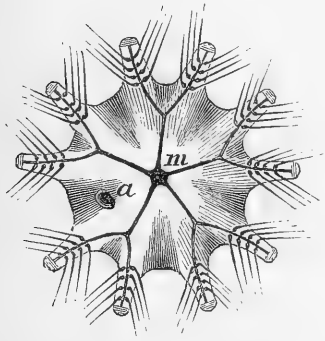

Fig. 1. Recent Crinoid.

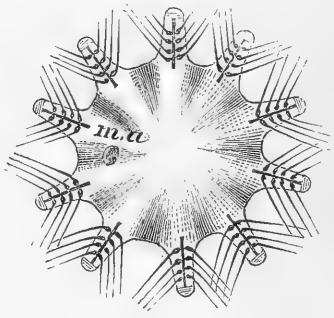

Fig. 2. Palæozoic Crinoid.

Figure 1 is a diagram of the ventral surface of a recent Crinoid with the mouth, *m*, situated in the centre, and the ambulacral grooves radiating from it to the arms. The anus, *a*, is situated between the centre and the margin, and in some of the species of the genus *Comatula* it forms a tubular projection of several lines in length.

Figure 2 is an ideal representation of the ventral region of a palæozoic Crinoid, with only one opening, *m a*, but with no grooves leading from it to the arms.

All palæontologists are agreed that this single aperture, found in all the ancient Crinoideæ, is both the mouth and the anus. It is sometimes situated in the centre, equidistant from the bases of the arms; sometimes between the centre and the margin; and in a few species, such as in *Caryocrinus ornatus* (Say), it is placed at the edge of the cup, between the bases of two of the arms. It is often level with the surface, but in many species it is in the top of a long tube, the so-called proboscis, which is frequently longer than the arms, and projects above their extremities when they are erect. The ambulacral grooves however are only found in the arms. They are not continued along the surface of the body to the mouth, as in the Star-fishes and recent Crinoids; and unless, therefore, there be some other provision made for their entrance, it is difficult to see how the ambulacral canals, nerves and blood-vessels could communicate with the interior. In those species with the mouth not elevated they might find their way along the surface, but it is improbable that they could do so without leaving some trace of their passage; and in Crinoids with a proboscis it appears impossible that this course could be followed at all. Provided therefore the usual description of the palæozoic Crinoids be correct, *i. e.*, that they have only one aperture, then their ambulacral system must have been totally disconnected from the interior of the animal—a supposition that would be contrary to all the analogies furnished by the structure of the other groups of the Echinodermata.

I have long been of opinion, that at the bases of the arms of the extinct species there were special apertures provided for the passage of the ambulacral vessels, but the evidence in my possession did not appear sufficient of itself to warrant the publication of such a view. Having had however, within the last few months, opportunities of studying a large number of specimens in the collections of England and France, I am now satisfied that there can be no doubt about the matter. It is quite certain, that a great many of the extinct Crinoids had either five, ten, twenty, or more of these openings, and that through them the vessels of the ambulacra passed from the grooves of the arms directly into the visceral cavity. While examining the magnificent collection of the Geological Survey of the United Kingdom I found many species which exhibit these apertures in a most perfect state of preservation; and upon consulting Mr. Thomas A. Huxley, F.R.S., who is profoundly acquainted with the details of the structure of all the orders of the Echinodermata,

I was delighted to find that he had already arrived at the same results, and had it in view to prepare a paper upon the subject for the "Transactions of the Geological Society." Upon my informing him however that I was also about to publish the same discovery in this decade, he in the most liberal manner made over his materials to me, and I am thus enabled to give a figure of *Actinocrinus rugosus*, which shews the course of the ambulacra under the ventral surface.

The principal difficulty in proving the existence of these orifices is to find specimens so little mutilated at the base of the arms as to exhibit the apertures with their margins uninjured. Hundreds of examples occur with large, irregular openings, but as the edges are fractured all around it is impossible to say whether or not there were originally any natural apertures. It is only in individuals which have been well preserved, and carefully collected and cleaned, that the facts can be clearly observed. In some of the species the apertures are exceedingly small, and so filled with crystalline matter that they can only be seen very indistinctly. In *Caryocrinus ornatus* (Say), for instance, there are certainly indications of the existence of minute apertures, yet in the best specimens I have seen it would be hazardous to assert it positively. In all the species of *Rhodocrinus*, *Actinocrinus* and *Platycrinus*, the apertures are in general large and easily observed. Most of the Lower Silurian specimens are in such a condition that nothing can be determined with certainty concerning any of the orifices. In one species from the Chazy and two from the Trenton limestone, all of the genus *Hybocrinus*, I have however ascertained their existence.

The following are some of the species in which I have seen clearly that these apertures actually do penetrate through into the interior of the visceral cavity:—

1. *Eucalyptocrinus decorus* (Phillips).—In this remarkable Crinoid the arms are always found closed into the niche-like divisions of the proboscis and ventral portion of the cup. It is one of those species whose structure renders a passage for the ambulacral canals through the mouth almost impossible, as the orifice is situated in the apex of a tube that projects above the extremities of the arms. In order to enter the body in that direction, the vessels, after descending the groove on the inside of the arm, could only proceed by climbing the outside of the proboscis, by which course the projecting knob of plates at the top would have to be surmounted. A more inconvenient route could scarcely be imagined, and we find that nature has provided a much shorter one. While collecting fossils in the

Niagara limestone last year, I procured at Thorold, near the Welland Canal, a specimen which had been split in two from the apex downward. I found only a portion of one of the halves. The cavity of the body and proboscis had been filled with some soft material, which, upon exposure to the weather, had totally disappeared, thus exposing the structure of the inside of the cup as distinctly as could be desired.

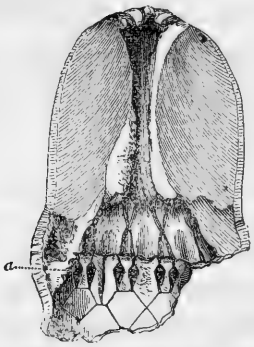

Fig. 3. Fragment of *Eucalyptocrinus decorus* (Phillips), shewing six of the ambulacral orifices.

There are two orifices at the base of each arm, and consequently twenty in all, as this species has ten arms. The specimen only retains six. They are of an oval shape, about one line in length and one-third of a line in greatest width. Each pair is separated by a small elongated ridge-like plate or process, which cannot be seen on the outside of the cup. All the inter-radials which are situated in the same level with the apertures have at each of their upper angles a sharp process, which projects inwards about half-a-line. (In figure 3, if the dotted line from the letter *a* were continued, it would cross the centres of the apertures and inter-radials here referred to.) The processes are above the line, and cannot be shewn by wood-engraving. The small plates which separate the two pores of each pair of the orifices have also each a similar process, between which and the process of the contiguous inter-radial there is a very narrow passage from the orifice upwards; and it is possible that the ambulacral canals took an ascending course by this route after gaining the interior. Upon such points however of the internal structure of the Crinoids, all that can be offered perhaps for an age yet to come must be merely conjectural. The main fact proved by this specimen is the existence of the ambulacral orifices at the base

of the arms, and that consequently it was not necessary for the vessels to climb the proboscis in order to reach the interior.

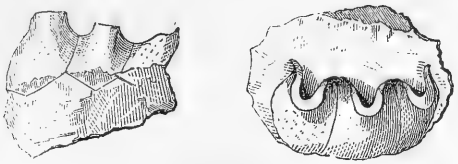

Fig. 4. Side view of a fragment of *H. pristinus*.
Fig. 5. The same, seen from above, shewing the continuation of the ambulacral grooves of the arms into the interior.

2. *Hybocrinus pristinus*, *H. conicus*, and *H. tumidus*, (Billings,) have five ambulacral orifices each, and they are formed according to a plan which will be found somewhat common among the species of those genera which have short cup-shaped or round bodies, such as *Cyathocrinus*, *Poteriocrinus*, *Dendrocrinus* and others. The first radial plate has a projection of the central portion of the upper margin, which folds round and makes a conspicuous rounded channel which descends along the inside of the plate to the interior. The upper edge has a horse-shoe form, corresponding exactly to the first joint of the arm which is seated upon it. These species shew that generally the notches which we see in the detached first radial plates of so many others are only continuations of the grooves of the arms into the interior.

3. *Rhodocrinus bursa* (Phillips).—Good specimens of this species exhibit very distinctly ten ambulacral openings. They penetrate into the interior at about one-half the height of the body, and their margins are formed on the lower sides by a semi-circular notch in the upper edge of the second plate of each of the secondary rays, and on the upper by several of the small abdominal plates. In no other species is there more unequivocal evidence of the existence of these openings, but they are accompanied by a structure which seems to indicate two sets of arms placed one above the other. Beneath the orifices there are two articular surfaces, which mark the bases of two arms; and above each pair of the orifices there is a projection, which also much resembles the base of one or two more arms. They are very accurately figured in Phillips' "Geology of Yorkshire," vol. ii. pl. v. figs. 23, 24, 25. I shall introduce one of these figures here, in order to shew their peculiar structure :—

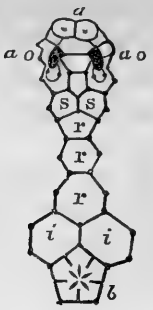

Fig. 6. One of the rays of *Rhodocrinus bursa* (Phillips).

In this figure *r*, *r*, *r*, are the three primary radials; *s*, *s*, the secondaries; *a*, *o*, the ambulacral orifices; *b*, the five basal plates; *i*, two of the sub-radials; and *a*, what appears to be the place of a pair of arms. In some of the specimens this feature is exhibited so prominently that it strongly impresses the observer with the idea of two tiers of brachial appendages. It may be however that there were projecting from this part of the vault a set of large spines corresponding in numbers with the arms. *Rhodocrinus* differs in no respect from *Thysanocrinus* (Hall), provided we still depend for generic characters altogether on the structure of the cup below the point where the arms become free. But if the form of the vault be taken into account, then the English genus is different from the American.

The vault in *R. bursa* rises above the ambulacral orifices, and in fact projects a little outward over them, so that they penetrate into the side of the cup, below the margin, instead of being placed immediately above and inside of the margin, which, from the position of the arms, must be their place in *Thysanocrinus*.

4. *Actinocrinus rugosus*.—For the structure of this interesting species I am indebted to Mr. Huxley, and the figures given in the following page were drawn from a specimen in his possession.

In this species the plates are very thick, and the ventral side rises dome-shaped above the point of attachment of the arms, so that the ambulacral orifices are rather nearer the bottom than the top of the body. The proboscis is excentric, large, and not perpendicular, but projecting obliquely, so that when the arms were closed its apex probably was thrust out between two of them on one side. The mouth appears to have been closed by a number of small plates, which were no doubt so connected by an extensible membrane as

to permit of a considerable amount of dilation. The ambulacral orifices are ten in number, and enter the cup at the base of the arms. They do not however immediately penetrate into the cavity of the body, but ascend towards the top of the ventral elevation by five tunnel-like passages, which lie under the external plates and extend nearly to the apex of the dome. These passages are floored by a series of plates, which form an elongated arch under them. They do not reach the centre at the summit, but are discontinued at about two-thirds the distance from the base of the arms.

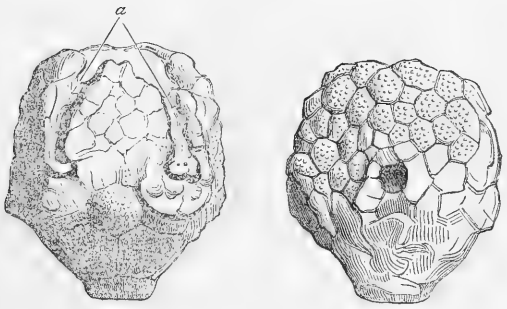

Fig. 7. A specimen of *A. rugosus*, shewing the course of the ambulacral channels from the orifices towards the summit. The exterior plates have been removed, leaving the floors of the channels visible. They terminate below the summit, at the points indicated by the lines diverging from *a*.

Fig. 8. View of the opposite side of the same specimen.

In order to ascertain whether these tubes might exist in other individuals, I procured several other specimens from the dealers in fossils and, upon removing the outer plates, found the same structure in all. Upon grinding down the summit of one of these, I find that the tubes do not reach the top of the vault, but terminate at a short distance below.

Fig. 9.

Figure 9 is a view of a section made transversely through the upper half of the ventral dome of a specimen. The unshaded border shews the great thickness of the plates of the vault. The tubes and visceral cavity are filled with soft light-brown rock. *m* is the mouth, which is cut through; at 1 is a tube, the floor of which has thinned out so, that it already communicates with the visceral cavity; *a*2 is another, with the floor remaining; 3 and 4 are in communication with the interior, although in consequence of the truncation being a little oblique, they are exposed at a lower level than the others; 5 is one with the external plates removed, leaving the bottom of the channel exposed down to the arm. The floor extends upwards four lines and a-half, and thins out just before it reaches the level of the truncation.

The important additional fact established by these specimens, and first ascertained by Mr. Huxley, is that at least in this species the ambulacral vessels, after entering the body, turn upwards towards the centre of the summit.

Fig. 10.

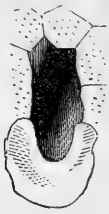

Fig. 11.

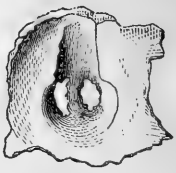

Fig. 12.

5. *Actinocrinus stellaris* (DeKoninck) has twenty ambulacral orifices which enter the body from the second or third plates of the tertiary rays. The ventral dome is very large, and at its base forms five projecting lobes, in each of which are four of the orifices. Figure 10 represents one of the lobes of a specimen in my possession. One of the orifices (fig. 10) is perfect, and shews that the margin of the upper half is formed of five small plates, while the lower side lies in the excavation in the tertiary radial plate. This excavation is simply the ambulacral groove, which is here continued into the body. Fig. 11 is an enlarged view of another orifice. A fragment of the vault of this species, which is empty, exhibits a broad rounded furrow, bounded on each side by two angular ridges running towards the summit (fig. 12). It occupies the position of one of the internal channels in *A. amphora*, and no doubt, as in that species, served to

conduct the ambulacral canals towards the summit of the ventral side.

6. *Pradocrinus Baylii* (deVerneuil*), a species which occurs in the Devonian rocks of Sabero, in Spain, has ten ambulacral apertures very clearly exhibited. The ventral surface of this fine species consists of numerous small plates, the mouth is excentric, and there are ten arms. The apertures are formed by a notch in the second plate of the secondary radials on one side, and on the other by several small ventral plates, as in *Actinocrinus stellaris*. Good specimens are in the collection of the Geological Survey of the United Kingdom, Jermyn Street. See also the figures given in the work cited.

Among the species figured in various works, the following are some that shew these apertures very distinctly :—

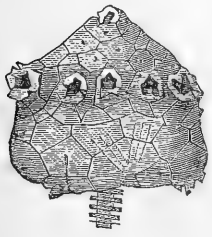

Fig. 13.

Fig. 14.

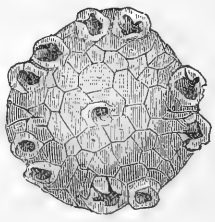

Fig. 15.

Figure 13. *Dolatocrinus lacus* (Lyon). Side view.
" 14. Diagram of one of the rays.
" 15. View of the ventral surface.

Dolatocrinus lacus occurs abundantly in the Devonian formation of Kentucky, and the above figures are taken from the beautifully illustrated Report of Mr. Sidney S. Lyon, of the Geological Survey of that State, published in 1857. (Plate iv. figs. 2, 2*a*, 2*b*.) There are ten ambulacral orifices, and the mouth is central, but there are no grooves from it to the arms. The generic figure given by Mr. Lyon—of which the above fig. 14 is a portion—shews all the apertures. In the same plate there are several figures of another species, *Vasocrinus valens* (Lyon), with five orifices; but of these only the grooves on the inner margins of the primary radials are preserved. All the ventral plates appear to be absent, and it

* Bulletin Geo. Soc. France, 2d series, 1850, vol. vii. page 184, plate iv. fig. 11.

cannot thus be seen whether the mouth was central, proboscidiform or otherwise, or whether the grooves of the arms were continued along the surface.

The following three figures are taken from the Report of the Geological Survey of Missouri, vol. i. part ii. plate A. Dr. Shumard, the Palæontologist of Missouri, in his descriptions of the species, expressly recognizes these apertures. He says that the example of *A. rotundus* figured "exhibits twenty-one arm-openings." (p. 191.) Of *A. Verneuilianus* he states "the vault consists of numerous small pieces, united so as to form a nearly smooth convex surface. *Proboscis*, sub-central. *Arms, unknown;* the number of arm-openings in the specimens under examination varies from fourteen to fifteen." (p. 194.) In the same plate there are figured *A. Christyi* (Shumard), *A. Missouriensis* (Shumard), *A. pyriformis* (Shumard), and *A. parvus* (Shumard), each of which exhibits a belt of ambulacral apertures.

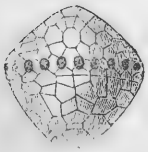

Fig. 16.

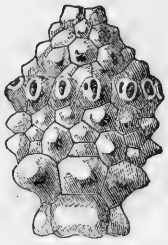

Fig. 17.

Fig. 18.

Figure 16. *Actinocrinus rotundus* (Yandell and Shumard).
" 17. *Actinocrinus Koninckii* (Shumard).
" 18. *Actinocrinus Verneuilianus* (Shumard).

The above figures and remarks, if not sufficient to establish the existence of these orifices, may, it is hoped, at all events indicate that the subject is worthy of investigation. There are many species that represented in the publications of different writers which shew that there are some very interesting questions relating to the structure of the ambulacra of the Crinoids yet to be worked out, and that probably principles for both zoological and geological classification may be drawn from this source. See the following, in Pictet's *Traité de Palæontologie*, Plate XCIX. :—Fig. 1. *Solanocrinus costatus* (Goldfuss). Fig. 2. *S. Jægeri* (Goldfuss). Fig. 3. *Decamerus mysticus* (Hagenow). Fig. 20. *Calliocrinus costatus* (Hisinger). Plate C. Fig. 2. *Haplocrinus mespiliformis* (Rœmer). Fig. 3. *Coccocrinus rosaceus* (Müller); and Fig. 7. *Gasterocoma antiqua* (Goldfuss).

IV. *The Cystideæ.*

Concerning the functions of the apertures of the Cystideæ there has always been much doubt; and in fact, at the present moment, the only point that can be regarded as established by positive evidence is, that the apical opening was the passage through which the vessels of the ambulacra issued from the visceral cavity. All the grooves of the arms or pinnulæ take their departure from it;—there are no other apertures so situated with respect to the brachial furrows that they could have subserved this function, and therefore the conclusion, that it was the ambulacral orifice, seems as well founded as could be desired. There is not the least proof, except the remote analogies furnished by the Star-fishes and recent Crinoids, that it was the mouth; and in selecting a name, therefore, the safest course is to be guided by some known character, rather than resort to the unknown.

The large opening in the side, called the mouth in this memoir, has been usually described as a genital or ovarian aperture, a view first entertained by the late Baron Leopold von Buch, and accepted with more or less hesitation by most authors up to the present time. The idea originated altogether in the supposition that the Cystideæ were armless, and consequently that the ovaries could not have been situated outside of the body. The following is von Buch's description of the Cystideæ:—

"The *Cystideæ* were natural bodies supported on a stem or pedicle, which was attached to the ground; their surface, more or less spherical, was covered by a great number of polyhedral plates, accurately fitted to one another, and between these plates were certain openings necessary for the performance of the animal functions; *but from none of these did arms proceed resembling those of the Crinoideæ. The animal was completely without arms.*

"With regard to the openings on the surface, we find in all the Cystideæ:—1*st*. That the mouth was planted in the central part of the upper surface, generally in a movable proboscis covered with minute plates. 2*nd*. That besides this mouth, and close to it, there is generally, if not always, a small anal orifice penetrating the plates, but not itself surrounded with any plates peculiar to it. 3*d*. That further towards the middle, but almost invariably on the upper half of the body on which the mouth is placed, there rises a round or oval aperture, not connected with the mouth, and often covered by a five or six-sided pyramid, which seems to be composed of as many little valves. This probably forms the ovarian orifice of the animal.

"These openings, with the exception of the mouth, *are not found to exist when arms begin to be developed from the upper surface;* and we may easily understand this when we remember that in the latter case the ovaries are carried out with the arms beyond the rim of the cup-like body, *so that a separate opening for them would be useless.* In all Cystideæ the presence of these ovarian orifices is however manifestly essential."—*Von Buch: Uber Cystideen*, Berlin, 1845. Translated in the Journal of the Geological Society, May, 1845.

It is quite clear from the above extracts that the only reason upon which von Buch founded his opinion was, that the Cystideæ are without arms. From the expressions in italics, there can be little doubt that if he had examined specimens with arms well preserved, such as some of those figured in this decade, the idea of an ovarian aperture would scarcely have occurred to him; in fact it would, to use his own words, have appeared to him 'useless.' Since therefore it is now beyond all question that the Cystideæ had true crinoidal arms, the only reason that ever suggested to any one the necessity of a genital aperture has no longer an existence, and the question remains exactly as it was before the publication of his memoir on the Cystideæ.

If then we should no longer regard it in the light of a genital opening, the next question to be decided is, What was its function? I believe that in those species which were provided with an anus, it was the mouth, and in the others both mouth and anus. The following are my reasons:—

1. In *Echinosphærites aurantium*, *Caryocystites granatum*, and many others, there is a well-defined anal aperture; and if the ambulacral orifice were also the mouth, then it would follow that the lateral opening had no function. The same would be true of the genera *Echino-encrinites*, *Apiocystites* and *Callocystites*, all of which are said to exhibit anal pores near the summit. But if the apical opening be an ambulacral orifice only, then there is no place for the mouth but in the lateral aperture.

2. The position of the organ in question is not inconsistent with the idea of its being an oral aperture, because in many of the Echinodermata we find it not only in the side but even on the under surface of the body. Thus in the Echinidæ the mouth is in the under side, and the anus either in the very highest part of the body or in the side. The Star-fish always crawls with his mouth under, and so do the Ophiura, Euryale and Comatula. The fact therefore that the lateral aperture of the Cystideæ is lower down than the anus is no proof that it is not the mouth, but directly the reverse, since it is the natural position for the organ in the class.

Even among the true Crinoids, we have at least one species with the mouth in the side, as represented by the following wood-cut, taken from the figure in plate C. of Pictet's Atlas. The genus has five basal plates and five radials; the mouth penetrates the large inter-radial, and there appears to be five ambulacral orifices. There can be no doubt but that this species is a true Crinoid, as the rays

originate in the sides and not in the centre of the ventral surface, as in the Cystideæ.

Fig. 19. *Epactocrinus irregularis* (Wirtgen and Zeiler).

3. In *Pentacrinus caput-Medusæ*, the mouth, although combined with the ambulacral orifice, has a structure similar to that of the Cystideæ. This fact is pointed out by MM. Koninck and Le Hon in their magnificent work upon the Crinoids of the Carboniferous rocks of Belgium.* The observations were made upon a fine specimen captured by a fisherman in the harbor of Moule, Island of Guadaloupe, and sent by Dr. Duchassaing to M. Michelin. The following is Duchassaing's description of the mouth :—

"The mouth of the Encrinite is surrounded by five lips, and can be seen only when these five lips are opened. It then appears as a small round aperture about two lines in diameter. The lips are not free, and can be opened to the extent of about three lines. They are adherent to the five furrows which departing from the commissures are prolonged to the circumference of the disc. Mastication is effected, not by the mouth, but by the lips, which are armed to that effect with small stiff spines. As to nourishment, I found the debris of small crustaceans."

Upon the above extract, MM. Koninck and Le Hon make the following remarks : —

"It is perhaps well to observe here, that it results from the remarks of M. Duchassaing that what he calls lips are veritable triangular valves, hard, and armed at their points and internal surfaces, and designed to hold and crush Crustaceans and other animals upon which the *Pentacrinus* appears to feed.

"They have exactly the same form as the ossicles which in the Cystideæ cover the aperture which L. von Buch has considered as an ovarian orifice.

"We have no doubt that the illustrious palæontologist whose recent death science deplores, did not recognize the true function of that opening. We are persuaded that it served the same purposes as those which have been observed in *Pentacrinus*. Our conviction is so much the more profound that we have never been able to discover upon the triangular valves of the Cystideæ the least trace of a perforation, and that those which cover the mouth of *Pentacrinus* offer nothing more.

"It would be besides very extraordinary that these calcareous plates whose position and form are perfectly identical in these animals, belonging to the same class, should

* Recherches sur les Crinoids du Terrain Carbonifère de la Belgique. Par L. De Koninck et H. Le Hon, 1844 ; page 33 et seq.

be designed for such very different purposes as would result from the adoption of the opinion of L. von Buch, on the one hand, relative to the use of the triangular plates of the Cystideæ, and, on the other, from the direct observations made by Dr. Duchassaing."

From the above remarks, it is evident that MM. Koninck and Le Hon, who have profoundly studied the Crinoideæ, are of opinion that the ovarian pyramid of the Cystideæ is the exact homologue of the buccal apparatus of *Pentacrinus*, a view in the correctness of which I entirely concur. The only difference is that in *Pentacrinus* the ambulacral orifice with its grooves is combined with the mouth and its pyramid of valves, while in the Cystideæ they are separate. Von Buch was of the opinion that the five valves of the Cystideæ were perforated by five minute pores which were the ovarian pores. The organ would then present a greater resemblance to the ordinary arrangement of the reproductive system in the Echinodermata. In most of the families of this class when the ovaries are contained in the visceral cavity, there are many of them, and they have their orifices disposed according to the radiated division of the body. Thus in the Echinidæ there are five ovarian pores, sometimes it is true, reduced to four in the abnormal forms; in the Blastoidea there are five, in the Ophiuridæ ten, and in many of the Star-fishes five or ten.* It is thus contrary to analogy that when an Echinoderm has the reproductive system included in the cavity of the body, there should be but one genital opening.

4. If we consider the relative dimensions of the several apertures, we find that in general the mouth is larger than the anus. Although in the fossil Echinidæ the anal aperture often appears to be as large as the oral, yet this is owing to the destruction of a portion of it. In the living specimens the opening is covered over with the exception of a mere pore, while the mouth is of a large size. In the Star-fishes, wherever an anus exists it is always many times smaller than the mouth. In *Glyptocystites multiporus* the apical aperture is only one-tenth the size of the lateral opening; in *Malocystites Murchisoni* one-ninth; in *Echino-encrinites angulosus* one-ninth; in *Hemicosmites pyriformis* it consists of a minute three-rayed fissure (see the beautiful figure in plate iv. fig. 5, *Müller, Uber den Bau der Echinodermen)*; in all the species of *Pleurocystites*, although it has not been observed, yet the structure of the parts proves that

* See the figures of the genital pores of *Asteracanthion rubens* and *Solaster papposus*, Plate xii. *System der Asteriden*, von Müller und Troschel.

it must be exceedingly small. The same may be said of almost every Cystidean that has been described and figured: the lateral aperture is ever the largest, and when it is considered that the one in the apex, whether it be the mouth or not, always receives the ambulacral vessels by which its capacity is further diminished, the argument has still greater force.

5. The objection that it is contrary to analogy that the mouth of an Echinoderm should be situated any where else than in the central point where the grooves meet, is not borne out by the facts, because in a vast number of species of Crinoidea, the group most nearly related to Cystidea, it is not so placed. The grooves do not come near the mouth in the palæozoic Crinoids, and therefore the analogy wholly fails.

6. With respect to the bearing of the arrangement of the apertures of the recent Crinoids upon this question, there appears at first sight to be some difficulty, as in these there are two orifices, one of which not only receives the ambulacra, but is also the mouth, while the other is said to be the anus. If we were to be guided altogether by this analogy, the lateral opening of the Cystideæ would be, at least in some species, the anal aperture. There is however a great difference in the structure of the two groups. Any one who will take the trouble to examine, the figures of the species given in most elementary works, will see that the rays of *Pentacrinus caput-Medusæ* spring from the very base of the body. The first radial plates of all the rays rest upon the upper joint of the column, and the others follow in succession up the sides. If the point of the attachment of the column be the dorsal side, then the rays are developed from the centre of the back. The same structure occurs in *Comatula*. But in the Cystideæ it is the very reverse: the rays spring from the centre of the ventral side. The whole of the cup of the Crinoid is radiated, but in the Cystidean it presents no trace of a radial arrangement: all below the apex is unradiated; the bases of the arms are crowded together, so that they all originate in a narrow space upon the upper side of the body, where they surround the ambulacral orifice. The first primary radial plates, which in *Pentacrinus* rest upon the column, are in the Cystideæ transferred to the opposite pole of the body, and are there represented by the circle of plates which surround the ambulacral orifice. This view of the structure of the Cystideæ was first put forth by Volborth, and afterwards adopted by Professor J. Müller of Berlin. Neither of those authors however

appear to have been aware of the existence of special orifices in the Crinoids for the passage of the ambulacral vessels, and hence they still regarded the apical aperture as the mouth. Volborth says:

"All the Cystideæ were, like Crinoids, provided with articulated arms; and this statement is not mere hypothesis, but is the result of philosophical induction from distinct well-grounded facts, determined by observation—by the actual presence of arms in some species, and the presence of tentacle furrows in others. The Cystideæ were also *true Crinoids*. Either in the young state or throughout life they were attached by an articulated stalk, or by a pedicle, either to the bottom of the sea or to foreign bodies. They had articulated arms which, as in Crinoideæ, proceeded from the dorsal pole of the cuticular skeleton. Diametrically opposite to the orifice of the pedicle is placed the buccal orifice, and generally close to it is the sub-central anal orifice. The cup differs however from that of the Crinoids, by such a predominance of the dorsal side over the ventral, that the latter is often reduced to a minimum, consisting only of the orifice of the mouth, so that the arms appear to be much nearer the mouth than is the case with Crinoids."—*Volborth on the Arms of Cystideæ*. Trans. Min. Soc. of St. Petersburgh, 1845—6.

Professor Müller, whose extraordinary researches in the department of the development of the recent Echinodermata have never been excelled, says:—

"The development of the antambulacral side of the radii in Crinoids takes place either from the very base of the calyx, or from its circumference, or in the neighborhood of the mouth, as in most *Cystideæ*. In the latter case the calyx presents no radial arrangement of plates from the base to the immediate neighborhood of the mouth; it begins only at the mouth in the oral arms, whose ambulacral grooves however lead to the mouth, and, like the articulated antambulacral surface of the arms, present no traces of the general plan of the Echinoderms. Hence it is intelligible why, so long as the Cystideæ were held to be armless, the radial arrangement of the Echinoderm was unrecognized."—*Uber den Bau der Echinodermen*, p. 55. Translated by Mr. Huxley in the Annals of Natural History, 2d series, vol. xiii. p. 242. April, 1854.

Professor Müller terms the dorsal side of the arm of a Crinoid antambulacral, thereby distinguishing it from the ventral side, which is grooved and holds the ambulacra. The genital and ocular plates of the sea-urchins are also antambulacral, but they are few in number, and usually confined to one spot in the centre of the back; and therefore the principles contained in the above extract may be applied to shew that the Cystideæ are not so nearly related to the recent Crinoids as they are to the palæozoic species.

a. If we take a sea-urchin and placing it with the mouth upwards, which is the usual position of that organ in the Crinoids, then imagine a plane to be projected horizontally through the circular area occupied by the antambulacral plates, the whole of the body of the animal will lie above the plane. Its skeleton is composed

altogether of ambulacral and interambulacral plates, with the exception of the small space in the back, consisting of the ocular and genital plates.

b. If a similar plane be extended through the lower edges of the first primary radials of *Pentacrinus caput-Medusæ*, the body, as in the sea-urchin, will lie above it; but then it is covered at the sides by the plates of the rays, and on its upper surface by the ventral plates, all of which are antambulacral.

c. In such Crinoids as the species of *Poteriocrinus* and *Cyathocrinus*, which have two rows of plates below the radii, a plane through the lower points of the primary radials would have about one-half of the body below it, and the other half above. Here we see a tendency in the radiated skeleton to transfer its base from the dorsal to the ventral side; and it is interesting to perceive that in Crinoids of this structure we first find species which indicate their approach to the Cystideæ by the exhibition of poriferous areas, which are at least analagous to the pectinated rhombs of that group. These exist in *Porocrinus conicus* (Billings) of the Trenton limestone, and *Caryocrinus ornatus* (Say) of the Niagara group.

d. The Cystideans with a definite number of plates, such as the genera *Echino-encrinites*, *Glyptocystites*, *Apiocystites* and *Prunocystites*, are certainly more nearly related to the Crinoids than those with the body covered by a large and indefinite number, as, for instance, *Echino-sphærites aurantium*. The number five, so dominant in the arrangement of the parts of the body in the Crinoids, is apparent in these genera, although no trace of it can be seen in the sphæronites. Thus in *E. angulosus* (see plate iii. fig. 1*b*) there are four basal plates, but one of these is hexagonal, and can be divided so as to make two, which would be pentagonal like the other three. Above the basal plates are three other series of five each. It may be granted that the plates of the fourth series are the homologues of the five first primary radials of *Cyathocrinus planus* (Miller), which form a circle round the margin of the cup. When closely examined it will be seen that in both the Crinoid and the Cystidean these plates are notched in their upper margins by the ambulacral grooves; and it is therefore probable that they are strictly the homologues of each other.

If now in these two species we draw the plane as before, about one-half the body of the Crinoid and nearly the whole of the Cystidean will lie below it. The radiated skeleton in *E. angulosus* has ascended from the base to the apex of the body, and it is there

compressed into so small a space that there is no longer any room for the mouth in its centre. The organ is crowded outside of the circle of radial plates, and lies lower down in the body. If the arm-bearing plates of *Caryocrinus ornatus*—a species admitted to be almost a Cystidean—were thus drawn together into the centre of the ventral surface, the mouth would certainly be left outside, because it is situated in the margin, between two of the arms. It would not however on that account change its nature and become a genital aperture.

e. In all the species with an indefinite number of plates the difference is still greater. If we extend the plane through the base of the arms in *E. aurantium*, we would have the very opposite of what occurs in the instance of the sea-urchin. The body would form a large globe-like expansion below the plane, while in the sea-urchin it lies altogether above. The Cystideans of this type must be regarded as the extreme in one direction, and the Echinidæ the extreme in another. Prof. Müller says:—"In an Echinoderm which remains antambulacral quite up to the mouth, and develops arms only from the oral part of the calyx, we have at its maximum that condition which in the *Echinidæ* is at its minimum. To borrow the phraseology of the 'Natur-philosophie,' we may say that the calyx of a *Pseudocrinites*, *Agelocrinites*, *Echinosphærites*, *Echinocrinites*, is the apex of an *Echinus;* it is however an expansion of the apex large enough to enclose the whole of the intestines of the animal, while in the *Echinus* these are invested for the most part by the ambulacral zone of the perisoma."—*Uber den Bau der Echinodermen*, p. 16; *Annals of Natural History*, 2 ser. vol. xiii. p. 9.

If now we place the above forms in series arranged according to the greater or less concentration of the antambulacral side of the rays towards the centre of the back, all the Crinoids would lie between the Echinidæ and the Cystideæ. Thus:

In the Echinidæ the antambulacral radiated skeleton is absorbed into the middle of the back.

In *Pentacrinus* and *Comatula* it is also strongly concentrated, but covers the whole of the back and sides.

In *Thysanocrinus* (Hall), a genus which appears in the Trenton limestone, the unradiated space at the base of the cup is larger than it is in *Pentacrinus*. There are two series of plates below the first primary radials. There is then in this genus a tendency in the radiated portion of the skeleton to depart from the centre of the back and take its origin from the upper part of the body.

When we examine a specimen of any species of *Cyathocrinus*, we perceive another step in the same direction. There are, as in the last genus, two rows of plates below the radii; but, in addition to this character, the ventral side of the animal does not rise above the upper margins of the first primary radials. The radiated skeleton forms a belt round the upper part of the body, and *Cyathocrinus* is therefore nearer to *Echino-encrinites* than is *Pentacrinus*, because the bases of the rays are nearer the ventral side.

Many other examples might be given in illustration of this point, were it necessary. The general conclusions I draw from the whole of the above are, that when we compare the recent and ancient Crinoids with the Cystideæ, the latter two are seen to be the most nearly related upon the whole—that those genera with two series plates below the radii are the nearest to the Cystideæ, and that the genera with the rays developed from the base are the most distant of the Crinoids, the Echinidæ being still further away.

If these conclusions be correct, then the apertures of the Cystideæ should be more properly compared with those of the palæozoic than with those of the recent Crinoideæ. These latter have no special ambulacral orifice, the function being exercised through the mouth. But the palæozoic Crinoids have the ambulacral orifices separate from the mouth, and so it would most probably be in the Cystideæ.

Classification of the Cystideæ.

The following passage, extracted from the memoir of Professor Müller on the Structure of the Echinoderms, contains the outlines of a system of classification which will most probably be generally adopted. It should be borne in mind that he was not aware of the existence of the ambulacral orifices in the Crinoids, otherwise no doubt some portion of his paper would have been directed to their examination:—

"*Cystideæ.*—Among the Crinoids the *Cystideæ* of L. von Buch form a group which is distinguished by the inclusion of the genital organs, together with the other organs, in the calyx. In the *Pentacrinites* and *Comatulæ* on the other hand, the sexual organs are attached to the pinnulæ of the arms; in those Crinoids which have only one calycine opening (mouth), as *Actinocrinus*, *Platycrinus*, &c., the exclusion of the sexual organs from the calyx is at once rendered probable by the

absence of any aperture corresponding with them. The *Cystideæ*, on the other hand, have at least two and sometimes three apertures to their calyx, one of which, distinguished by its valvular closure, is found in no other Crinoids than the *Cystideæ*. L. von Buch has determined that this valvular pyramid is the genital aperture.* We owe to him the recognition of the close alliance of these forms with the Crinoids, and at the same time of their peculiarities, the exact analysis of their calyces, and the exposition of their genera. That they are not armless, as had hitherto been generally supposed, was first observed by A. von Volborth, who discovered the arms in *Echino-encrinus angulosus* and *striatus*, subsequently in *Echinosphærites aurantium*, where they proceed from the mouth. The figures of the Duke of Leuchtenberg, and those of Volborth of *Sphæronites Leuchtenbergii* and *Protocrinites oviformis* would indicate the presence of arms in these also, although they have not been actually obtained. In fact, branched grooves run from the mouth over a great part of the calyx; the branches of the grooves however end in papillæ of the calyx, which must be regarded as points of origin of arms—a circumstance so much the more remarkable, as it would follow that the arms of these *Cystideæ* must have had a position far removed from the mouth (Verhandl. d. Konigl. Mineralog. Gesellschaft zu Petersburg, 1845-6, Petersb. 1849). A specimen of *Sphæronites Leuchtenbergii* in von Buch's collection agrees exactly with these figures. When, in his second essay, L. von Buch founded the order *Cystideæ* (1844), the oral arms of *Echino-encrinus* were already known. He did not regard them as Crinoid arms, but called them feelers. With a correct foresight he even then arranged the *Pseudocrinites* and *Agelocrinus*, with long arms passing from the oral part of the calyx, among the *Cystideæ*, but was not inclined to consider these processes as true arms. He had even in 1840 termed the remains of the three arm-like processes in *Hemiscosmites* arms or proboscides, but was led away from a just comprehension of their nature by comparing them with oral tubes.

"In his beautiful monograph on the British Cystideans (Mem. Geol. Survey, t. ii. Lond. 1848) Forbes has increased the number of forms with oral arms. He divides the *Cystideæ* into,—1*st*, those with arms: *Pseudocrinites*, *Apiocystites*, *Agelocrinites*—2*nd*, those with

* In my copy of Müller, "Uber den Bau der Echinodermen," the following sentence follows here:—"*Eine Vermuthung, die freilich nicht sicher beweisen werden konnte*," which may be thus rendered: "*An opinion which surely cannot be positively proved.*" Müller appears therefore to have believed that Von Buch's demonstration was not complete.

oral pinnulæ: *Prunocystites*—and 3*rd*, armless forms: *Caryocystites* and *Sphæronites;* to which latter the British form *Echino-encrinus* is added. Forbes considers that the arms observed by Volborth in the Russian species of *Echino-encrinus* are oral pinnulæ. The oral arms of *Echino-encrinus* and *Prunocystites* are articulated in two series. Volborth observed that in the former they are beset with small plates upon their ambulacral surfaces, which he calls tentacles, remarking that pinnulæ are absent. These plates have the characters of marginal plates, which in the Crinoids (*Pentacrinus*) occur on the arms as well as on the pinnulæ. In *Echino-encrinus angulosus* the remains of six arms were present. That this number does not agree with the five depressions which usually surround the mouth is explained by the fact, that the number of these facets varies; Von Buch states that there are five or six; and I possess a specimen with eight round depressions about the mouth, which are united with the mouth by grooves. *Echino-encrinus striatus* possesses, according to Volborth, together with a very much narrower pointed oral extremity of the calyx, only two much larger opposed oral arms, which have the same structure as in *Echino-encrinus angulosus*. From their relations, however, it is probable that these are not pinnulœ, but arms; for it is not usual for pinnulæ to be isolated. If they both belong to a single ambulacrum how are we to imagine a single ambulacrum in this locality in the immediate neighbourhood of the mouth? If, however, they belong to two different ambulacra, they can, as solitary structures, be only arms.

"The arms of *Echinosphærites aurantium*, Wahlenb. (*Sphæronites aurantium*, His.) have essentially exactly the same relations as Volborth has described and figured. In such well-preserved specimens as now lie before me, the origins of three articulated arms at the oral region of the calyx are recognizable. The five uppermost calycine plates are raised into a three-sided pyramid transversely truncated above, whose obtuse edges are prolonged into the arms. Two sides of the pyramid are broader than the third. The sutures between the five pieces are so disposed that two of them are situated upon the broader side of the pyramid, the three others in the obtuse edges. Two supplementary pieces, however, are added to the five principal portions of the pyramid, and extend from the calyx into two of the angular sutures. The pore-grooves of the plates of the calyx extend only on to the lower portion of the circumference of all the seven pieces. The

arms immediately subdivide again. From the oral aperture grooves beset with marginal plates, pass on to the arms. For the rest, the division of the arms shows that they are arms, and not pinnulæ. Whether these arms, like those of a few other Cystideans, as *Pseudocrinites*, were provided with articulated pinnulæ, cannot be decided, since they are broken short off. Whether the *Caryocistites* possessed arms is not as yet known, but it can hardly be doubted, since they are not certainly distinguishable from *Echinosphærites*.

"In *Hemicosmites* three of the six uppermost plates of the calyx are provided with an insection, which arises from the tri-radiate median calycine opening. Each of the insections is continued into a groove; the groove terminates after a slight expansion in an elevation of the calyx which served for the attachment of an arm. The elevation no longer lies on the plates of the uppermost, but upon three of the plates of the second series. The elevation exists only in specimens which are not worn down, and is beautifully obvious in a specimen which M. Ewald has sent me. The tri-radiate clefts of the calyx, and the calycine grooves continued from them, are covered with minute plates which readily fall off. In the specimens figured by L. Von Buch, they are still perfect, and form a fine series of plates from the mouth to the ventral surface of the three arms. In this series again, three delicate grooves are distinguishable, as in *Echinosphærites aurantium*, which correspond with the subjacent clefts of the large plates of the calyx and their grooves. In the always much worn specimen of *Cryptocrinites cerasus*, no indications of arms have hitherto been observed.

"Forbes regards the *Cystideæ*, like the *Blastoidea*, as sections of the Echinoderms different from the Crinoids. The *Sphæronites* were already arranged among the Crinoids by reason of their stalks before their arms were discovered, and we now have still more reason for considering this to be their true position. Volborth and Rœmer consider the *Cystideæ* as a group of Crinoids, which is also my own view. The position of the the arms however, must not be regarded as one of their characters; for in *Sphæronites Leuchtenbergii* and *Protocrinites oviformis* the arms were situated far away from the mouth, as in the other Crinoids.

"The suctorial feet of the Cystideans were unquestionably placed as in *Pentacrinus*, on the ambulacral side of the arms and in the calycine grooves. In the introductory part of this essay however, it has been demonstrated to be contrary to all analogy, that

suctorial feet should exist in any Echinoderm upon the antambulacral side of the persoma from the apical end to the arms, or between the ambulacral radii. In the *Cystideæ* therefore, the whole calyx, with the exception of the calycine grooves, is to be regarded as anambulacral.

"The genera *Pentacrinus*, *Caryocrinus*, and most Cystideans are distinguished among the Crinoids by the existence of very peculiar pores in the anambulacral plates of the calyx. *Pentacrinus* alone has afforded the opportunity of an exact investigation of these pores. I have described and figured them in the essay upon *Pentacrinus*.

"The interambulacral (interpalmar as well as intrapalmar) calycine pores of *Pentacrinus* pierce the ventral calycine plates, and lead beneath the inner membrane of the calyx. They possess no soft external prolongations. In contrast with the ambulacral calycine pores for feet, these may be called anambulacral calycine pores. Their signification is not understood, only it is certain that they are not passages for feet. A comparison with the respiratory pores of the *Asteridæ* suggests itself; soft tubes project from these, with regard to which Ehrenberg has shown (and I can confirm his statement by my own observation,) that they are cæca, which are indeed connected wiih the abdominal cavity, but are perfectly closed externally.

"The calycine pores of *Caryocrinus* are equally without relation to the arms; and thence, though differently distributed, resemble the anambulacral calycine pores of *Pentacrinus*. They occupy the antambulacral part of the calyx behind the arms as far as its base.

"Most Cystideans (*Cryptocrinites cerasus* excepted,) possess calycine pores, which are distributed over a greater or smaller part of the calyx without radiation and in a very peculiar manner. In those forms with calycine grooves, as *Protocrinites* and *Sphæronites Leuchtenbergii*, these pores again appear to be anambulacral, since, like the anambulacral pores of *Pentacrinus*, they are disposed in the areas external to and between the ambulacral grooves; here however, their distribution is far wider, since they extend as far as the base.

"Two principal divisions have been made, according to the distribution and combination of these pores:—

"I. Cystideans with pore-rhombs. The pores are disposed in rhomboidal figures, the one-half of which belongs to one plate, the other to its contiguous neighbour. Every two pores of these rhombs appear to be invariably united by canals or grooves,

which are visible either upon the outer or on the inner side of the plates, in such a manner that the united pores belong to two different adjacent plates.

"*a.* Pore-rhombs without external connexion of the pores. *Hemicosmites* and *Caryocrinus;* in *Hemicosmites* the combining grooves are according to Volborth, upon the inner surface of the plates.

"*b.* In *Echinosphærites granatum*, Wahlenb. (*Caryocystites granatum*, v. B.), the pores are united by bands projecting externally, which contain the connecting canal of the pores, and this canal is always a single one between each pair of pores, or even a series of pores.* The more importance is to be attached to this circumstance, as the number of the calycine plates, even of the basal plates in *Caryocystites granatum*, varies, so that some specimens possess more superimposed plates than others, and even specimens with five basal plates are not rare. According to the arrangement of the plates, I do not think that *Caryocystites* and *Echinosphærites* could be separated.

"A form nearly allied to *Caryocystites granatum*, observed by M. Beyrich (Drift [*Geschiebe*] near Berlin), the plates of whose calyx are more numerous, is distinguished by the bands which unite the pores belonging to an entire series of pores, which penetrate the entire thickness of the plates, so that the series of pores appear also upon the inner surface of the plates. Something similar may also be observed in many specimens of *Caryocystites granatum*, inasmuch as the canals of the bands not unfrequently also exhibit clefts here and there between the terminal pores. These clefts may indeed be readily explained by the grinding down of the canals; the occurence of the regular rows of pores in the species above mentioned, however, leads us to question whether they always have this origin.

"*c.* In *Echinosphærites aurantium* and *E. aranea* every two pores of two plates are not uncommonly connected by one, usually by two canals, which are recognizable upon the outer surface of the plates; *Echinosphærites testudinarius*, included by Von Buch in the ill-defined genus *Caryocystites*, is an elongated Echinosphærite. Its pore-rhombs agree more closely with the previously-named species than with *Caryocystites granatum*, though the number of the pore-canals between every pair of pores is in some localities still greater.

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* .... und dieser Canal ist immer ein einziger zwischen je zwei Poren, oder selbst einer Porenreihe.

In fact, we not unusually observe not only two, but three or even four conjoined canals, which open at both ends into a pore, and are so connected.

"*d.* The genera *Echino-encrinus*, *Pseudocrinites*, *Apiocystites*, *Prunocystit s*, are distinguished by possessing only a few pore-rhombs—fragments of the system—which however are here justly termed pore-rhombs. In *Echino-encrinus angulosus* and *E. striatus* there can be no doubt that the elongated pores of these rhombs are clefts which penetrate the whole thickness of the plates. Forbes remained in doubt with regard to these pores, and was inclined to interpret the 'pectinated rhombs' as the situation of ciliary organs comparable with the ciliated epaulettes of the larvæ of *Echini*. Seeing the very problematical nature of all pore-rhombs, and of all non-ambulacral pores of the Crinoids in fact, the supposition that the cilia are connected with the pores and pore-canals is not to be excluded.

"The number of the pore-rhombs in the *Echino-encrinites* appears to vary, and *Echino-encrinus granatum*, Volb., would appear to be only such a variety of the *E. angulosus*.

"II. Cystideans with double pores upon the calycine plates, which belong not to two different plates, but to the same. The plates are facetted, and each facet possesses two closely approximated pores. Here belongs a small group of Cystideans, which, since it consists of many genera, might be called *Diploporitidæ (Diploporiten)*. The genera included in it are :—

"1. *Sphæronites pomum*, His., type of a peculiar genus, which may retain the name of *Sphæronites*, as opposed to the *Echinosphærites* with pore-rhombs.

"2. *Protocrinites (P. oviformis*, Eichw.).

"3. *Sphæronites Leuchtenbergii*, Volb., type of a peculiar genus, which may be termed *Glyptosphærites*. That the Russian *Sphæronites pomum*, Leuchtenb., or *S. Leuchtenbergii*, Volb., is not the Swedish *S. pomum*, Volborth thought probable from Gyllenhal's account. The specimens of the Swedish form in the Mineralogical Museum of this place put this beyond doubt. There are no calycine grooves on the true *Sphæronites pomum*, His.; on the other hand, the five outermost calycine plates are elevated into a triangular pyramid, truncated at the mouth, as in *Echinosphærites aurantium;* the edges of the pyramid are broken off in all the specimens, and leave a doubt as to the form of the arms which were probably present. The base of the calyx is transversely truncated, and very broad in relation to the diameter of the calyx; it consists of six to seven pieces.

"The relation of a few other *Diploporitidæ* to these genera is still unknown. Many of the Cystideans described by Forbes, and enumerated by him among the *Caryocystites*, viz. *C. Litchii* (F.), *C. pyriformis* (F.), *C. munitus* (F.), do not belong to the genus *Caryocystites* (von Buch), being rather *Diploporitidæ* allied to *Sphæronites pomum*, which require further investigation."

SECTION III.

DESCRIPTIONS OF THE LOWER SILURIAN SPECIES OF CYSTIDEÆ OF CANADA.

Genus PLEUROCYSTITES, Billings.

(*Canadian Journal*, vol. ii. p. 250, 1854; *Geol. Survey of Canada, Report*, 1857, p. 284.)

Generic Characters.—Body, oval, flat; dorsal side composed of large polygonal plates; ventral side almost entirely occupied by a large oval space protected by an integument of numerous small plates; arms or pinnulæ, free, two in number, articulated in two series; mouth, situated at the base on the left side; a small aperture near the apex; ambulacral orifice not yet observed; pectinated rhombs three, one in the lower half of the body and two in the upper half; column, short and tapering. Generic name from *pleuron*, a side.

The following is the arrangement of the plates:—The pelvic or basal plates are four in number; the dorsal pair pentagonal, and forming by their upper sloping sides a broad re-entering angle, in which is supported a large hexagonal plate belonging to the next series; the other two pelvic plates are situated one on each side of the dorsal pair, and partly beneath them; they do not unite on the ventral side to form the cup-shaped pelvis of the ordinary cystideæ, but spread out wing-like from the sides of the column; only a small slender projection of these plates extends round so as to meet on the ventral side. (Pl. i. fig. 1*c*.)

In the second series there are five plates; two of these are situated at the lower outer angles of the body, and from their position in the same level with pelvic plates, appear to belong to that series. They are however the exact homologues of the two plates which support the mouth in such genera as *Echino-encrinites*, *Apiocystites*, *Glyptocystites*, and others of similar structure, but separated and thrust out of

their normal position by the introduction of the area of small plates. The other three plates of the second series form a regular row across the body above the pelvic plates. The central one is hexagonal, it has one-half of the posterior pectinated rhombs on the right lower side, and is flanked on each side by a large heptagonal plate.

The third series consists of four large plates, elongated vertically; one of these, situated on the right hand of the centre of the back, is pentagonal, and next to it, on the left, is another of nearly the same form, but made hexagonal by the truncation of one of the upper angles. These two plates are narrowed above to correspond with the decreasing dimensions of the body, which here begins to contract. The other two plates of this series are either heptagonal or slightly octagonal, and at their upper extremities they fold around the body and unite on the ventral side by narrow projections, which arch over the area of small plates. Above the third series are ten smaller plates, which close the summit and form a solid support for the arms.

The ventral side, as before mentioned, is mostly occupied by an area of small plates (see plate i. fig. 1*c*, and plate ii. fig. 1*b*) which are altogether of a different character from those of the dorsal side. They vary greatly in size in the different species; for instance, in *P. squamosus* there are several hundreds of them, and in *P. filitextus* only about forty or fifty. The margins of the dorsal plates being folded over, form a solid smooth border around the whole space, and to this border the small plates do not seem to be connected. According to my view, the whole of the oval space on the ventral side surrounded by the border, was covered by a flexible integument, strengthened by the small plates, and these cannot therefore be regarded as normal plates in the sense in which the term is used in describing genera of Crinoids or Cystidea, but rather as the remains of a partially calcified dermal covering for a part not protected by the true skeleton. It follows that in this genus the dorsal side is composed of a definite number of plates, arranged according to a permanent plan, and in this respect is related to that group to which *Echino-encrinites* belongs; while the ventral side, by the indefiniteness of the number and arrangement of the plates, is more like the body of a Sphæronite.

The mouth is situated on the left hand side of the base, and opens out through a notch excavated in the border. In most specimens the sutures between the plates cannot be detected in the border, owing to the close manner in which they have been anchylosed. It can be seen however, that if the two anterior basal plates were

folded round and brought up into their proper position, the mouth would lie partly in the suture between two of the plates of the second series, which is its position in many of the ordinary Cystideæ which have the definite number and arrangement of the plates.

The ambulacral orifice probably lies in the apex in the bottom of the groove between the two arms, and must be exceedingly minute, as I have been unable to detect it in several specimens that I have disarticulated for that purpose.

The anal? aperture is also very small, and situated on the anterior side, close to the apex. It consists of a small rugged notch in the edges of two of the small plates, below the arms.

The arms are articulated in two series, and the ambulacral groove is continuous from one to the other across the space between their bases. On each side of the groove is a row of small marginal plates, two or three to each joint of the arm.

The pectinated rhombs are three in number; one of them is placed half on the right dorsal basal plate and half on the large hexagonal plate of the second series; the other two are also situated on the dorsal side, one upon the left pair and the other on the right pair of plates of the third series. Of these two rhombs the left one is the larger in all the specimens I have seen.

This genus was first discovered in the Trenton limestone at the city of Ottawa, and afterwards at Montreal in the same rock. In 1856 Mr. Richardson found one species in the Hudson River group at Anticosti. In the Museum of Practical Geology, Jermyn Street, London, are specimens of a species, *P. Rugeri* (Salter), collected in the Caradoc formation of Wales; and M. Barrande informs me that a species, which appears to be referable to the genus, occurs in his Étage D, in Bohemia, the equivalent of the Landeilo and Caradoc of Britain, and of the Trenton and Hudson River groups of America.

The species are so closely allied, that there is much difficulty in defining them; yet I am satisfied that there are several which are distinct. It is very improbable that a genus of Cystideans, ranging from the Chazy limestone to the Hudson River group, and spreading over so vast a geographical area as that which lies between Canada West and Bohemia, should have but one species. Still it is not easy to find many good specific characters to separate those in the collection at Montreal. The following appear to me to be distinct; but when the genus becomes better known, it may be necessary to make some other disposition of them :—

I. Pleurocystites squamosus, Billings.

Plate I. Figures 1*a*, 1*b*, 1*c*, 1*d*.

(*Canadian Journal*, vol. ii. p. 251, 1854; *Geol. Survey of Canada, Report*, 1856, p. 286.)

Description.—In this species the large plates on the dorsal side are smooth, or but slightly marked with obscure radiating and concentric ridges, and the opening on the anterior side is protected by an integument composed of a vast number of small, mostly hexagonal plates, each less than the fiftieth part of an inch in diameter near the border, and about the twentieth of an inch in the centre of the space. The rhombs are small and somewhat elliptical, the larger axes of the upper two being transverse to the length of the fossil; in a specimen with a body thirteen lines in length the left upper rhomb has a transverse axis of three lines and a vertical axis of two lines in length. The rhomb on the right is two lines long and one and a-half broad; the basal rhomb is about of the same size as the last mentioned; they are all slightly elevated above the general surface, and either flat or only a very little concave. The pores extend completely across the rhomb from one side to the other. The column is strongly annulated, and the projecting joints or rings striated vertically, so that when well preserved they have a nodulose appearance.

Explanation of Figures. Plate I.

Figs. 1*a* and 1*b*. Dorsal views of two specimens.

Fig. 1*c*. Ventral view of a specimen shewing the plated integument and strong borders formed by the folding over of the dorsal plates; the mouth is at *o*.

Fig. 1*d*. Ventral view of the upper part of the cup and arms of a specimen of this species, the remainder of which is completely buried in the stone; 1*e* is the same enlarged; at *a* is the small sub-apical aperture. It is represented too large in the figure.

Locality and Formation.—Trenton limestone, near the middle of the formation at Ottawa.

Collectors.—E. Billings, J. Richardson.

II. Pleurocystites robustus, Billings.

Plate I. Fig. 2*a*.

(*Canadian Journal*, vol. ii. p. 252, 1854; *Geol. Survey of Canada, Report*, 1856, p. 286.)

Description.—In this species the rhombs are obscurely elliptical, or rather in the shape of a spherical triangle; they have somewhat the appearance of a rhomboid, but then the angles are so much

rounded that an elliptical figure is approached, which owing to the slight curvature of the upper side, is also triangular. They very much resemble the rhombs of *P. squamosus*, but have a concave instead of a plane surface, as in that species; they are surrounded by an elevated rounded border. The surface of the plates upon the dorsal side is ornamented with fine rounded radiating striæ, which are always at right angles to the margin of the plates. In addition to the small striæ on some of the plates, an obscure ridge runs from each of the angles towards the centre of the plate.

This species only differs from *P. squamosus*, as far as can be ascertained from the few fragments collected, in the form of the rhombs and striation of the surface; it appears also to have been a larger and more vigorous species. It is very difficult to decide whether it be really distinct from the other or not.

Length of the upper left rhomb, three lines and a-half; breadth in the vertical direction, three lines; the right rhomb is somewhat smaller.

EXPLANATION OF FIGURE. Plate I.

Fig. 2*a*. Shews a fragment of the upper part of a specimen. From the position in which the artist viewed the specimen, the left rhomb in the figure appears too angular on the upper side.

Locality and Formation.—Trenton limestone, City of Ottawa.
Collector.—E. Billings.

III. PLEUROCYSTITES FILITEXTUS, Billings.

Plate II. Figs. 1*a*, 1*b*.

(*Canadian Journal*, vol. ii. p. 252, 1854; *Geol. Survey of Canada, Report*, 1856, p. 286.)

Description.—The pectinated rhombs of this species are of a very different shape from that of the same organs in *P. squamosus* and *P. robustus*. They have their greatest length in the vertical direction instead of the transverse, as in the other species. In the structure of the integument of the ventral side there is also a difference, which cannot but be of specific importance. The plates (see pl. ii. fig. 1*b*) are ten times the size, and consequently greatly less in number. The surface of the dorsal side of the specimen figured is marked by strong ridges radiating from the centre to the angles of the plates. Two fasicles of coarse rounded ridges, five in each, proceed from the centre of the large hexagonal plate of the second series on to the two central plates of the third series, crossing the sutures at right angles.

Similar ridges, but fewer in number, cross the sutures between the other plates at right angles. In some of the specimens there are pretty strong concentric lines interwoven with the others, and portions of the surface, especially where there is no striation, are roughened by the presence of small irregular tubercles. In other specimens the whole of the surface appears to have been striated at right angles to the sutures, and it is quite certain that in all the species of this genus there was more or less variation in the character of the striation.

Length of the upper left rhomb, five lines in a specimen fourteen lines long; of the right rhomb, three lines. The form of the basal rhomb has not yet been precisely ascertained, but appears to be of an elliptical shape, its greatest length lying in the direction of the suture upon which it is placed.

EXPLANATION OF FIGURES. Plate II.

Fig. 1*a* is a specimen which has the column and a portion of the arms firmly attached to a piece of limestone. The greater part of the body however is loose, and can be removed in one piece, giving a view of the ventral side. Fig. 1*b* is the ventral side, shewing the large plates of the integument, and obscurely the small aperture near the apex. The specimen is somewhat distorted by pressure, so that the true form of the rhombs cannot be made out. *o*, the mouth.

Locality and Formation.—Trenton limestone, City of Ottawa. In one locality the surface of a bed of limestone for several yards square was covered with the separated plates and joints of the columns of this species. The highly instructive and valuable specimen figured is the most perfect that has been found.

Collector.—E. Billings.

IV. PLEUROCYSTITES ELEGANS, Billings.

Plate II. Figs. 2*a*, 2*b*, 2*c*, 2*d*.

(*Geological Survey of Canada, Report*, 1856, p. 287.)

Description.—This species much resembles *P. filitextus*, but may be readily distinguished by the rhombs being shorter, and by the much stronger striation, in proportion to the size, over its whole surface. The rhombs have a more regular outline than those of *P. squamosus* or *P. robustus;* they are bounded by four nearly straight sides, instead of curved lines; the poriferous areas are however somewhat rounded at the upper angles, while the form of the border is such as to give to the whole organ a regularly rhomboidal aspect. The shape is best shewn in fig. 2*a*, and in the basal rhomb of 2*c;* by comparing

the latter with the portion of the basal rhomb of *P. filitextus*, represented in 1*a*, the difference will be at once detected; all the others are more or less distorted. In *P. filitextus* the left upper rhomb is a little more than one-third the length of the body, but in *P. elegans* it is a little more than one-fourth. The plates of the ventral side have not yet been seen.

EXPLANATION OF FIGURES. Plate II.

Figs. 2*a*, 2*b*, 2*c* and 2*d*? are dorsal views of this species. It is doubtful whether 2*d* should be referred to this species or to the thickly striated varieties of *P. filitextus*. The crushed condition of this, and indeed of all the specimens, renders it most difficult to decide when the species are so closely allied.

Locality and Formation.—Trenton limestone, City of Ottawa.
Collector.—E. Billings.

V. PLEUROCYSTITES EXORNATUS, Billings.

Description.—Rhombs sub-triangular, surrounded by a thin sharp border, which is a good deal elevated above the surface. The upper side of the rhomb is nearly straight, and the other two sides converge to a slightly rounded angle below. The outline of the rhombs of this species is like that of *P. robustus;* but, on the other hand, the poriferous area or portion has a flat surface, while in the other species it is concave. The plates of the ventral integument are about the size of those of *P. filitextus*, from which species it differs by the form of the rhombs; the size of the ventral plates also separates it from *P. squamosus*. The column is beautifully striated longitudinally.

Locality and Formation.—Lower part of the Trenton limestone, Montreal. Fragments resembling this species occur in the Chazy limestone near Montreal.

Collector.—E. Billings.

VI. PLEUROCYSTITES ANTICOSTIENSIS, Billings.

Plate I. Figure 3.

(*Geological Survey of Canada, Report*, 1856, p. 288.)

Description.—All that can be said about this species is that the rhombs are very long and narrow, and the large joints of the column so coarsely striated that they appear to be nodulose. Only a fragment, consisting of a portion of the column and the lower part of the body, has been collected; the specimen measures eleven lines

from the base of the body to the upper angle of the large dorsal hexagonal plate, and the right half of the left upper rhomb is in length five lines and in breadth one line. The plates appear to have been smooth, and in this respect principally does the species differ from *P. filitextus*, which is much ornamented with radiating striæ. This is the only species we have as yet from the Hudson River group.

Explanation of Figure. Plate I.

Figure 3. Dorsal view of an imperfect specimen of this species.

Locality and Formation.—Charleton Point, Island of Anticosti; Hudson River group.

Collector.—J. Richardson.

Genus Glyptocystites, Billings.

(*Canadian Journal*, vol. ii. p. 215, 1854; *Geol. Survey of Canada, Report*, 1856, p. 280.)

Generic Characters.—Body, elongate, cylindrical; test composed of four series of plates, of which there are four in the basal, and five in each of the second, third and fourth series; three of the basal plates are pentagonal, the fourth hexagonal; the mouth, in the only species in which it has been seen, is situated in the lower half of the body, its lower side being formed of a notch in that plate of the second series which rests upon the hexagonal basal plate; it is without a valvular apparatus; the ambulacral orifice is in or near the centre of the summit, where it receives the five ambulacral grooves of the arms; near it is a small anal? pore; there are from ten to thirteen pectinated rhombs; the arms are recumbent, and upon the apex of the fossil the ambulacral grooves are beset with small marginal plates; the pinnulæ are articulated in two series; the column is short, and tapering to a point at the lower extremity.

The plates of the cup of this genus are somewhat remarkable for their form. In the hitherto known Crinoideæ and Cystideæ they are polygonal and bounded by straight sides; but all the species of this genus yet observed have some of them with re-entering angles. By referring to pl. iii. fig. 1*a*, it will be seen that the basal series of *G. multiporus* is very regular, and exactly like that of the genus *Echino-encrinites* (Volborth), represented in fig. 1*b*, the only difference being that the dorsal plate is so much extended upwards as to separate two of the plates of the second series. These two plates are notched on the upper side for the reception of the small hexagonal plate of the third series. Several of the other plates are

also variously notched. In the species *G. Logani*, *G. Forbesi*, and *G. gracilis*, many of the plates have re-entering angles, but in their arrangement in the walls of the cup they form regular series.

The pectinated rhombs also exhibit some peculiar new features. In no other genus have more than three been observed, and these, in all the genera except *Echino-encrinites*, are placed one at the base of the dorsal side and two in the upper half of the body, as in the genus *Pleurocystites*. The surface of *Glyptocystites* shews that three is not the constant number. It was also supposed to be essential to these organs that each should occupy two contiguous plates, about half of the rhomb being upon one and the other half upon the other. In *Glyptocystites* we have the new character of-half rhombs in all the four species. Generic name from *glyptos*, sculptured.

Glyptocystites at one time appeared to me to be so closely related to *Echino-encrinites*, that I had much doubt as to the propriety of retaining the name. After having examined a number of good specimens of the Russian genus, in the Museum of Practical Geology, London, I am satisfied that there is no generic affinity between them, except in the presence of the two rhombs in the dorsal side of the base. In no other respect is there any near relationship. That the number and arrangement of the plates are the same in both genera, is not a character sufficient to unite them; otherwise we should be obliged to make but one genus of *Pseudocrinites* (Pearce), *Apiocystites* (Forbes), *Prunocystites* (Forbes), *Echino-encrinites* (Volborth), *Lepadocrinites* (Conrad), and *Glyptocystites*. In all of these there are four series of plates, as follows: Four basal plates, and five in each of the second, third and fourth series. If we seek for other characters, we find that the Russian genus consists of several species, which, taken together, constitute a group having in its general aspect no resemblance whatever to that group formed by the four species of the American genus. The European species have short angular bodies covered with thick plates, the ventral side sometimes greatly projecting, and only three pectinated rhombs obscurely developed; while all the species of our genus have elongated sub-cylindrical bodies, nearly covered with rhombs, some of them of a large size.

VII. Glyptocystites multiporus, Billings.

Plate III.

(*Canadian Journal*, vol. ii. p. 215, 1854; *Geol. Survey of Canada, Report*, 1856, p. 281.)

Description.—One inch in length, five lines in diameter, cylindrical,

obscurely five-sided, rounded at the apex, abruptly truncated at the base; mouth large, oval, without valves, situated with its upper margin about the centre of the length of the body; ambulacral orifice small, situated in the centre of the apex, a small pore near it on the right hand side; arms five, four of them extending down the sides to the base, the fifth only two or three lines in length; thirteen pectinated rhombs; column short, tapering to a point, annulated by alternately wide and narrow joints, the former of which are striated on their projecting edges in the longitudinal direction.

In this species the basal and second series of plates are pretty regular, but the third series contains two plates, which are very small in proportion to the others, an irregularity compensated by a corresponding enlargement of two of the plates of the fourth series, which are of so great a size that they extend from the top of the body down to the second series, and thus fill up the blank in the third series formed by the deficiency in the size of the two small plates mentioned (see pl. iii. fig. 1*a*). The whole of the upper half of the test presents very little of order in its structure, in consequence of this disproportion in the size of the plates.

The distribution of the pectinated rhombs is as follows:—

On the anterior side there are two rhombs, a small one just below the mouth on the right side and a large one above, which extends from the mouth nearly to the apex (see pl. iii. fig. *d*).

On the right side there are two; a small one near the apex and a large one below it, but still nearly altogether in the upper half of the fossil. Both of these are a little oblique, the large one with its upper extremity leaning forward, and the small one leaning backward (see pl. iii. fig. *c*).

On the posterior or dorsal side there are four, two at the base, one-half of each being on the basal plate of this side, and the other half on the contiguous plate of the second series; a third very small rhomb is situated between the two small plates of the third series, and a fourth very large one is divided between the two large plates of the fourth series in the upper half of the fossil (see pl. iii. fig. F).

On the left side there are five, a large one next the mouth, and at its upper angle another, which extends across the sides, sloping a little downwards, with a third which rises nearly perpendicularly from the posterior angle of the second one; below this there is a half-rhomb, and above the large one first mentioned in this division a very small rhomb, only seen in perfect specimens (see pl. iii. fig. E).

There is very little difference in the form of the rhombs. They have each, except the three smallest, a smooth space in the centre, which is a little elevated above the poriferous surface, and the pores are elongated clefts which pass under the central smooth place, so that the pores of the one side are continuous with those upon the other. The thin partitions between the pores penetrate some distance into the interior of the fossil. Figures *g* and *k*, plate iii. are sections made through a specimen to shew this character. In nearly all the rhombs one side of the smooth central space has an elevated border.

The arms are five in number, four of them extending down the sides from the apex to the base; the fifth is a short arm, and reaches only two or three lines from the summit on the left side (see pl. iii. fig. E). They are composed of double series of joints alternating with each other, and so loosely attached to the surface that they can be easily removed with the point of a sharp knife. The ambulacral grooves extend the whole length of the arms, and have on each side a row of seven or eight pinnulæ, those upon one side alternating with those on the other. The two anterior arms unite a short distance above the large rhomb, which is situated over the mouth (see figs. *a* and *n*); their two ambulacral grooves then form but one, and cross the apex to the posterior side (see fig. *g*), where they divide and run down the posterior pair of arms. In crossing the summit the groove sends out a branch to the short arm, and, throughout their length, small branches to the pinnulæ.

The ambulacral orifice is very small, and situated in the bottom of the groove, a little on the anterior side of that point where the groove from the short arm enters the main apical furrow. This aperture is usually concealed by the small marginal plates of the ambulacra shewn in fig. *g*. Of these there is a row on each side of the groove, and when the top of the fossil is so perfect as to exhibit them well-preserved, they are always so firmly interlocked that they completely close the furrow. In this state they no doubt formed a securely protected covered way for the passage of the ambulacral vessels to the arms.

The minute aperture on the left side of the apex, near the ambulacral orifice, is a minute pore situated in the centre of a small rounded tubercle (see fig. *g*).

The pinnulæ are scarcely one-third of a line in diameter, and about half-an-inch in length. They are articulated in two series.

EXPLANATION OF FIGURES. Plate III.

Fig. 1*a*. The plates of the calyx spread out; the dotted lines which extend from the top to the bottom indicate the course of the arms.
Fig. 1*b*. Plates of the genus *Echino-encrinites* figured here for comparison.
Fig. *d*. Anterior view of a perfect specimen of *G. multiporus*.
Fig. E. The left side of the same specimen.
Fig. F. The dorsal or posterior side of another specimen.
Fig. *c*. The right side.
Fig. *g*. The apex enlarged.
Fig. *i*. The base.
Fig. *n*. A specimen with the column attached, anterior view.
Fig. L. One of the rhombs enlarged.
Figs. *g* & *k*. Sections shewing the depth to which the partitions of the rhombs entered.

Locality and Formation.— Trenton limestone, City of Ottawa, Montreal and Beauport. Only fragments have been found at the latter two places, and all the perfect specimens, about sixty, were collected from a piece of shale about two yards square and one or two inches in thickness. There is good reason to believe that they lived and died upon this spot. The shale was a layer between two beds of limestone, the lower of which was partly composed of the detached plates of this species. Imbedded in its surface were several perfect specimens among the fragments. The shale which covered it was full of individuals with their columns and delicate pinnulæ attached. It is quite clear that they could not have been at all drifted about the bottom after death, otherwise they would at least have lost their columns and pinnulæ. It is more probable that they formed a little colony, growing on this spot at a considerable depth, and in clear water, and that the shale consists of a deposit showered down upon them from a superficial current, literally burying them alive.

Collector.—E. Billings.

VIII. GLYPTOCYSTITES LOGANI, Billings.

Plate IV. Figs. 1*a*–*h*.

(*Geological Survey of Canada, Report*, 1856, p. 282.)

Description.—Length of large specimens one inch and a-fourth; diameter eight lines; cylindrical, obscurely five-sided, abruptly truncated at the summit; base slightly rounded; each plate ornamented with from three to seven exceedingly elevated, somewhat thin, sharp ridges, which radiate from the centre to the sides; spaces between the ridges smooth, or very minutely striated concentrically; calycinal

ambulacral grooves, to the angles of the truncated apex, bordered by marginal plates, as in *G. multiporus*, and furnished near their extremities each with several smaller free arms, or stout pinnulæ, articulated in two series; there are about twelve or fifteen pectinated rhombs, each with a smooth central area, which is not elevated above the surface of the pores, but is quite flat, a character which separates this species from the next.

Neither the mouth nor the ambulacral orifice has been observed, owing to the imperfection of the specimens.

The column is short, strongly annulated, and tapering to a point at its lower extremity. The small joints are pentagonal, and present a very remarkable character in the fact, that their angles form five spiral lines round the column throughout its length. The large joints which constitute the annulations of the column appear to be circular; but none of the specimens are sufficiently well-preserved to shew clearly that they are so.

The pinnulæ are furnished on their ventral sides with minute marginal plates, similar to those of *Pleurocystites*. This appears to be one of those species in which the body of the arm was never developed, but only the grooves and pinnulæ.

The detached plates of this magnificent species can be readily distinguished from those of any other crinoid or cystidean of the Trenton limestone by the peculiar star-like appearance produced by the very elevated, sharp, and thin radiating ridges with which their surfaces are ornamented. Although a number of the bodies, many of them with the column attached, have been collected, yet none of them shew clearly that side upon which the mouth is situated. The plates are more regularly alternating than in *G. multiporus*. This species cannot be identified with the *Echino-encrinites anatinaformis* figured by Professor Hall in plate xxix. vol. i. Palæontology of New York. By referring to that work it will be seen, that the triangular spaces upon the plates between the large radiating ridges are strongly striated at right angles to the sides of the plates (see the two figures, 4*d* and also 4*g*, in the plate cited). In our species these spaces are quite smooth, or only marked by faint lines, which are concentric, and therefore run in a direction at right angles to that of the striæ of the New York specimens. Professor Hall's figures do not exhibit any pectinated rhombs; and further, by figure 4*c* it is shewn that the base of *E. anatinaformis* is composed of two pentagonal and two quadrangular plates; ours has three pentagonal and one hexagonal basal plate.

Explanation of Figures. Plate IV.

Figs. 1*a* and 1*b* are dorsal views of two specimens.

Figs. 1*c*, 1*d* and 1*e* are enlarged views of the interiors of three rhombiferous plates, shewing that the pores penetrate through, and that each on the inside is surrounded by an exceedingly thin elevated border.

Fig. 1*f*. A portion of the ambulacral groove of the apex, and one of the pinnulæ enlarged.

Fig. 1*g*. A fragment with two of the pinnulæ.

Figs. 1*i* and 1*j*. Fragments of columns; the specimens are crushed, and do not clearly shew the spiral arrangement.

Locality and Formation.—Trenton limestone, Island of Montreal; plates in an excellent state of preservation are extremely abundant in certain localities of the formation.

Collectors.—Sir W. E. Logan, E. Billings.

I beg to dedicate this species to the discoverer.

VIII. Glyptocystites Logani *var.* gracilis, Billings.

Plate IV. Fig. 2.

Description.—This species or variety differs from the last in its greater proportional length and form of the rhombs and column. There is a deep angular furrow around the margin of each rhomb, and the central space, instead of being quite level, is much elevated. In the only specimen collected there is no unperforated area in the centre of the rhomb, as in *G. Logani* proper. The large joints of the column are close together, whereas in the other form they are separated by an interval equal to or greater than their thickness. On account of these differences, I have thought it proper to name this form as a variety of *G. Logani*.

Locality and Formation.—Trenton limestone, Montreal.

Collector.—Sir W. E. Logan.

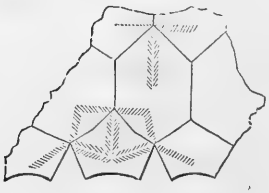
IX. Glyptocystites Forbesi, Billings.

Plate IV. Fig. 3.

(*Geological Survey of Canada, Report*, 1856, p. 283.)

Description.—The body of this species, judging from the fragments in the collection, is about two inches in length and three-fourths of an inch in diameter. The character of its surface is such, that detached plates may be distinguished at a glance from those of either of the two preceding species, being larger, thicker, and more

profusely ornamented with radiating ridges and striæ. Although there is an abundance of the comminuted remains in the Chazy limestone, yet only the base of the cup of one specimen has been found. Fortunately it is sufficiently well-preserved to shew that at least a great proportion of the numerous plates and columns with which it was associated belong to the same species. The specimen consists of four joints of the columns, two of the basal plates on the dorsal side, one large heptagonal plate of the second series, and portions of two others, one on each side of this latter. The following figure shows the disposition of the rhombs at the base of the dorsal side :—



At the base upon the dorsal side there are two perfect rhombs, one-half of each of which is on the central basal plate; the other two halves are upon the two plates of the second series, which rest upon the upper sloping sides of this basal plate. These two rhombs therefore correspond to the pair occupying the same position in *Echino-encrinites angulosus*, Volborth (see pl. iii. fig. 1*b*), and *G. multiporus*, pl. iii. fig. 1*a*. In addition however, we have in *G. Forbesi* two half-rhombs on two of the basal plates which do not occur in the other species; their positions are shewn in the above wood-cut.

The plates have two sets of surface ridges :—

1. From four to six large ridges, which radiate from the centre of each plate to the centre of each straight side of the plate. They are in general strongly elevated, with rounded or sharp edges and broad bases. In the angular spaces formed by the large ridges are smaller parallel ones, which form other included similar angular spaces (see plate iii. figs. 3*e* and 3*f*).

2. The whole surface of the plates is also covered with sharp concentric striæ, which are, on some of the plates, stronger between the ridges than upon them (see plate iv. figs. 3*e* and 3*f*). When the plates are worn, the large radiating ridges become rounded, and the concentric striæ are wholly obliterated.

The joints of the column attached to the fragment figured appear to be obscurely pentagonal; but in the same rock are many columns

which are round, and with the large joints ornamented with little pits or coarse striæ. It is not certain that these round columns belong to the same species.

EXPLANATION OF FIGURES. Plate IV.

Figs. 3*a* and 3*b*. Two views of the base of a specimen.
Figs. 3*c* and 3*d*. Imperfect plates, to shew the character of the rhombs. 3*d* has the remains of four rhombs; 3*e* is the basal plate of the right side; 3*f* the hexagonal basal plate of the anterior side; 3*g* and 3*h* round columns, with the edges of the large joints pitted.

Locality and Formation.—Chazy limestone at Caughnawaga, and on the Island of Montreal.

Collectors.—Sir W. E. Logan, J. Richardson, E. Billings.

Genus COMAROCYSTITES, Billings.

(*Canadian Journal*, vol. ii. p. 269; *Geological Survey of Canada, Report*, 1856, p. 288.)

Generic Characters.—Body, ovate, the smaller extremity being the base; pelvis, small, of three plates, above which are from eight to eleven irregular rows of plates, mostly hexagonal; mouth, near the summit, provided with a valvular apparatus; arms, free, grooved, and composed of a single series of joints bearing pinnulæ; ambulacral orifice in the apex between the arms; column, round and smooth. The plates of the only species that has been collected present, in some conditions of preservation, a peculiar vesicular structure of their exterior surfaces, while sometimes they are solid and smooth. Generic name, *comaron*, a strawberry.

X. COMAROCYSTITES PUNCTATUS, Billings.

Plate V.

(*Canadian Journal*, vol. ii. p. 270; *Geological Survey of Canada, Report*, 1856, p. 288.)

Description.—The body of this species is of an oval or pyriform shape, and in large specimens about one inch and a-half in length. It is protected by plates which have a deep concavity, occupying nearly the whole of the area of each, the effect of which is to cover the surface of the fossil with large rounded pits, an aspect that serves to distinguish it at the first glance from any other known in the Lower Silurian rocks of Canada. In certain states of preservation the sutures are marked by minute thickly-set square or oblong rough punctuations, which do not however appear to penetrate through to the interior. In some specimens there is only one, and in others

two or three rows of these punctures upon each suture. The greater portion of the area of the plate is marked with deep fissure-like striæ at right angles to the suture, and with thin erect lamellæ or partitions between them. These are sometimes crossed by other lamellæ parallel with the edges of the plates, the effect of which is to produce a peculiarly rough surface. Sometimes none of these are visible, and the surfaces of the plates are then uniformly smooth and solid. These variations are the results both of weathering and structure. Portions of the centres of the plates of the two specimens figured (pl. v. figs. 1 and 2) have the external surface smooth, while the margins are rough.

The mouth is large, near the apex, and closed by a pyramid of five triangular valves.

The ambulacral orifice has not yet been distinctly observed, but there can be little doubt of its existence. The arms are four in number, and consist of an anterior pair situated directly over the mouth, and a posterior pair placed opposite, on the posterior side of the summit; a deep narrow groove crosses the apex, in a direction from the anterior to the posterior side; from one end it sends up two branches into the anterior pair of arms, and from the other end two into the posterior pair. The arrangement of the ambulacral furrows in this species is then precisely as in *Glyptocystites multiporus*, and no doubt an orifice will yet be found in the bottom of the groove, upon the summit between the two pairs of arms. The arms consist of a single series of joints, each about one line and a-half in length; the pinnulæ are nearly cylindrical, and divided by joints at lengths of about half a line. In the only specimen known with the arms attached (plate v. fig. 1) one side of the arm only can be seen, the other being imbedded in the rock. It shews that upon at least the side exposed there is one pinnula to each joint, but whether there is a row on the other side of the groove or not remains to be ascertained.

The column is round and smooth, formed of very thin joints, and does not, in a specimen with three inches preserved, exhibit any signs of tapering.

EXPLANATION OF FIGURES. Plate V.

Fig. 1. Anterior view of a large specimen, with one arm and the pinnulæ attached. *o*, the mouth; 1*a*, a plate of the same enlarged, to shew the peculiar striation; 1*b*, the valvular apparatus of the mouth enlarged.

Fig. 2. View of the left side of another specimen; 2*a*, a plate of same enlarged; 2*b*, outline of the summit, shewing the positions of the bases of the arms, and the ambulacral groove between them.

Locality and Formation.—Trenton limestone, City of Ottawa. Fragments are not very uncommon, but perfect specimens exceedingly rare.

Collectors.—E. Billings, J. Richardson, and others. The specimen fig. 2 was found by Captain W. S. Hunter of Ottawa, and fig. 1 by E. Billings.

Genus Amygdalocystites, Billings.

(*Canadian Journal*, vol. ii. p. 270, 1854; *Geol. Survey of Canada, Report*, 1856, p. 288.)

Generic Characters.—Body, ovate; pelvis of three plates, above which are eight or more irregular rows of plates; the mouth is near the summit, closed by a valvular apparatus; arms, large, recumbent, composed of a double series of joints bearing a single row of pinnulæ; ambulacral orifice situated in the apex; ambulacral groove not in the centre of the upper surface of the arm, but on one side; column round; the plates are solid, or not poriferous. Generic name from *amygdale*, an almond.

Comarocystites differs from this genus by the possession of free arms and the porous character of its plates.

XI. Amygdalocystites florealis, Billings.

Plate VI. Fig. 1*a*–1*e*.

(*Canadian Journal*, vol. ii. p. 270, 1854; *Geol. Survey of Canada, Report*, 1856, p. 289.)

Description.—Body ovate, rounded at the apex, tapering towards the base, about one inch and a-half in length. Each of the plates of this species has a low rounded tubercle in the centre, from which ridges radiate to the angles; these ridges are scarcely elevated above the surface where they leave the border of the tubercle in the centre, but increase in width and height as they depart from it; they are sharp-edged, and attain their greatest height at the angles of the plates. The arm crosses the summit, and extends nearly down to the base upon one side, and only two or three lines from the apex on the other; it is composed of a series of large joints, which are about one line in height and scarcely so much in width, and a second series of smaller pieces about one-half the height which are placed at the bottom of the larger, upon one side. The arm thus composed forms a projecting ridge up the posterior side of the body across the apex, and a short distance down the anterior side.

Each one of the large joints bears a pinnula, and the ambulacral groove is situated not on the top of the arm, but on one side. On the posterior side of the fossil the groove is on the left side of the arm. On the apex there appears to be an interruption, as if one of the joints were absent; the ambulacral orifice is no doubt situated at this point, but it has not been clearly made out in any of the specimens yet procured. From this supposed position of the ambulacral orifice proceeding forward the groove is on the right side of the arm, the mouth being on the left, as shewn in plate vi. fig. 1*a*, at *m*.

The column is round, smooth, and composed of thin joints.

In this interesting form we have an example of a Cystidean with a body composed of an indefinite number of plates, like the *Sphæronites*, and with the arms arranged exactly as they are in *Pseudocrinites*, a genus characterised by a few plates which are definite in number.

EXPLANATION OF FIGURES. Plate VI.

Fig. 1*a*. The left side of a specimen; *m*, the mouth. Fig. 1*b*. Right side of the same. 1*c*, posterior; and 1*d*, anterior views. The groove is not clearly shown in this specimen. 1*e*, one of the plates enlarged.

Locality and Formation.—Trenton limestone, City of Ottawa.
Collector.—E. Billings.

XII. AMYGDALOCYSTITES TENUISTRIATUS, Billings.

Plate VI. Figs. 2*a*–2*f*.

(*Canadian Journal*, vol. ii. p. 271, 1854; *Geol. Survey of Canada, Report*, 1856, p. 289.)

Description.—Body elongate, ovate; plates smooth in the centre; a low rounded ridge proceeds from the smooth space in the centre of each plate to each of the angles, where it meets the similar ridges which radiate from the centres of the adjoining plates; between these ridges the triangular spaces are finely but very distinctly striated at right angles to the sutures. The mouth is close to the arm on the left side, near the summit.

The specimen represented by figs. 2*a* and 2*b* is the one upon which I drew up the original description published in the Canadian Journal in 1854. It shews only fragments of the arm, and the surface of the plates is so different from that of *A. florealis*, that I then had no doubt of the distinctness of the two species. Last summer, however, I found at Belleville, Canada West, the other specimen, fig. 2*c*, which has much the form of *A. florealis*, and the

arm almost precisely the same, but the plates are striated like those of *A. tenuistriatus*. It seems to connect the two species, but until good clear specimens can be examined, it would be the better plan to retain the two names.

EXPLANATION OF FIGURES. Plate VI.

Figs. 2*a*, 2*b*. Right and left side of the Ottawa specimen; *m*, the mouth. 2*c*. Left side of specimen from Belleville, shewing a portion of the arm. 2*e*. The arm enlarged, shewing the ambulacral groove. 2*f*. View of the top of the arm, shewing the articulating cavities of the pinnulæ, and the branches of the ambulacral grooves leading to them. 2*d*. A plate enlarged, shewing the striæ.

Locality and Formation.—Trenton limestone: one specimen from the city of Ottawa and one from Belleville. The species appears to be excessively rare.

Collector.—E. Billings.

XIII. AMYGDALOCYSTITES RADIATUS, Billings.

Plate VI. Figs. 3*a*, 3*b*.

(*Canadian Journal*, vol. ii. p. 271, 1854; *Geol. Survey of Canada*, *Report*, 1856, p. 289.)

Description.—Body ovate; 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 tubercles, which disappear when the plates are a little worn.

Of this fine and very distinct species, enough has not yet been found to shew 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.

EXPLANATION OF FIGURES. Plate VI.

Fig. 3*a*. A specimen crushed flat. 3*b*. One of the plates enlarged. The specimen is worn, and does not shew the granular surface of the spaces between the radiating ridges.

Locality and Formation.—Trenton limestone, City of Ottawa.

Collector.—E. Billings.

Genus Malocystites, Billings.

Generic Characters.—Body ovate or globular, composed of an indefinite number of plates, usually about forty or fifty; mouth, almost apical; ambulacral orifice on one side, but in the upper half of the body; arms recumbent, in some species numerous; plates thick solid, not poriferous; column unknown. Generic name from *malum*, an apple.

This genus is composed of some species of Cystideans lately discovered in the Chazy limestone. They are usually globular, and covered with smooth plates, and in general form and aspect much resemble the *Echinosphærites* of Scandinavia and Russia, from all of which however they differ in the absence of pores in their plates.

The genus *Cryptocrinites* (Von Buch) is related to *Malocystites* so far as regards the absence of pores or pectinated rhombs, but differs in having the ambulacral orifice in the apex, the mouth being in the side, and appears to be composed of a definite number of plates, there being three in the basal series, five in the second series, and alternating with these, five others in the second series.

Malocystites differs from *Amygdalocystites* in being composed of a lesser number of plates, and in having the ambulacral orifice in the side, and the mouth nearly in the centre of the apex. The arms appear also not to be alike in the two genera, although none of the specimens are sufficiently well-preserved to shew the structure very distinctly.

XIV. Malocystites Murchisoni, Billings.

Plate VII. Figs. 1*a*—1*i*.

Description.—Body globular, or slightly ovate; plates varying from plane to convex, covered with small granular tubercles; arms usually eight, forming two fascicles of four in each, connected by a short groove, in the bottom of which is the ambulacral orifice; they are long, and wind around the body obliquely descending from the orifice nearly to the base; mouth nearly circular, without valves. In a specimen eleven lines long and ten lines in greatest breadth the ambulacral orifice is half a line broad, and the mouth one line and a half. The area of the mouth is therefore about nine times greater than that of the ambulacral orifice.

This species presents some variations in form and size. The greater number of the specimens are nearly globular, and about one inch in diameter. Fig. 1*e*, plate vii. represents an individual that is ovate, the length being fifteen lines and the breadth twelve lines. Fragments have been observed which must have belonged to specimens two inches in diameter. The plates are also sometimes exceedingly convex, the sutures being depressed. In specimens with smooth surfaces, or with the plates not convex, it is almost impossible to distinguish the sutures.

Dedicated to Sir Roderick I. Murchison, F R.S., G.S., &c. &c. Director-General of the Geological Survey of the United Kingdom of Great Britain and Ireland; author of "The Silurian System," etc.

Explanation of Figures. Plate VII.

Fig. 1*a*. Right side of a specimen, shewing the ambulacral orifice and the eight arms. 1*b*. The left side, shewing the position of the mouth, *m*. 1*c*. Vertical view of the ambulacral orifice. 1*d*, 1*e*, Left sides of two other specimens. 1*f*. Apex of 1*e*. 1*h*. Base of 1*d*, shewing the three basal plates. 1*i*. Portion of upper surface of an arm magnified.

Locality and Formation. — Chazy limestone, Caughnawaga and Island of Montreal. Fragments are exceedingly abundant; good specimens rather uncommon.

Collector.—E. Billings.

XV. Malocystites Barrandi, Billings.

Plate VII. Figs. 2*a*—2*c*.

Description.—In this species the body is nearly globular, and the plates smooth, or very minutely granulated with small tubercles. The mouth is five-sided, and situated almost exactly in the centre of the apex or diametrically opposite the point of the attachment of the column. The arms are two in number, and very short, each being not more than three or four lines in length. They are so disposed as to form two half-circles, with the inner curves facing in opposite directions. They are connected by the usual ambulacral groove, in the bottom of which is the orifice. There are eight joints in the arm preserved in the specimen fig. 2*b*, pl. vii. which is the posterior arm, or that most distant from the mouth. The specimen represented by fig. 2*c* has the anterior arm preserved, and it shews only four joints.

If a section be made passing through the ambulacral orifice, the mouth and base of a specimen of this species, it will exhibit the following arrangement of the orifices:—

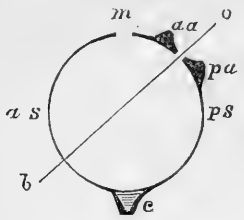


Fig. 1.

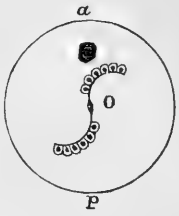


Fig. 2.

In the above fig. 1, *m* is the place of the mouth, *aa* the anterior arm, *o* the ambulacral orifice, *pa* the posterior arm, *c* the column, *as* the anterior, and *ps* the posterior side. Fig. 2 is a diagram of a specimen seen in the direction of the line *ob* of figure 1, shewing the arrangement of the arms in two half-circles, one of which is between the mouth and the ambulacral orifice, the other being on the opposite side.

The mouth of this species being five-sided, was probably provided with valves. It is one line in diameter, and is therefore more than four times the area of the ambulacral orifice, which has a length of less than half a line.

Some small specimens in the collection shew that when young this species was of an oval or pyriform shape.

Dedicated to M. J. Barrande of Prague, Bohemia, author of "Systême Silurien du centre de la Bohême," &c. &c.

EXPLANATION OF FIGURES. Plate VII.

Fig. 2*a*. View of the left side of a specimen; *a*, the arm. 2*b*. Posterior view of the same. 2*c*. Anterior view of another specimen. 2*d*. The arm of 2*a* magnified, shewing the short branches of the ambulacral furrow to the bases of the pinnulæ.

Locality and Formation. — Chazy limestone, near the city of Montreal.

Collectors.—E. Billings and J. McMullen.

Genus PALÆOCYSTITES, Billings.

Generic Characters.—The body is oval or pyriform, composed of numerous plates, which are poriferous; the pores penetrate the

margins of the plates and extend towards the centre, but do not open out on the exterior surface. On the interior surface they open between the edges of the plates. Column, arms and orifices unknown. Generic name from *palaios*, ancient.

The most abundant species of this genus appears to be identical with that fossil of the Chazy limestone to which Professor Hall has given the name of *Actinocrinus tenuiradiatus*. (See Palæontology of New York, vol. i. p. 18, plate iv. figs. 8 and 9.) I have ascertained however that it is a Cystidean. No perfect specimens have been found, but several fragments, which I have collected, consisting each of about one-third of the body, shew that it is a genus allied to *Comarocystites*, *Sphæronites* and others of the many-plated group.

This genus appears to be closely related to *Amygdalocystites*.

XVI. Palæocystites tenuiradiatus, Hall sp.

(*Actinocrinus tenuiradiatus*, Hall. Pal. N. Y., vol. 1, p. 18, pl. iv, figs. 8 and 9.)

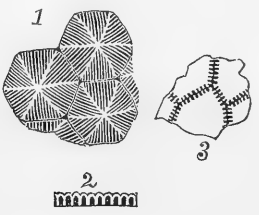


Fig. 1. View of exterior of several plates of *P. tenuiradiatus*.
Fig. 2. Edge of a plate, shewing the entrances of the pores.
Fig. 3. Inside of several plates, shewing the opening of the pores in the suture.

Description.—Large specimens are two inches or more in length and pyriform in shape, the upper part of the body being the largest. The plates are depressed conical, and when a little worn are all covered with deep fissure-like striæ, which are at right angles to the edges. These striæ cross from one plate to the next contiguous, so that one half is upon one plate and the other half upon another. At the suture in the bottom of each of those fissures is a small aperture that penetrates through, being partly excavated in the margins of each of the plates respectively. The effect of this mode of striation is to cover the whole surface of the fossil with small rhomboidal areas, each of which occupies portions of two plates. There are as many half-areas on each plate as the plate has sides. When the surface has not been worn the interesting fact may be clearly

seen, that all the striæ are covered by a thin external layer, which closed them completely over, so that there were no pore-mouths on the exterior. It therefore follows, that what appears to be ordinary striæ are in fact the channels of a peculiar set of pores which run beneath the surfaces of the plate, and communicate with the interior through orifices in the suture. Hence in a perfect plate, the margin on the inside is deeply notched, each notch being one-half of a pore-mouth. On the outside it is not notched. The pores do not open any where upon the surface of the plate, neither do they communicate with each other. When the plates are perfect, the surface is still striated; but the striæ correspond to, and are situated over, the partitions between the channels of the pores which constitute the striæ of the worn plates. The number of pores in the sutures depends upon the size of the plates. In a plate, with sides two lines in length, there are nine pores.

Geological Position and Locality.—Detached plates, common in the Chazy limestone at Caughnawaga and on the Island of Montreal. They also occur in the same formation near Hawkesbury, and at Chazy, in the State of New York.

Collectors.—Sir W. E. Logan, J. Richardson, E. Billings, R. Bell, and J. McMullen.

XVII. Palæocystites Dawsoni, Billings.

Description.—Of this species I have collected several fragments of the body, two of which are especially interesting, as they exhibit the exterior of some of the plates, and thus afford the means of shewing that they are generically related to the last species. The body is elongated pyriform, or rather fusiform, the lower part being the smaller extremity. The apex appears to be rounded. The plates are ornamented with strongly elevated rounded ridges, the number of which corresponds to the number of the sides; those with five sides having five ridges, and those with six or seven sides, six or seven ridges. Each ridge is continued from the centre of one plate straight across the suture to the centre of the next. There are no pore-mouths on the outside; but on the inside there is one for each ridge, situated on the suture, exactly as in the last species. The pores in this species do not penetrate so far towards the centre as in the last.

The largest specimen collected, is a fragment of the lower half, and indicates that the length of the body was about one inch, its

greatest diameter being half-an-inch. Another specimen, nearly perfect, was about half-an-inch in length, and one-fourth in breadth; it was unfortunately destroyed in getting it out of the rock. A fragment of the top however was preserved, and although half imbedded in the matrix, shews clearly enough that it has a rounded summit.

Dedicated to Dr. J. W. Dawson, LL.D., author of "Acadian Geology," &c. &c. Principal of the University of McGill College, Montreal.

Geological Position and Locality.—Chazy limestone, near the first mile-post, St. Lawrence Street, Montreal.

Collector.—E. Billings.

XVIII. Palæocystites Chapmani, Billings.

Description.—The few plates of this species that have been collected exhibit the peculiar character of the genus in a most interesting and satisfactory manner. Without being acquainted with the structure of the plates, the observer would almost unhesitatingly refer them to two very distinct species, so great is the change in their appearance produced by the wearing away of the external surface. The perfect plates resemble those of *P. Dawsoni*, inasmuch as the number of radiating ridges is the same as the number of sides. The ridges are however of a different form. In *P. Dawsoni* they are narrow at the base, and the space between them is flat; but in *P. Chapmani* they are broad at the base, or roof-shaped, the base of each spreading out to a breadth equal to the length of that side of the plate to which it extends. A perfect plate of this species, for instance one of six sides, may therefore be described as presenting six furrows radiating from the centre to the six angles, these furrows gradually increasing in depth and width as they recede from the centre of the plate. Or it may be characterised as exhibiting six roof-shaped ridges radiating from the centre to the sides, and increasing in height and width at the base as they approach the side.

When however the external surface is worn away, the plates assume a very different appearance. They then become covered with deep fissure-like striæ, like those of *P. tenuiradiatus*, to which they bear so close a resemblance, that to the unpractised eye, they appear to be the same. They can always however be distinguished by this character. The ridges or partitions between the fissures, which terminate at the centres of the sides of the plates, are the

highest, those at the angles being the lowest; but in *P. tenuiradiatus* it is the very reverse: the angles of the plate are more elevated than the centres of the sides.

I dedicate this species to E. C. Chapman, Esq., Professor of geology and mineralogy, in University College, Toronto.

Locality and Formation.—Lot 26, Front Concession of Clarence, Ch\izy.

Collector.—J. Richardson.

XIX. Ateleocystites Huxleyi, Billings.

Description.—The extraordinary little fossil, for which the above name is proposed, is no doubt a Cystidean; but of a group somewhat widely separated from the ordinary types. There are several specimens in the collection, but they all are half imbedded in stone, and with one exception exhibit only the dorsal side. The form is subquadrate, rounded at the apex and nearly straight at the base. The dorsal side appears to have been quite flat when perfect, as the plates which constitute the edges are bent forward towards the ventral aspect at more than a right angle, so that the sides instead of being rounded presented a rather sharp edge. The ventral side was probably convex.

The plates of the dorsal side are arranged in four series. The basal series consists of four oblong plates, each of which is about twice as high as wide. These four constitute rather less than the lower half of the body.

In the second series there are three plates, the central one being broader than either of the other two; it rests upon the upper edges of the two plates which form the central pair of the basal series, and is about equal to them in width. The right side of this plate is longer than the left, owing to the truncation of the upper left hand angle. These three sides occupy a little more than one-fourth of the length of the dorsal side.

The third series consists of an irregular row of four or five small plates. There are two at the sides, and apparently three others resting on the large central plate of the second series. Of these however only two are distinctly visible, one in the centre and the other on the left sloping upper side of the plate below.

The fourth series is composed of a row of three or four small plates, forming the margin of the cup on the dorsal side. Above these and imbedded in the matrix are several small points which are suggestive of the marginal ambulacral ossicula of the ordinary Cystideæ.

One specimen shews a portion of the ventral side, consisting of numerous small plates, thus resembling the genus *Pleurocystites*.

The two large side-plates at the base are obscurely striated transversely. The body is one-third longer than wide. The plates are thin. The length of the largest specimen a little more than half-an-inch; width about four lines. All the characters that can be collected from the specimens are comprised in the above description. They are sufficient to shew that this is a distinct genus, and I propose for it the name of *Ateleocystites* from the Greek *ateles*, "defective or incomplete."

Professor Hall has kindly furnished me with some of the printed sheets of his forthcoming Vol. 3 of the Palæontology of New York, in which he has described a new genus *Anomalocystites*, from the Lower Helderberg series. The materials in my possession are not sufficient to enable me to refer the above to the New York genus.

The genera of Cystideæ have not usually so great a vertical range as that between the base of the Trenton and the top of the Upper Silurian. Should it be ascertained hereafter that the two genera are identical, this species must be referred to *Anomalocystites*, which has the precedence.

Another form belonging to this group has been discovered in the Upper Silurian in England.

Fig. 4.

The above wood-cut, fig. 4, represents the structure of the dorsal side as nearly as can be made out from the specimens in the collection.

The species is dedicated to T. A. Huxley, Esq., F.R.S., of the Geological Survey of the United Kingdom.

Locality and Formation.—Trenton limestone, farm of Mrs. Brigham, Township of Hull, near Ottawa.

Collector.—E. Billings.

In addition to the nineteen species of Cystideans described in the foregoing pages, there are fragments of two others, which are too imperfect to indicate the genus; but still sufficiently well preserved

to shew that they do not belong to any known species. One of them appears to be a *Glyptocystites*, and the other will I think yet turn out to be a small Cystidean of a new genus, with a nearly globular body, and three or four pectinated rhombs. I have seen them only in the Trenton limestone at Ottawa.

On the Asteriadæ *of the Lower Silurian Rocks of Canada.* By E. Billings, Esq., F. G. S.

The following species of Star-fishes were described in the Report of the Geological Survey published in 1857, page 290 *et seq.*, with the following introduction:—

"The species of Star-fishes in the collection appear to be referrable to the genera proposed by Mr. Salter at the meeting of the British Association, in August last. I have seen no other description of these genera than that given in Silliman's Journal of November, 1856, which is as follows:

"Palæaster.—Without disc, avenues deep.

"Palæasterina.—Pentagonal, disc moderate.

"Palæocoma.—No disc, avenues very shallow.

"It is probable that our species, when opportunity can be had for a direct comparison with British specimens, will be found congeneric."

Since then Mr. Salter has published full details of the above and some other genera,* and I have also examined some of the species described by him and Prof. Forbes.

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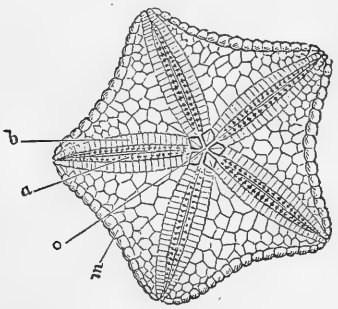
* On some New Palæozoic Star-fishes. By J. W. Salter, Esq., F. G. S. Annals and Magazine of Natural History, November, 1857.



The above diagram is given to explain the sense in which the following terms are used in this memoir:

a. Ambulacral ossicles,—the small plates in the bottom of the ambulacral furrows, between which the pores for the passage of the suctorial feet pass.

b. Adambulacral plates,—the rows of plates which border the ambulacral grooves.

m. Marginal plates,—the row of plates round the margin of some of the species.

o. Oral plates,—situated at the angle of the mouth. In many species these consist of the ten terminal adambulacral plates.

Disc-plates,—I propose to call all the plates of the body which cannot be comprised in any of the above four classes, disc-plates.

After much consideration, I have resolved to adopt the following arrangement for the Canadian species.

Genus PALASTERINA, McCoy.*

(As defined by Mr. Salter, 1857.)

Generic Characters.—"Pentagonal, depressed; the arms a little produced, with three or five principal rows of tubercles above, combined with a plated disk which fills up the angles; ambulacra rather shallow, of sub-quadrate or slightly transverse ossicles, bordered by a single row of squarish large plates, the lowest of which (*ad-oral* adambulacral plates, Huxley†) are large and triangular, leaving combs of spines."

The following species having been already placed in the above genus, I am unwilling to create a new one for them until more is known as to what constitutes a generic character among the Star-fishes. Our specimens do not shew any spines, but perhaps they have not been preserved; and even could it be shown that *P. stellata* was without these appendages, it would still remain to be settled whether this difference is or is not of generic importance.

I. PALASTERINA STELLATA, Billings.

Plate IX. Fig. 1*a*, 15.

(P. stellata, Geological Survey of Canada, Report, 1856, p. 290.)

Description.—Pentagonal; disc about one half of the whole diameter; ambulacral grooves narrow and deep, bordered on each side by a row of small nearly square adambulacral plates; a second row consisting of disc plates extends nearly to the end of each ray, the remainder of the disc covered with smaller plates. All of these plates are solid and closely fitted together; the disc-plates in the angles in contact with the oral plates are much larger than any of the others.

In the only specimen in the collection the length of the rays measured along the ambulacral grooves is three lines; number of adambulacral plates on each side of the grooves sixteen; the rays diminish somewhat rapidly in size, and terminate in a rounded point; diameter of the disc four lines. The plates are all a little worn, so that the character of their surfaces cannot be observed; they were probably nearly smooth.

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* Suggested by Prof. McCoy, who did not however define the genus. British Palæozoic Fossils, p. 59, 1851.

† Angle-ossicula (Forbes), oral plates of this memoir.

EXPLANATION OF FIGURES.

Fig. 1*a*. The specimen natural size.
1*b*. The same enlarged.

Locality and Formation.—City of Ottawa. Trenton limestone.
Collector.—E. Billings.

II. PALASTERINA RUGOSA, Billings.

Plate IX. Fig. 2*a*, 2*b*, 2*c*.

(*Geological Survey of Canada, Report*, 1856, p. 291.)

Description.—Two inches in diameter; rays five, acute at their apices and rapidly enlarging to a breadth of four lines at the disc, which is eight lines in width. The specimen shews the upper side of the fossil only; some of the plates are absent from the centre of the disc, but those which remain are very prominent in their centres, and roughly ornamented with four or five deep crenulations or furrows from near the centre to the edges, producing a star-like appearance resembling a half-worn plate of *Glyptocrinus decadactylus*; their diameter is from one to two lines.

The rays are composed (at least the backs and sides of them,) of four rows of plates, which are so very prominent that they appear to be almost globular, and even pointed in their centres; the central rows are the smallest; the first four plates of the outer row occupy three lines in length, and of the inner rows nearly as many. Towards the point of the arm all diminish rapidly in size.

Beneath the outer rows two others can be seen, which are probably the outer marginal plates of the under side, corresponding to those of *P. rigidus*.

EXPLANATION OF FIGURES. Plate IX.

Fig. 2*a*. Dorsal view of a specimen. 2*b*. Fragment of another individual. 2*c*. One of the plates of 2*a* enlarged.

Locality and Formation.—Charleton Point, Anticosti. Hudson River Group.
Collector.—J. Richardson.

Genus STENASTER, Billings.

Generic Characters.—No disc; rays linear, lanceolate or petaloid; grooves bordered by solid oblong or square adambulacral plates; oral plates triangular and ten in number; two rows of ambulacral

pores. Dorsal side of disc and rays covered with small plates, which appear to be tubercular and not closely fitted together. The generic name is from the Greek *stenos*, narrow, in allusion to the contracted body.

As it has been suggested that the two species hereinafter described should be referred to *Palæaster*, I give the following figure of that genus in order to show the difference.

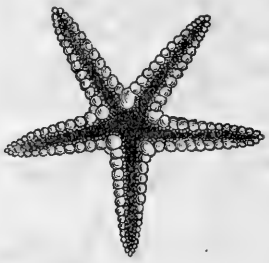

Fig. 1, *Palæaster Niagarensis*, Hall.

Upon examining the above figure, it will be seen that there is a great difference between *Stenaster* and *Palæaster*, for the following reasons:

1. If the large plates which border the groves in *Palæaster* be adambulacral, then there are only five oral plates, whereas in *Stenaster* there are ten.

2. But if they be not adambulacral but marginal plates, then *Palæaster* must have both marginal and adambulacral, while *Stenaster* has only the latter.

III. Stenaster Salteri, Billings.

Plate X. Fig. 1*a*, 1*b*.

Description.—This species has rather short broad rays, which are narrower where they are attached to the very contracted body than they are at about the centre of their length. In consequence of this form, the sides of the rays are not parallel, but a little curved outwards. As however only two specimens have been collected, and both appear to be a little flattened by vertical pressure, it may be that this leaf-like shape of the rays is accidental, and that in perfect specimens they taper uniformly from the body outwards. The adambulacral plates are oblong, and the sutures between them are nearly at right angles to the ambulacral grooves; those next the body are a

little sloping outwards. Their length is about twice their breadth, and they are so disposed that the greater dimension is transverse or at right angles to the groove; the extremities which lie next to the grooves are angular, and some of them appear to have the contiguous pores partly excavated in them. The oral plates are acutely triangular, the sharpest angle being towards the mouth. The plates are smooth. The ambulacral pores are very large, and the ossicles are much contracted in the middle and greatly expanded along the median line of the bottom of the groove.

The most perfect specimen is one inch in diameter measured between the tips of the rays; diameter of disc three lines; width of ray at mid-length two lines and a half.

Dedicated to J. W. Salter, Esq., Palæontologist of the Geological Survey of the United Kingdom.

Explanation of Figures. Plate X.

Figure 1*a*.—Ventral view of a specimen collected at Belleville.
1*b*.—The same enlarged.

Locality and Formation.—Belleville, Canada West. Trenton limestone.

Collector.—E. Billings.

IV. Stenaster pulchellus, Billings.

Plate X. Fig. 2.

(*Palæaster pulchella, Geological Survey of Canada*, 1856, p. 292.)

Description.—Rays long, slender and sub-cylindrical; adambulacral plates transversely oblong; grooves narrow; dorsal plates small and tubular. Diameter of the only specimen in the collection two inches and one-fourth measured between the tips of the rays; rays one inch in length, and two lines and a-half in width at the base; disc three lines and a-half in diameter.

Explanation of Figure. Plate X.

Fgure 2.—Ventral view of the only specimen collected.

Locality and Formation.—Ottawa. Trenton limestone.

Collector.—E. Billings.

Genus Petraster, Billings.

Generic Characters.—This genus has both marginal and adambulacral plates, with a few disc-plates on the ventral side. The general

form is deeply stellate, and the rays long and uniformly tapering. A single specimen has been collected, and as it shews the under side only, the characters of the dorsal surface cannot be given. The structure of the mouth is also unknown. Generic name from *petra*, a stone.

It differs from *Palasterina* by the presence of large marginal plates outside of the disc-plates, and still more from *Stenaster*, which has neither disc nor marginal plates. It is allied to *Astropecten*.

V. Petraster rigidus, Billings.

Plate X. Fig. 3.

(*Palasterina rigidus, Geological Survey of Canada, Report*, 1856, page 291.)

Description.—This species has much the aspect of an *Astropecten*; the disc is one-fourth the whole diameter, the rays rather slender and uniformly tapering; the angles between the bases of the rays rounded. The plates, which appear to be adambulacral, are quadrate and a little convex; the marginal plates oblong, and also convex; the disc-plates consist of three at each angle, and a single row on each side of the ray, but extending only one-third or one-half of the length of the ray; they all lie between the marginal and adambulacral plates.

The specimen figured was about two inches in diameter when perfect; width of disc half-an-inch, and of rays at the base about three lines.

Explanation of Figure. Plate IX.

Fig. 3*a*.—Ventral view of an imperfect specimen.

Fig. 3*a* appears to be the dorsal side of an individual of this species with the plates along the centre of the rays removed.

Locality and Formation.—Trenton limestone, Ottawa.
Collector.—J. Richardson.

Genus Tæniaster, Billings.

Generic Characters.—Body deeply stellate; no disc or marginal plates; rays long, slender, flexible, and covered with small spines; two rows of large ambulacral pores; adambulacral plates elongated and sloping outwards so that they partly overlap each other; adambulacral ossicles contracted in the middle, dilated at each end. Generic name from *tainia*, a riband.

This genus differs from *Protaster* as described by Mr. Salter in the Annals and Magazine of Natural History, November 1857, in the following particulars:—

1. *Protaster* has a well-developed disc.

2. It has also the pores outside of the ambulacral ossicles. See Mr. Salter's fig. 4*c*, in the article above cited.

3. The same figure shows that the oral plates of *P. Miltoni* are formed of two of the ambulacral ossicles, instead of two of the adambulacral plates.

These differences are too great to admit of our species being at all, unless very remotely, allied to *Protaster*.

VI. Tæniaster spinosus, Billings.

Plate X. Fig. 3*a*, 3*b*, 3*c*, 3*d*.

(*Palæocoma spinosa*, *Geological Survey of Canada*, *Report*, 1856, page 292.)

Description.—The specimens collected are about seven lines in diameter; the rays linear-lanceolate, one line in width at the base, and covered at the sides with numerous small spines.

In the view of the enlarged specimen (pl. x. 3*b*), the ambulacral ossicles appear in some places to alternate with each other, but this is owing to a distortion. Those on one side of the furrow are opposite those upon the other. The adambulacral plates are elongated, and so placed that the outer extremity of the one lies upon the inner extremity to the next. The rays are flexible.

Explanation of Figures. Plate X.

Figure 3*a*.—Ventral view of a small specimen.
3*b*.—The same enlarged.
3*c*.—Another specimen, with the rays bent upwards.
3*d*.—The same enlarged.

Locality and Formation.—Falls of Montmorency, Trenton limestone.
Collector.—E. Billings.

VII. Tæniaster cylindricus, Billings.

Plate X. Figs. 4*a*, 4*b*.

(*Palæocoma cylindrica*, *Geological Survey of Canada*, *Report*, 1856, page 292.)

Description.—About an inch and a half in diameter or a little more; rays sub-cylindrical, regularly rounded on the upper side, flattened on the lower, covered above with spines; about a line in width at the base, and tapering to an acute point.

This species is larger and more robust than the former. Both appear to be somewhat common, and the specimens are often found with their rays variously curved, showing that they were extremely flexible.

EXPLANATION OF FIGURES. Plate X.

Figure 4*a*.—Dorsal view of a specimen.

4*b*.—Ventral view of a different specimen.

Locality and Formation.—City of Ottawa. Trenton limestone.
Collector.—E. Billings.

Genus EDRIOASTER, Billings.

(Genus *Cyclaster, Geological Survey of Canada, Report*, 1856, page 292.)

Generic Characters.—Body sessile, circular, discoid, covered with numerous irregularly polygonal plates; mouth large, sub-pentagonal; five ambulacral grooves, each composed of two series of oblong ossicles; four rows of ambulacral pores to each groove. The mouth is formed of five oral and apparently five internal ossicles. The sutures between the ambulacral ossicles, in certain conditions of preservation, are enlarged so that the pores on each side are connected, and thus there appear to be two instead of four. Hence in the first description I gave of this species it was described as having two rows. Since then more perfect specimens have been procured, and I am enabled to correct this misconception. Generic name from *edriao*, to seat, in allusion to the sessile condition of the species.

In my report for 1856 this genus is called *Cyclaster;* but I find that this name had been a short time previously given to a genus of sea-urchins by M. Cotteau, and it is therefore necessary now to provide a new one. (See *Catalogue des Echinides Fossiles des Pyrénnées.* Par MM. Leymerie et Cotteau. Bulletin de la Société Géologique de France, 18 Fevrier à 17 Mars 1856.) This number of the Bulletin was published in March 1857, but my Report was not issued until the autumn following.

VIII. EDRIOASTER BIGSBYI, Billings.

(*Cyclaster Bigsbyi, Geological Survey of Canada, Report*, 1856, page 293.)

Description.—The body of this species is circular, about one inch and a half across, and half an inch in height in the centre. It is covered with numerous small plates of various sizes, and, except in the ambulacral areas, disposed without order. The mouth, situated

in the centre of the upper side, is about two lines in diameter, and apparently five-sided. The other aperture between the rays consists of a space covered with plates much smaller than the average size; these form a small elevation, which is imperfect in all the specimens I have seen, but enough remains to render it almost certain that there was an aperture of some kind in this place.

The ambulacral areas are five in number, radiating from the mouth, precisely like those of a common star-fish, and composed of two series of oblong plates which alternate with each other in the centre of the furrow. There are about ten of these plates to five lines in length, on each side of the ambulacrum. The pores pass between the plates, two being situated between each two. The ambulacra are three lines wide at the mouth, and about an inch and a half in length in full-grown specimens. As they recede from the centre they curve round towards the right in some specimens, and towards the left in others.

The mouth appears to be composed of ten plates; five of these are at the ends of the ambulacra, and the other five placed in the angles between the ambulacra. In some of the specimens the plates are all smooth, in others covered with small tubercles.

All the specimens that I have collected were seated upon the rock with the mouth upwards, and apparently somewhat flattened by pressure. It is probable that when perfect they were more globular than they are present. One specimen is detached, and shows that the plates covered the whole of the under surface, except a small space in the centre which appears to be without plates; perhaps this was the point of attachment; I see no evidence of a column.

Dedicated to Dr. Bigsby, one of the most able of the first explorers of the geology of this country.

I regret, that, in consequence of mistaking the meaning of Prof. E. Forbes' remarks on the genus *Agelacrinites* in his memoir on the British Cystideæ, I supposed this to be the specimen discovered by Dr. Bigsby, and accordingly gave it his name. Since then I have seen Dr. Bigsby's specimen, and find it to be *A. Dicksoni*. It is too late now to change the names.

Explanation of Figures. Plate VIII.

Figure 1.—Upper side of a specimen partly embedded in stone.

1*a*.—A polished section through the mouth and two of the grooves, showing that the pores penetrate through.

2.—Fragment of a crushed specimen, showing two of the rays.

2*a*.—A portion of fig. 2 enlarged to show the pores.

Locality and Formation.—City of Ottawa. Trenton limestone.

Collector.—E. Billings.

Agelacrinites Dicksoni, Billings.

Plate VIII. Figs. 3, 3*a*, 4, 4*a*.

(*A. Dicksoni, Geological Survey of Canada, Report*, 1856, page 294.)

Description.—The diameter of this species is from three quarters of an inch to an inch and a half; the rays are five in number, and constructed upon a plan somewhat different from that of *E. Bigsbyi*, being bounded by two rows of small plates, which rise from the surface and arch over the grooves. The upper ends of the plates on one side meet those of the opposite side, in a line along the centre of the ray, thus forming for each ray a sort of covered way. The spaces between the rays are paved with numerous flat sub-imbricating plates. The specimens do not show the central aperture distinctly, but between two of the rays there is an orifice which appears to have been surrounded by small plates. The width of the rays at their bases is from one to two lines, according to the size of the individual, and they taper uniformly to their extremities. In all the specimens I have seen, the rays curve round to the right hand, if we suppose that the side with the aperture is posterior. The marginal plates of the rays do not appear to alternate regularly, as in some of the figured species of this genus.

There are two rows of small circular indentations on each side of the rays, corresponding in their position to the ambulacral pores of *E. Bigsbyi*, only that in the latter they are in the bottom of the grooves. It cannot be ascertained whether they penetrate through between the marginal plates or not.

I have dedicated this species to Andrew Dickson, Esquire, of Kingston, C. W., one of the best workers in the field of Canadian geology.

The first specimen was discovered by Dr. Bigsby at the Chaudière Falls, at Ottawa, in 1822.

Explanation of Figures. Plate VIII.

Figure 4.—The original specimen discovered by Dr. Bigsby, and now in the Museum of Practical Geology, Jermyn Street, London.

4*a*.—The same enlarged.

3.—View of a different specimen, in the collection of the Geological Survey of Canada.

3*a*.—The same enlarged.

Locality and Formation.—City of Ottawa. Trenton limestone.
Collectors.—Dr. Bigsby, E. Billings.

I have placed *E. Bigsbyi* in the order Asteriadæ, because its structure appears to me to be more like that of the Star-fishes than that of the Cystideæ. None of the Cystideæ have ambulacra whose pores penetrate through the covering of the body, and therefore all such genera as *Edrioaster*, *Agelacrinites* and *Hemicystites*, belong to a very different division of the Echinodermata. When we know more of their structure it is probable that they will be arranged as a sub-order, for which the name *Edrioasteridæ* would be appropriate, as it would suggest their sessile condition on the one hand, and on the other their affinity to the Asteriadæ.

On Cyclocystoides, *a new genus of Echinodermata from the Lower and Middle Silurian Rocks.* By J. W. Salter, Esq., of the Geological Survey of Great Britain; and E. Billings, Esq., of the Canadian Geological Survey.

Under this name we wish to describe a form which has come under the notice of each of us—in the one case in a series of instructive specimens shewing the structure of the different parts from the Trenton limestone rocks of Canada; and in the other, a specimen shewing the entire form and general surface, which has been long known in the Llandovery Rocks or May-Hill Sandstone of England.

The affinities of the fossil may perhaps be better discussed when the structure of the two species with which we are acquainted has been described.

Genus Cyclocystoides, Billings and Salter. PLATE X.

Generic Characters.—Discoid, surfaces formed of an integument composed of numerous small granular plates, which appear to be radiately arranged; margin entirely surrounded by thick subquadrate plates, each of which presents upon its outer half two deep obtusely oval excavations. These, in perfect specimens, are covered over by minute polygonal plates, thus forming a tubular channel around the whole animal. This channel appears to have been connected with the interior by small pores penetrating through the marginal plates, there being one pore leading from each of the excavations. The margin or (perhaps) disc was also connected with a long tube, like the proboscis of some of the Crinoids, formed of many small polygonal plates.

I. Cyclocystoides Halli, Billings.

Description.—Flat, circular, from one to two inches in diameter; about thirty-six marginal plates, the unexcavated inner portions of which are subquadrate, convex, and slightly granular upon their

surfaces. The two marginal excavations of each plate are separated by a thin wall-like partition, and bordered at the sides and outer edge of the plate by a sharp rim. It thus follows that the channel around the margin of the animal was divided into twice as many compartments as there are marginal plates. The integument of the upper side, supposed to be the side on which the marginal plates are excavated, is connected to the inner edge of those plates, and does not extend over them; its surface is roughened by small tubercles. The integuments of the under side appears to extend under the marginal plates, and connect with the small plates which cover the excavations above.

Fig. 6 represents the remains of a specimen which was perfect, but imbedded in the rock to such an extent that only eight or nine of the marginal plates and a small portion of the integument of the upper side were visible. It was silicified, but not to such an extent as to resist completely the action of hydrochloric acid. It shewed clearly that the integument was attached to the inner edges of the marginal plates.

The following description of the figures contains all that can be be said further about these specimens:—

The specimens, four in number, collected by Sir William E. Logan, shew:—

1. In fig. 1, an impression of a nearly complete disk, more than an inch broad, with all the marginal ossicles complete. They form very nearly a circle, deficient only at one point, *a*, which may be only accident, or possibly as both the outer rim and inner series of ossicles are deficient at this point, it may indicate the position of a stem or attachment. At one other point, *b*, the margin is broken, but the inner row of ossicles appears to be continuous, so that if there be not an attachment at *a*—and no trace of any appendage exists—the animal was most probably free.

2. Fig. 2 shews the marginal plates, and in a good state of preservation, of more than three-fourths of the ring. There are twenty-six of these, and their form is rudely sub-quadrate, rounded on the inner margin, truncate and bilobed on the outer; each is divided into two conspicuous halves, of which the inner is convex, granuloso-tuberculate, and with close, parallel, vertical striæ on their sides (fig. 3*b*); the outer half, on the contrary, is deeply excavate, smooth, divided by a radiating ridge into two shovel-shaped portions, which at their inner base are each deepened into a circular pit, with a tubercle in it (as seen more plainly in the cast, fig. 6 and *a*). The outer free

edge, 3*d*, is furnished with one, two, or more transverse plates, which also appear granular, supporting other smaller ones which appear to fill up all the space over the excavations, and to form a sort of polygonally plated tube. This tube is nearly complete at *a*, fig. 1, and from near this point a similar but truly cylindrical tube extends out beyond the ring of ossicles, and is seen at *b* complete, and at *c* with its upper surface broken away, forming a continuous tube fully three-quarters of an inch beyond the disk, and apparently not terminated even then; 2*d** shews it magnified.†

3. Fig. 5 shews a still more complete development of this marginal plating, and the difference in size of the basal plates (see fig. 5* and the marginal ones, *b*) is such as to suggest the idea of a distinct species. It is perhaps only a younger specimen, considerably abraded, but may however receive provisionally the name of *C. depressus*. The specimen 5 shews a considerable portion of the loosely-arranged and flattened ossicles of the disk, which are not closely plated, but leave large interstices between them. This structure is better seen in the small fragment of the central disk of figure 2 (magnified in figure 4), in which the granular surface of the plates, and their irregular arrangement with interstices, is very distinct.

Figs. 8 and 9 shew still more clearly the radiated structure of the upper surface in another species.

Fig. 6 is the opposite or under-side (at least the flatter and less ornamented side), and may be presumed to be *C. Halli*. The great ossicles here are marginal, and have no plated integument stretching out beyond them, the outer edge, 6*b*, corresponding to the edge, 3*d*, on the opposite face.

The silicified specimen, 6, has been macerated in muriatic acid to expose it, and has suffered abrasion—neither the marginal ossicles, *b*, nor the reticular surface, *a*, shewing so clearly as they should do the real structure of the surface. At *a* a portion of the upper-side is seen, viz., impressions of three of the large granular ossicles, with their external deep pits (represented in the cast as circular elevations, with a minute central pit in each).

It is this specimen which so satisfactorily explains the meaning of the cast next to be described, and which, though differing specifically and from another formation, also helps materially to elucidate the specimens already described.

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† Upon a re-examination of this specimen I can detect no connection between the fragment of the tube and the disc, although it may have been connected.—E. B.

We dedicate this species to Professor J. Hall, the distinguished palæontologist of the New York survey.*

Locality and Formation.—Trenton limestone, City of Ottawa, and Lake St. John.

Collectors.—Sir W. E. Logan, E. Billings, J. Richardson.

II. Cyclocystoides Davisii, Salter.

C. ovalis? uncialis et ultra, ossiculis marginalibus 48-49, *convexis, lævigatis, extus profunde excavates, simplicibus nec radiatim bilobis, margini recurvo, superficie obscure* 8, *radiato.*

This species certainly differs from the American one in that the number of marginal ossicles is much greater (forty-eight or forty-nine), while the ossicles themselves, instead of being granular, are smooth, and have the outer division much deeper, the margin being produced upwards as a distinct rim. Neither the division of the ossicles in this outer portion into two lobes, nor the separation of one ossicle from its neighbour, is at all distinctly marked; but just at the base of the deep excavation short-raised ridges indicate faintly these divisions, while the annular pits at the bottom are still deeper and more distinct than in the *C. Halli.*

This species shews the complete surface, on which about as many

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* Professor Hall in 1851 described a species of this genus in the palæontological part of Foster and Whitney's Report on the Geology of Lake Superior, page 209. Each of the specimens which he figures (see plate xxv. fig. 4, *a*, *b*, *c*, of the work cited) exhibits twenty-nine marginal plates. The smallest of ours (plate x. figure 5 of this decade) although exactly the size of the largest figured by Prof. Hall, has thirty-six, and so have our two largest. The Escanaba specimens are therefore most probably of a different species, which has not yet been named. The following is Prof. Hall's description:—

"This body consists of a ring, or a sac, the upper edge of which only appears, composed of numerous plates joining by their broader edges. The upper or exposed surface of the plates is sculptured or granulated, convex, and not closely joined together at the upper angles, presenting the appearance of somewhat quadrangular tubercles; exterior margin of each plate furnished with a thin wing-like expansion, marked by two diverging ridges.

"This curious body is evidently Crinoidean, from the character and structure of the plates. The ring presents an appearance very similar to the row of plates surrounding the valves which close the ovarian aperture in some Cystideans, but the number is far too great, being in one specimen twenty-nine, and apparently not less in the other. The inner faces of the plates moreover do not present any appearance, as if for the attachment of other plates or valves. It is possible that it may be the elevated marginal ring of some one of the sessile Crinoids, though the arrangement of the plates is more regular than in any species known to me.

"*Locality.*—Banks of the Escanaba river, two miles below the mouth of Indian creek, in the Trenton limestone."

radiations mark the margin as there are ossicles, and the centre of the flat disk is occupied by a star of about eight narrow rays, with a central depression. All of these markings are obscure, but were still capable of demonstration in the specimen (unfortunately since lost, after an accurate drawing had been taken).

The margin is peculiarly deep and raised like a rim all round; the outer half of the ossicles, being deprived of radiating ridges, combine to form a smooth channel. The deep-set annular pits shew on the cast as projecting rings with a central depression.

Locality.—May-Hill Sandstone of Prof. Sedgwick (Upper Llandovery Rock, Murchison), Presteign, Radnorshire, South Wales. Found by J. E. Davies, Esq., F.G.S.

Regarding the affinities of the fossils, the choice seems to be between Star-fishes and Cystideæ.

At first sight of the more perfect evidence thus brought together—for neither the Canadian or British specimens are complete without the other—the impression certainly was, that we had here a truly circular Star-fish, an extreme form of what is so often approached by some of the Gonialites of the chalk formation. We have figured one (figure 10) to illustrate this comparison, where the marginal ossicles of the disk and of the rays are so much alike, and the latter much shortened as to present nearly a circular outline.

In the loosely reticular skeleton of the disk there is an additional character, very common in Star-fish, but rare in Crinoids or Cystideæ. Against this supposition there is the peculiar excavation of the marginal ossicles, not for the attachment of large marginal spines, such as Goniaster and other star-fishes often exhibit on a small scale, but forming a hollow space, covered over with closely plated ossicles.

The discovery of the long tube, fig. 2, *b*, *c*, made (during the etching of the specimens) by our valued friend, Mr. Sowerby, threw still further doubt on this explanation. It appears as if continuous (though the connection cannot quite be traced,) with the marginal tesselated portions (*a*, *a*), and if this were the case there would be a channel running along the outer margin of the disk, and thence out freely at one end, a structure incompatible with that of any known Star-fish, or indeed any Echinoderm whatever. If on the other hand comparison be made with certain known forms of Cystideæ, although the reticular structure of the disk is abnormal, yet in the arrangement of the marginal ossicles there is a not indistinct resemblance to such forms of Cystideæ as *Pseudocrinites* (fig. 12), or perhaps still nearer to the Canadian form *Amygdalocystites*, described by one of the authors.

On the Palæozoic Bivalve Entomostraca *of Canada.* By T. R. Jones, Esq., F.G.S.

I. Beyrichia Logani, Jones.

Plate XI. Figs. 1–5.

(*Annals of Natural History*, 3d series, vol. i. p. 244, plate ix. figs. 6–10.)

Length $\frac{1}{16}$, breadth $\frac{1}{26}$ inch.

This is a small *Beyrichia* of the unisulcate group ("Simplices," Annals Nat. Hist., 2 ser. vol. xvi. p. 85); variable in shape, from reniform to oblong; dorsal edge straight, extremities rounded and almost equal; ventral edge varying in its convexity. Surface of the valves somewhat depressed, most convex a little above the median line, sloping more gently to the ventral than to the dorsal margin; usually punctate, sometimes smooth; always bearing a distinct narrow depression on the dorsal region, usually on its anterior third; this dorsal notch reaches across a third or even more of the breadth of each valve. Ventral and terminal margins bordered by a narrow depressed rim.

I cannot regard the extreme shapes of the gregarious and innumerable individuals of this *Beyrichia* as typical of specific distinction. The general form, the relative convexity, and the dorsal notch are the more characteristic features.

a. Var. *reniformis.* The extreme of the kidney-shaped form is well shown in fig. 1, a specimen from Hawkesbury, where this shape occurs, with many of oblong outline, and others of intermediate shapes. The specimen here figured is strongly punctate: smooth specimens of this variety occur at Grenville.

b. Var. *leperditioides.* In fig. 5 we have one of the specimens in which the antero and postero-dorsal corners of the valves become modified towards the well-marked oblique dorsal angles of *Leperditia.*†

Locality and Formation.—Grenville and Hawkesbury; with the following species in the lower part of the Chazy.

Collector.—Sir W. E. Logan.

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† See p. 92 for further remarks on *B. Logani* and its varieties, in relation to *L. Canadensis.*

II. Leperditia Canadensis,* Jones. *a.* Var. nana.

Plate XI. Figs. 6, 7, 9, 10.

(*Annals of Natural History*, 3d series, vol. i. p. 244, plate ix. figs. 11–15.)

Length $\frac{1}{5}$, breadth $\frac{1}{13}$ inch.

Small; somewhat variable in shape, but always retaining the characteristic Leperditia-outline, with straight back, more or less obliquely-rounded belly, and sloping dorsal angles. Carapace usually short (the height or breadth being about two-thirds of the length), somewhat variable in the amount of convexity (thickness), which is usually greatest at the antero-ventral third. Surface smooth. Eye-tubercle generally well marked, and muscle-spot often distinct; but occasionally the latter becomes involved in the nuchal depression, and the former is sometimes obsolete.

This is the smallest form of *Leperditia* which I have yet met with. It occurs in great numbers, together with *Beyrichia Logani* in equal abundance, in a dark-grey friable limestone, mainly composed of these Entomostraca, fragments of trilobites and shells, at Grenville and near Hamiltonville in Hawkesbury, on the Ottawa. This Leperditia limestone forms part of a band of limestone, about two feet thick, which extends over a wide district†, and is of importance as marking the position of a continuous band of rock holding nodules of phosphate of lime which is beneath it; it belongs to the base of the Chazy limestone.

This variety of *L. Canadensis* occurs also in a dark-grey, crystalline, shelly limestone (of the Calciferous Sandrock) on the north side of Grande Isle,‡ in the St. Lawrence. In two hand specimens of this limestone a few separate valves and one pair of valves are present.

Beyrichia Logani and *Leperditia Canadensis*, var. *nana*, occur together in immense numbers, forming indeed a considerable portion of the limestone rock in which they are chiefly found. I believe that the former is not the young of the latter (although perhaps the differences of shape and structure are not greater than such as we find to occur between the young and adult forms of recent Entomostraca and other Crustacea), because, where the allied *Beyri-*

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* Referred to in Quart. Journ. Geol. Soc. vol. viii. p. 202 and p. 207.

† "This rock, having been quarried for lime-burning in several places, has been followed from Carillon to Grenville (thirteen miles)." Quart. Journ. Geol. Society, vol. viii. p. 207; and Logan's Report Geol. Surv. Canada, 1851–52, p. 18.

‡ Quart. Journ. Geol. Soc. vol. viii. p; 202; and Logan's Report, 1851–52, p. 15.

chiæ, such as *B. strangulata*,* *B. mundula*, and *B. simplex*, occur, even in as great numbers, in the rocks of other localities, the *Leperditiæ* are not found with them; the latter also occur unaccompanied by these *Beyrichiæ*, *L. Canadensis* itself being found alone in Grande Isle. The close resemblance in outline of some specimens of *B. Logani* (var. *B. leperditioides*, fig. 5) to the *Leperditiæ* is, I believe, merely a mimetic resemblance of outline, such as we find taking place among many groups, both of the lower and the higher animals.

b. Var. LABROSA.

Plate XI. Fig. 8.

Length $\frac{1}{6}$, breadth $\frac{1}{10}$ inch.

The extremities of the valves in this specimen from Hawkesbury are marked by a broad marginal depression, which is continued less strongly along the ventral border, and the antero-dorsal corner is more produced than usual.

This may be an individual modified by accidental circumstances of growth.

c. Var. LOUCKIANA.

Plate XI. Fig. 11.

Specimens of possibly the same species as the foregoing, but of a considerably larger size (often twice as large), occur in two other limestones, specimens of which Sir William Logan has confided to my examination.

Imbedded in bits of black fine-grained limestone from Louck's Mill, on the Castor River, in the township of Russell, are three glossy black valves, in good preservation, and of different sizes (one specimen being $\frac{3}{10}$ in. long and $\frac{2}{10}$ broad, the others being respectively $\frac{3}{20}$ in. and $\frac{3}{40}$ in. in length). In each of these the eye-spot is very distinct, and accompanied by a local ruggedness of the surface of the valve (not amounting to a sulcus); the valves are faintly rimmed.

This black limestone is referred to the Trenton in Geol. Survey Canada, Report, 1851-52, p. 73; but, according to a letter of later date from Sir W. E. Logan, it may be Birdseye limestone.

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* *Beyrichia strangulata* takes on a variety of forms (see Annals of Natural History 2nd series, vol. xvi. pl. 6, figs. 18–22) analogous to those of *B. Logani*.

d. Var. PAUQUETTIANA.

Plate XI. Fig. 12.

A small specimen of brownish, fine-grained limestone (weathering grey, and containing shells), from Pauquette's Rapids, Allumette Island, Ottawa River, contains one well-preserved brown coloured valve (fig. 12), $\frac{1}{4}$ inch long, $\frac{3}{20}$ inch broad, much like the largest specimen from Louck's Mill, but showing no marginal rim, and feeble traces only of the eye-spot and its accompanying depression. In this fragment of limestone (probably Trenton) smaller Entomostracous bivalves abound (see p. 99 and 100).

Except in the relative size, the form of the eye-spot, and the valve-margin (in which latter points one of these larger specimens varies from the others), the two sets of specimens (the large and the small) do not appear to disagree essentially, as far as my means of examination at present enable me to judge. At the same time, as we know that in some recent bivalved Entomostraca, different species and even subgenera may present a great similarity in their carapaces, it is possible that we have here a distinct specific form.

Mr. Conrad has briefly described,* under the name of *Cytherina fabulites*, a bivalved Entomostracan, from the Trenton limestone of Mineral Point, Wisconsin. This appears to be a *Leperditia* half an inch in length, and therefore surpassing in size the specimens under notice, to which it may be allied.

See Annals of Natural History, 3rd series, vol. i. p. 340, for descriptions of this and the following variety.

e. Var. JOSEPHIANA.

Plate XI. Fig. 16.

A small specimen of grey Trenton limestone, from the east side of St. Joseph's Island, Lake Huron, containing a Bryozoon, and weathering yellowish, bears a right valve of a *Leperditia* $\frac{2}{4}\frac{1}{0}$ inch long, and $\frac{1}{4}\frac{3}{0}$ inch broad; there is also a separate perfect carapace of the same form ($\frac{1}{4}\frac{1}{0}$ inch thick) from the same limestone. The valves are of a light-brown color; the eye-spots are indistinct; the radiate markings of the muscle-spot are more visible on the left than on the right valve; the overlapping ventral edge is neither straight, nor symmetrically curved; the general form of the lower half of the carapace is rounded and bulky.

* Proceedings of the Philadelphia Academy, 1843, vol. i. p. 332.

This Trenton form, which I have termed *L. Canadensis*, var *Josephiana*, may possibly be the same as Conrad's *L. fabulites*; if so, his name has priority.

f. Var. ANTICOSTIANA.

Plate XI. Fig. 17.

A piece of light-grey limestone (of the upper portion of the Hudson River group) from East Point, Anticosti, bears on its weathered surface encrinital ossicles and eleven separate valves of a *Leperditia* of different sizes; there is besides a separate perfect carapace of the same form, half an inch long, $\frac{13}{40}$ inch broad, and $\frac{8}{40}$ inch thick). These specimens have a rather short hinge-line, a well-marked ocular tubercle, and a muscle-spot visible only by its slightly darker tint. In some instances these valves appear to have a peculiar delicacy of make and substance; they slope rapidly from the central convexity; the ends of the carapace are thin, and the overlapping part of the right valve is distinctly central and neatly curved. This form differs from that of St. Joseph's in having a shorter hinge-line and a more prominent eye-spot; in the apparent absence of external radii to the muscle-spot; in the somewhat more delicate substance of the valves; in the lesser thickness of the carapace, in its attenuated edges before and behind, and in the symmetrical curvature of the overlapping ventral edge.

This neatly shaped *Leperditia* from Anticosti more nearly resembles its almost gigantic allies of Sweden* than do any other American *Leperditiæ* that I have seen. Still it is not without good points of relationship with *L. Canadensis*, and I have provisionally termed it *L. Canadensis*, var. *Anticostiana*.

The St. Joseph's form more nearly resembles the large varieties of *Leperditia Canadensis* (pl. xi. figs. 11 and 12) than do the Anticosti specimens; and as I did not feel authorized to separate specifically the little Grenville varieties, that from Louck's Mill, and that of Allumette, neither can I at present regard these comparatively large and well-grown specimens as belonging to another specific type.

Mr. Salter having lately favoured me with better specimens of the *Leperditia alta*, from Wellington Straits, than I had previously seen, I am enabled to point out, that though in size and general form the Arctic *L. alta* much resembles the *Leperditiæ* from Louck's Mill, Pauquette's Rapid, St. Joseph's, and Anticosti, it has a thinner shell, and a distinct muscular spot, with vascular radii; and further,

* Annals of Natural History, 2nd series, vol. xvii. p. 85, pl. 6.

it shows an inclination to vary extremely in the vertical dimensions of the carapace, so that in the same hand specimen, some individuals are ovate-oblong, and others narrow and pod-shaped. This habit of variability of outline is not apparent in the Canadian *Leperditiæ* above described.

Other localities in Canada are mentioned by Sir W. E. Logan and Mr. Murray for Entomostraca—probably *L. Canadensis* or allied forms, namely:—

Three miles above Lachine; in the Trenton limestone? *

Indian Lorette near Quebec; in the Birdseye limestone? †

Three or four miles from Montreal, in a line a little west of north; in the Birdseye limestone. ‡

Sheik's Island, Cornwall,§; with *Atrypa plena* in the Chazy.

Cornwall; in the Trenton limestone‖.

Lancaster; in the Black River limestone¶.

Winchester; in the Trenton limestone**.

III. Leperditia Anna, Jones.

Plate XI. Fig. 13.

(*Annals of Natural History*, 3d series, vol. i. p. 247, plate ix. fig. 18.)

Length $\frac{1}{6}$, breadth $\frac{1}{9}$ inch.

Small, convex; ovate-oblong, somewhat narrower in front than behind; the ventral curve nearly uniform; hinge-line straight; dorsal angles slightly truncate. Surface of valves most convex at the posterior third; smooth, thickly punctate, each of the little shallow circular pits having a minute central tubercle. Eye-spot distinct and raised.

Locality and Formation.—Several valves of this neatly-pitted *Leperditia* are present in a small hand-specimen of a hard dark colored concretionary limestone, under the zone of *Atrypa plena*, and belonging to the Calciferous Sandrock, from immediately behind the village of St. Ann's††, at the confluence of the Ottawa and St. Lawrence. This is probably the oldest known species of the genus.

Collector.—Sir W. E. Logan.

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* Quarterly Journal Geological Society, vol. viii. p. 205.

† Letter, Jan. 17, 1853. ‡ Letter.

§ Geol. Sur. Canada, Report, 1851–52, p. 70.

‖ *Ibid.* p. 70. ¶ *Ibid.* p. 71. ** *Ibid.* 72.

†† Quart. Jour. Geol. Soc. *loc. cit.*; and Geol. Sur. Canada, Report, 1851–52, p. 16

IV. Leperditia amygdalina, Jones.

Plate XI. Figs. 18, 19.

(*Annals of Natural History*, 3d series, vol. i. page 341.)

Several specimens of a dark-grey limestone, from near L'Orignal, are rich in separate valves of a handsome *Leperditia*, which at first sight has much the aspect of *Isochilina Ottawa;* but it is larger, blacker, and has a proportionally shorter hinge-line, the hinder portion of the valves being boldly and obliquely rounded, forming about one-third the length of the carapace; though the valves have a marginal rim, this is only on the two ends, being wanting below, where the middle third of the ventral border is turned in, overlapping on the right, and overlapped on the left side. The surface is smooth; the eye-spot prominent, and accompanied by a slight, irregular nuchal furrow; muscle-spot indistinct. The carapace is $\frac{3}{20}$ inch long, $\frac{5}{20}$ in. broad, and $\frac{3}{20}$ in. thick, and most convex at the anterior third.

Though numerous in the rock, the individuals are not massed together in layers, as are the *Isochilinæ* at L'Orignal, Grenville, and White Horse Rapids.

Locality and Formation.—One mile west of L'Orignal, Chazy.

Collector.—R. Bell.

Genus Isochilina*. *Subgenus of* Leperditia.

Equivalve; the margins of the valves meeting uniformly, not overlapping as in *Leperditia;* greatest convexity of the valves either central or towards the anterior portion. Eye-tubercle present. Muscular spot not distinct externally.

V. Leperditia (Isochilina) Ottawa, Jones.

Plate XI. Fig. 14.

(*Annals of Natural History*, 2d series, vol. i. p. 248, plate x. fig. 1.)

Length $\frac{1}{6}$, breadth $\frac{1}{10}$ inch.

Leperditia-like in outline, somewhat elongate, smooth; marginal border distinct, frequently seen to be marked by a line of small, distinct pits; eye-spot distinctly raised.

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* *Equal lip.*

From the canal at Grenville. Gregarious; the separated valves forming a thin layer about half an inch thick, in a dark-grey limestone of the Calciferous Sandrock, a foot or two beneath the "two-foot limestone," and traceable for some miles.

In several specimens of Leperditia rock from the Chazy limestone near the N.W. corner of the township of L'Orignal, I have recognized the *Isochilina Ottawa*, under similar conditions to those in which it occurs at the Grenville canal, except that in one specimen it is associated with a *Modiolopsis*-like shell. I have only to remark, that when the shell is broken off, the casts of the valves show a distinct muscle-spot (concave on the inner side of the valve) with numerous radii.

Collectors.—Sir W. E. Logan, J. Richardson, R. Bell.

VI. Leperditia (Isochilina) gracilis, Jones.

Plate XI. Fig. 15.

(*Annals of Natural History*, 3d series, vol. i. p. 248, plate x. fig. 2.)

Length $\frac{1}{4}$, breadth $\frac{1}{12}$ inch.

Carapace sub-rhomboidal, narrow and slender when compared with the *Leperditiæ* proper; anterior extremity obliquely rounded, with the antero-dorsal angle produced, slightly obtuse; posterior extremity rounded, with the postero-dorsal angle obliquely truncate. Ventral curve uniform. Surface of valve convex centrally, black, shining, smooth, sparsely punctate; the pitting partial often obscure, or nearly obsolete. Depressed margin broad, in many specimens bearing a row of rounded pits (about thirty-two), which are represented on the inside of the rim by corresponding raised obtuse points.

Locality and Formation.—Gregarious; in loose fragments of a black, fine-grained fœtid limestone from the White Horse Rapids, Isle Jesus, referred, with doubt, to the Trenton limestone in the Quart. Journ. Geol. Soc., vol. viii. p. 205, but to the Birdseye limestone in a letter of later date from Sir W. E. Logan. The disunited valves lie matted together, and sprinkled with minute iridescent crystals of pyrites, in a thin layer or layers in the rock.

Collector.—Sir W. E. Logan.

Genus Cytheropsis, M'Coy.

This generic appellation is affixed to a bivalved Entomostracan (figure 2, plate l. L.) in the 'Systematic Description of the British

Palæozoic Fossils in the Geological Museum of the University of Cambridge,' 1855, but neither the characters of the genus nor of the fossil are described, owing probably to the author not having had time to add this description to the great work referred to.

Cytheropsis appears to me to be a useful term for the distinction of those palæozoic Entomostraca that do not closely assimilate either to *Leperditia* or *Beyrichia*, but much resemble in outline and size many of the *Cytheres* of the existing seas, differing however from them in sometimes having eye or muscle-spots, and other peculiar features, such as a comparatively great thickness of the valves. Though based chiefly on negative characters, this group may for the present be conveniently referred to as being generic.

I have noticed several minute Entomostraca in the Silurian rocks of Wales and Sweden, which may probably belong to this group.

VII. Cytheropsis concinna, Jones.

(*Annals of Natural History*, 3d series, vol. i. p. 249, plate x. figs. 3, 4.)

Length $\frac{1}{17}$, breadth $\frac{1}{33}$ inch.

Carapace subcylindrical, tapering anteriorly; ends rounded; back straight; dorsal angles slightly truncate; ventral edge of right valve overlapping that of the left. Surface smooth, shining, light-brown, partially pitted. In some specimens a very slight marginal rim is traceable.

Locality and Formation.—Many specimens, both of double and single valves, in the Trenton? limestone of Pauquette's Rapids, Allumette Island, Ottawa River.

I have had some doubt whether this may not be the young of a *Leperditia;* but it has no eye-spot and is too narrow, young *Leperditiæ* being proportionally broader than the adults.

Collector.—Sir W. E. Logan.

VIII. Cytheropsis siliqua, Jones.

(*Annals of Natural History*, 3d series, vol. i. p. 249, plate x. fig. 6.)

Length $\frac{1}{12}$, breadth $\frac{1}{40}$ inch.

Carapace-valves long, narrow, pod-like or skiff-shaped; ends acute, one much sharper and more tapering than the other; dorsal edge long and straight; ventral edge convex; one valve overlapping the other. Smooth, shining, brown.

Two separate valves of this curious and rather obscure form (so much resembling *Bairdia siliqua* of the Chalk, and the recent *B. Minna*) occurred in the limestone from Pauquette's Rapids.

IX. Cytheropsis rugosa, Jones.

(*Annals of Natural History*, 3d series, vol. i. p. 249, plate x. fig. 5.)

Length $\frac{1}{30}$, breadth $\frac{1}{46}$ inch.

Small, convex, subreniform, broad, rounded at both ends, the anterior one of which is smaller than the other. Coarsely sculptured with broad shallow pits. One specimen, showing the two valves united, and of a light-brown color, occurred with the many other Entomostraca in the small specimen of limestone from Pauquette's Rapids.

Locality and Formation.—Pauquette's Rapids.

Collector.—Sir W. E. Logan.

To give a general view of the distribution of the known species and varieties of Bivalved Entomostraca in the Lower Palæozoic strata of the United States, Canada, and Arctic America, the following Table is appended:—

TABLE OF THE PALÆOZOIC BIVALVED ENTOMOSTRACA OF NORTH AMERICA.A

Genera and Species.	Localities.	New York Groups.	British groups.
1. Beyrichi rugulifera, *Jones*	Beechey Island		Wenlock group.
2. —— sigillata, *Jones*	Beechey Island		Wenlock group.
3. —— clathrata, *Jones*	Beechey Island		Wenlock group.
4. —— plagosa, *Jones*	Beechey Island		Wenlock group.
5. Leperditia gibbera, *Jones*	Beechey Island		Wenlock group.
6. —— Arctica, *Jones*	Wellington Straits		Wenlock group.
7. —— marginata, *Keyserling*	Rupert's Land (and Petschora Land)	?	?
8. —— alta, *Conrad*	Schoharie (and Wellington Straits)	Coralline Limestone & Tentaculite Limestone (Lower Helderberg)	Wenlock group.
5*a*. —— gibbera, var. scalaris	Williamsville and Pennsylvania	Waterlime	Wenlock group.
9. Beyrichia Maccoyiana, *Jones*	Pennsylvania	Onondaga Salt-group	Wenlock group.
10. —— Pennsylvanica, *Jones*	Pennsylvania	Onondaga Salt-group	Wenlock group.
11. Leperditia Pennsylvanica, *Jones*	Pennsylvania	Onondaga Salt-group	Wenlock group.
12. Beyrichia lata, *Vanuxem*	Oneida County, &c.	Clinton group	Llandovery group.
13. Isochilina cylindrica (?) *Hall*	Medina, &c.	Medina Sandstone	Llandovery group.
20*a*. Leperditia Canadensis (var)	Anticosti	Hudson River group	Llandeilo and Caradoc groups.
14. Leperditia fabulites, *Conrad*	Wisconsin	Trenton Limestone	Llandeilo and Caradoc groups.
15. Cytheropsis concinna, *Jones*	Allumette Island, Ottawa	Trenton Limestone	Llandeilo and Caradoc groups.
16. —— siliqua, *Jones*	Allumette Island, Ottawa	Trenton Limestone	Llandeilo and Caradoc groups.
17. —— rugosa, *Jones*	Allumette Island, Ottawa	Trenton Limestone	Llandeilo and Caradoc groups.
20*a*. Leperditia Canadensis (var.)	Allumette Island, Ottawa	Trenton Limestone	Llandeilo and Caradoc groups.
20*a*. —— —— (var.)	St. Joseph's Island	Trenton Limestone	Llandeilo and Caradoc groups.
18. —— ovata, *Jones*	Pennsylvania	Blackriver Limestone	Llandeilo and Caradoc groups.
20*a*. —— Canadensis (var.)	Louck's Mills, Canada	Birdseye Limestone	Llandeilo and Caradoc groups.
19. Isochilina gracilis, *Jones*	Isle Jesus, Canada	Birdseye Limestone	Llandeilo and Caradoc groups.
20. Leperditia Canaden. (var. *nana*) *Jones*	Grand Isle, Grenville, & Hawkesbury	Chazy Limestone	Llandeilo and Caradoc groups.
21. Beyrichia Logani, *Jones*	Grenville and Hawkesbury	Chazy Limestone	Llandeilo and Caradoc groups.
22. Isochilina Ottawa, *Jones*	Grenville, Canada	Chazy Limestone	Llandeilo and Caradoc groups.
23. Leperditia amygdalina, *Jones*	L'Orignal, Grenville	Chazy Limestone	Llandeilo and Caradoc groups.
24. —— Anna, *Jones*	St. Ann, Canada	Calciferous Sandrock	Llandeilo and Caradoc groups.

Two other forms of Entomostraca, with which I am as yet unacquainted, are described by Prof. J. Hall; namely *Cytherina spinosa*, Pal. New York, vol. ii. p. 317, pl. 67, fig. 17–21, and *Beyrichia symmetrica*, *loc. cit.* f. 16, from the Niagara Shale, Lockport. Hall also mentions and figures another form (*op. cit.* vol. i. p. 44, pl. 10, f. 12) from the Birdseye Limestone and Trenton Limestone.

EXPLANATION OF FIGURES. Plate XI.

Fig. 1. *B. Logani* (var. *reniformis*); magnified 4 times: *a*, right valve; *b*, dorsal view; *c*, anterior view. From Hawkesbury.

Fig. 2. *B. Logani;* magnified 4 times: *a*, left valve; *b*, dorsal, and *c*, posterior view. From Hawkesbury.

Fig. 3. *B. Logani;* magnified 4 times: *a*, left valve; *b*, ventral, and *c*, posterior view. From Grenville.

Fig. 4. *B. Logani;* magnified 4 times: *a*, right valve; *b*, dorsal view. From Hawkesbury.

Fig. 5. *B. Logani* (var. *leperditoides*); magnified 4 times: *a*, right valve; *b*, anterior view. From Grenville.

Fig. 6. *Leperditia Canadensis* (var. *nana*); magnified 4 times: *a*, left valve; *b*, ventral, and *c*, posterior view. From Grenville.

Fig. 7. *L. Canadensis* (var. *nana*); magnified 4 times: *a*, right valve; *b*, ventral view. From Grenville.

Fig. 8. *L. Canadensis* (var. *labrosa*): magnified 4 times: *a*, left valve; *b*, ventral, and *c*, anterior view; *d*, portion of surface of *a*, very highly magnified (× 75).

Fig. 9. *L. Canadensis* (var. *nana*); magnified 4 times: *a*, left valve; *b*, dorsal, and *c*, anterior view. From Grande Isle.

Fig. 10. *L. Canadensis* (var. *nana*); dorsal view of the united valves (nearly closed); magnified 4 times. From Grande Isle.

Fig. 11. *L. Canadensis* (var. *Louckiana*); *a*, right valve, magnified 2 diameters; *b*, ventral view; *c*, anterior view; *d*, outline, magnified 4 times. From Louck's Mill.

Fig. 12. *L. Canadensis* (var. *Pauquettiana*): *a*, right valve, magnified 2 diameters; *b*, the ventral, and *c*, the anterior view, showing the inner flange of the ventral edge; *d*, outline, magnified 4 times. From Pauquette's Rapids, Allumette Island.

Fig. 13. *L. Anna;* magnified 4 times: *a*, right valve; *b*, ventral, and *c*, anterior view; *d*, portion of surface of *a*, highly magnified (× 25). From St. Anne's.

Fig. 14. *Isochilina Ottawa;* magnified 4 times: *a*, left valve; *b*, anterior, and *c*, ventral view. From Grenville Canal.

Fig. 15. *I. gracilis;* magnified 4 times: *a*, right valve; *b*, anterior view, and *c*, ventral; *d*, magnified portion of the marginal rim. From White Horse Rapids.

Fig. 16. *L. Canadensis* (var. *Josephiana*); natural size: *a*, right valve; *b*, ventral, and *c*, anterior view. From St. Joseph's Island.

Fig. 17. *L. Canadensis* (var. *Anticostiana*); natural size: *a*, left valve; *b*, ventral view. From Anticosti.

Fig. 18. *L. amygdalina;* natural size: *a*, right valve; *b*, ventral, and *c*, anterior view. From L'Orignal.

Fig. 19. *L. amygdalina;* natural size: *a*, left valve; *b*, ventral, and *c*, anterior view From L'Orignal.

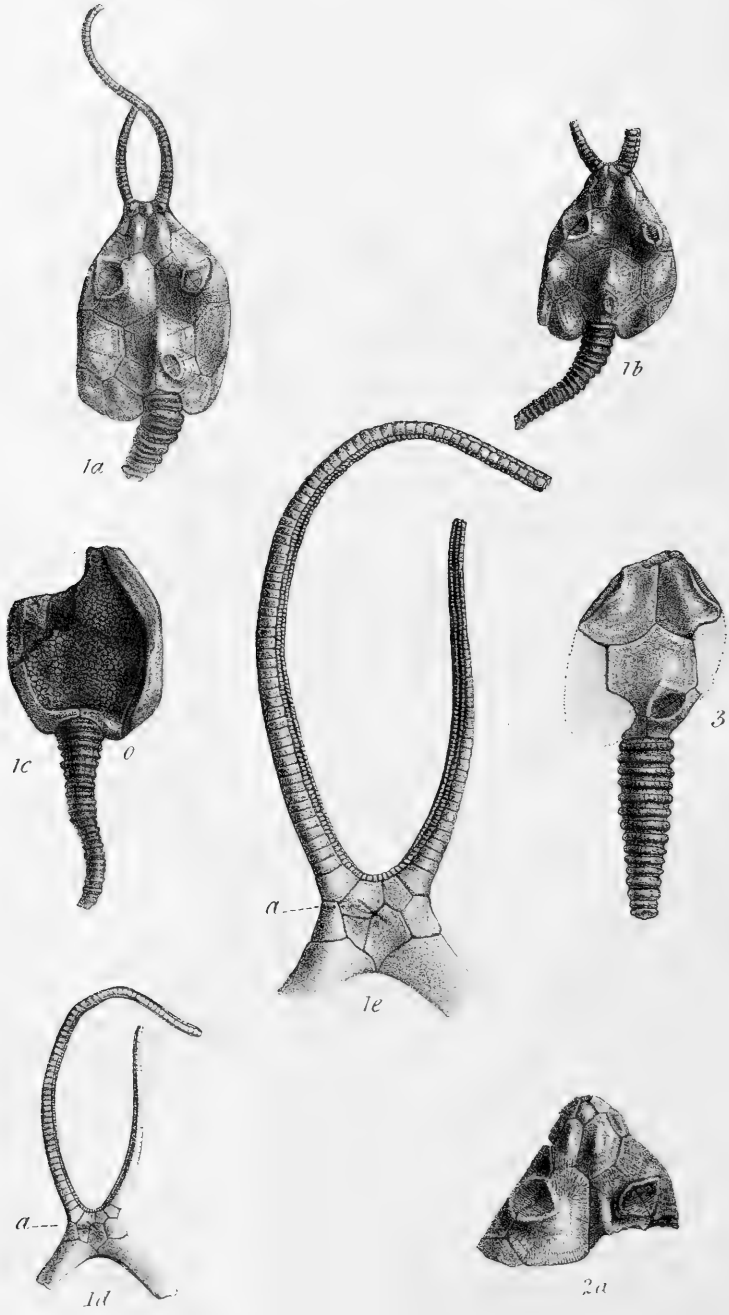

1a
1b
1c
o
a
1e
3
a
1d
2a

PLATE I.

PLEUROCYSTITES SQUAMOSUS (page 49).

Figures 1*a* and 1*b*. Dorsal views of two specimens.

" 1*c*. Ventral view of a specimen, shewing the plated integument and strong borders formed by the folding over of the dorsal plates; *o*, the mouth.

" 1*d*. Ventral view of the upper part of the cup and arms of a specimen of this species, the remainder of which is completely buried in the stone.

" 1*e*. View of the same, enlarged; at *a* is the small sub-apical aperture. It is represented too large in the figure.

PLEUROCYSTITES ROBUSTUS (page 49).

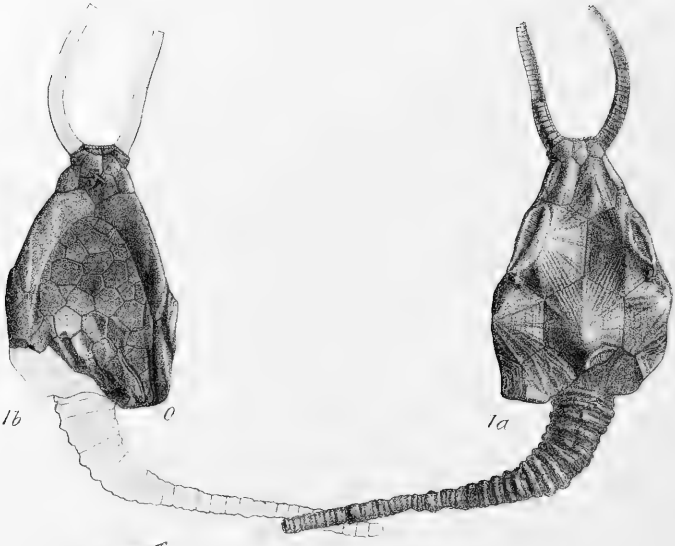
Figure 2*a* shews a fragment of the upper part of a specimen. From the position in which the artist viewed the specimen, the left rhomb in the figure appears too angular on the upper side.

PLEUROCYSTITES ANTICOSTIENSIS (page 52).

Figure 3. Dorsal view of an imperfect specimen of this species.

2a

2b



1b c 1a

2d

2c

PLATE II.

Pleurocystites filitextus (page 50).

Figure 1*a* is a specimen which has the column and a portion of the arms firmly attached to a piece of limestone. The greater part of the body however is loose, and can be removed in one piece, giving a view of the ventral side.

" 1*b* is the ventral side, shewing the large plates of the integument, and obscurely the small aperture near the apex. The specimen is somewhat distorted by pressure, so that the true form of the rhombs cannot be made out. *o*, the mouth.

Pleurocystites elegans (page 51).

Figures 2*a*, 2*b*, 2*c*, and 2*d*? are dorsal views of this species. It is doubtful whether 2*d* should be referred to this species or to the thickly striated varieties of *P. filitextus*. The crushed condition of this, and indeed of all the specimens, renders it most difficult to decide when the species are so closely allied.

a

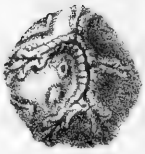
b

c

d

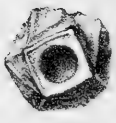
e

f



g

n



i

g

L

k

PLATE III.

GLYPTOCYSTITES MULTIPORUS (page 54).

Figure 1*a*. The plates of the calyx spread out; the dotted lines which extend from the top to the bottom indicate the course of the arms.

" 1*b*. Plates of the genus *Echino-encrinites*, figured here for comparison.

" *d*. Anterior view of a perfect specimen of *G. multiporus*.

" E. The left side of the same specimen.

" F. The dorsal or posterior side of another specimen.

" *c*. The right side.

" *g*. The apex, enlarged.

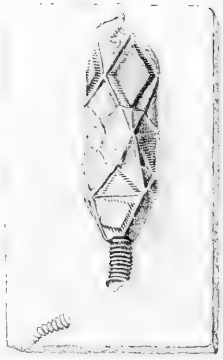
" *i*. The base.

" *n*. A specimen with the column attached; anterior view.

" L. One of the rhombs enlarged.

" *g* and *k*. Sections shewing the depth to which the partitions of the rhombs entered.


1c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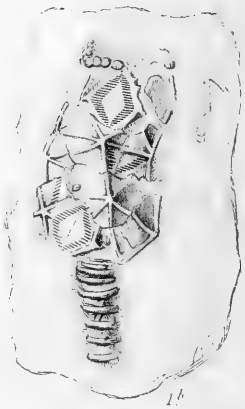

1b


1


1a


1g


1f


1e


1d


1h


2


3c


3a


3b


3e


3d


3g


3h


3f

PLATE IV.

GLYPTOCYSTITES LOGANI (page 57).

Figures 1*a* and 1*b* are dorsal views of two specimens.

" 1*c*, 1*d* and 1*e* are enlarged views of the interiors of three rhombiferous plates, shewing that the pores penetrate through, and that each on the inside is surrounded by an exceedingly thin elevated border.

" 1*f*. A portion of the ambulacral groove of the apex, and one of the pinnulæ enlarged.

" 1*g*. A fragment with two of the pinnulæ.

" 1*i* and 1*j*. Fragments of columns. The specimens are crushed, and do not clearly shew the spiral arrangement.

G. LOGANI, *var.* GRACILIS (page 59).

Figure 2. Dorsal side of the only specimen collected.

GLYPTOCYSTITES FORBESI (page 59).

Figures 3*a* and 3*b*. Two views of the base of a specimen.

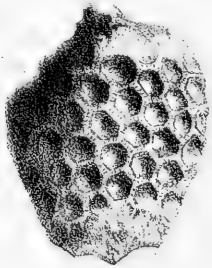
" 3*c* and 3*d*. Imperfect plates, to shew the character of the rhombs.

" 3*d* has the remains of four rhombs.

" 3*e* is the basal plate of the right side.

" 3*f* is the hexagonal basal plate of the anterior side.

" 3*g* and 3*h*, round columns, with the edges of the large joints pitted.



Horace S. Smith, del. et. lith.

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PLATE V.

COMAROCYSTITES PUNCTATUS (page 61).

Figure 1. Anterior view of a large specimen, with one arm and the pinnulæ attached. *o*, the mouth.

" 1*a*. A plate of the same, enlarged, to shew the peculiar striation.

" 1*b*. The valvular apparatus of the mouth, enlarged.

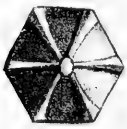
" 2. View of the left side of another specimen.

" 2*a*. A plate of same, enlarged.

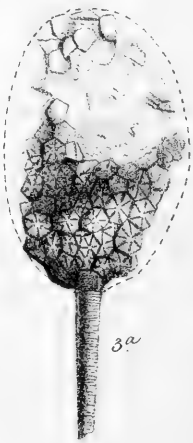
" 2*b*. Outline of the summit, shewing the positions of the bases of the arms, and the ambulacral groove between them.

Dr. E. Van Cortlandt of Ottawa, has kindly sent me from his cabinet two of the best specimens of *C. punctatus* that I have yet seen, both of which have the mouth furnished with six valves instead of five, and it thus appears that the number is variable as it is in the Crinoid *Caryocrinus ornatus* (Say). Where the plates are very perfect they are striated in the manner represented by fig. 2*a*, and the ridges between the plates are quite sharp and imperforate. It is probable, therefore, that in no case are the pores visible externally, unless where the surface is worn. This latter fact, first clearly exhibited by Dr. Van Cortlandt's specimens, shews that *Camarocystites* and *Palæocystites* are closely allied genera.

These specimens did not reach me until after the foregoing sheets had been printed, otherwise they would have been noticed in the body of the work.



1e



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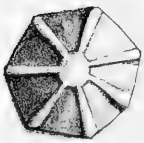
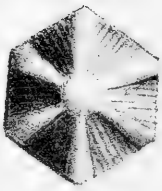


3b

2c

2e

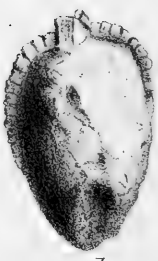
2f



2d

1a

2b



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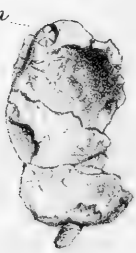
1c



2a

1d

Horace S. Smith, del. et. lith:

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PLATE VI.

AMYGDALOCYSTITES FLOREALIS (page 63).

Figure 1*a*. The left side of a specimen; *m*, the mouth.

" 1*b*. Right side of the same.

" 1*c*. Posterior view.

" 1*d*. Anterior views. The groove is not clearly shown in this specimen.

" 1*e*. One of the plates enlarged.

AMYGDALOCYSTITES TENUISTRIATUS (page 64).

Figures 2*a*, 2*b*. Right and left side of the Ottawa specimen; *m*, the mouth.

" 2*c*. Left side of a specimen from Belleville, shewing a portion of the arm.

" 2*e*. The arm enlarged, shewing the ambulacral groove.

" 2*f*. View of the top of the arm, shewing the articulating cavities of the pinnulæ, and the branches of the ambulacral grooves leading to them.

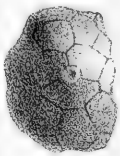
" 2*d*. A plate enlarged, shewing the striæ.

AMYGDALOCYSTITES RADIATUS (page 65).

Figure 3*a*. A specimen crushed flat, imbedded in stone.

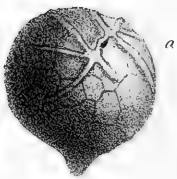
" 3*b*. One of the plates enlarged. The specimen is worn, and does not shew the granular surface of the spaces between the radiating ridges.

2 d

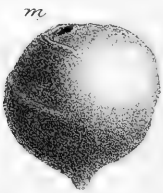


1 h

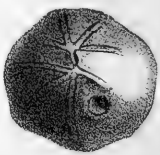
1 i



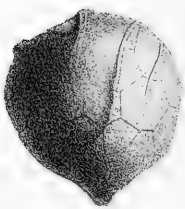
1 a



1 b

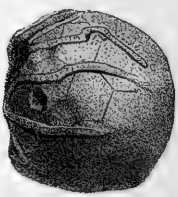


1 c



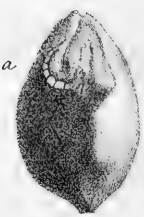
1 d

1 e

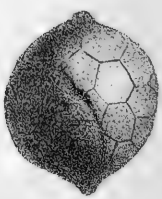


1 f

2 a



2 b



2 c

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PLATE VII.

MALOCYSTITES MURCHISONI (page 66).

Figure 1*a*. Right side of a specimen, shewing the ambulacral orifice and the eight arms.

" 1*b*. The left side, shewing the position of the mouth, *m*.

" 1*c*. Vertical view of the ambulacral orifice.

" 1*d*, 1*e*. Left sides of two other specimens.

" 1*f*. Apex of 1*e*.

" 1*h*. Base of 1*d*, shewing the three basal plates.

" 1*i*. Portion of an upper surface of an arm magnified.

MALOCYSTITES BARRANDI (page 67).

Figure 2*a*. View of the left side of a specimen; *a*, the arm.

" 2*b*. Posterior view of the same.

" 2*c*. Anterior view of another specimen.

" 2*d*. The arm of 2*a* magnified, shewing the short branches of the ambulacral furrow to the bases of the pinnulæ.

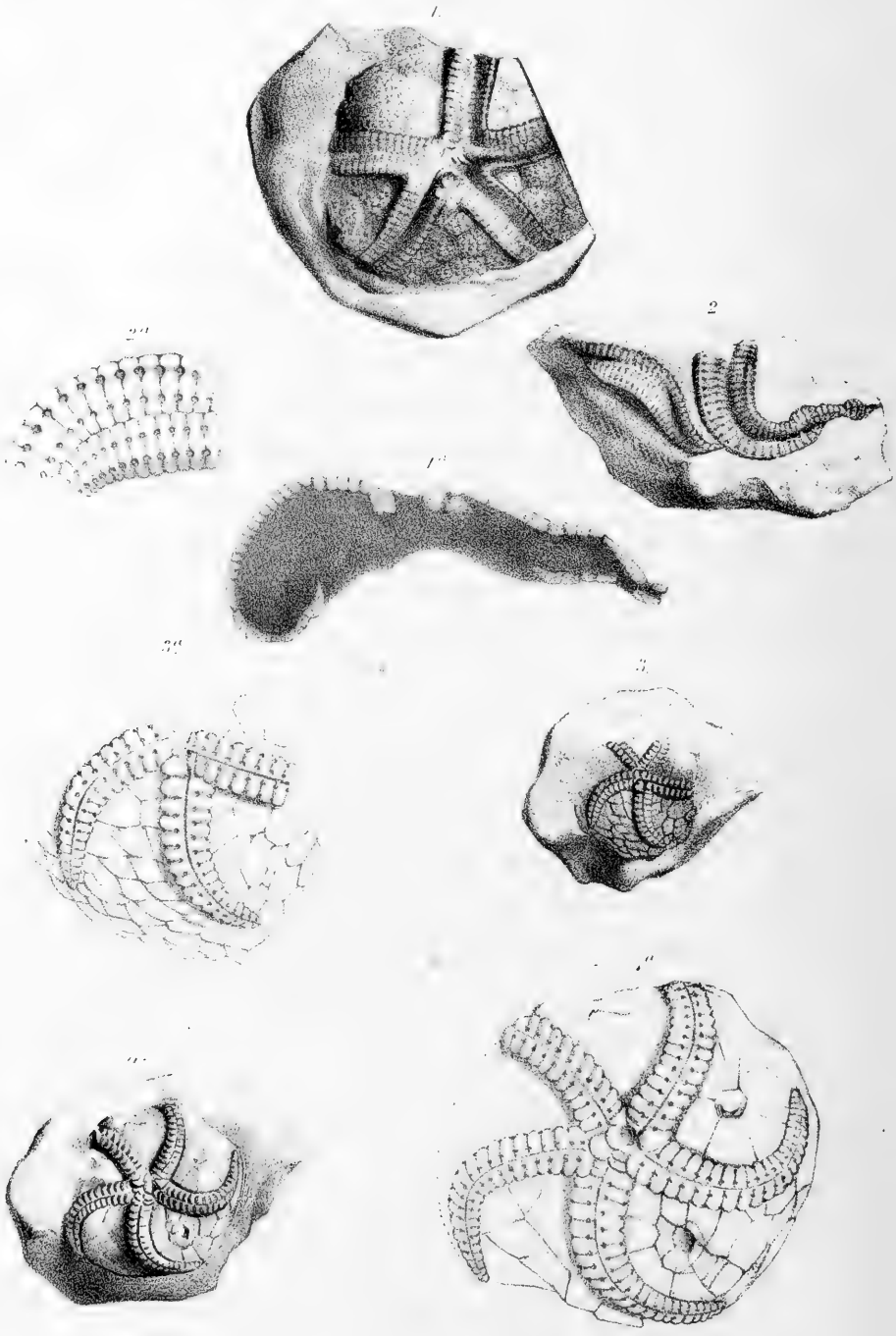

1.
2.
2a.
1a.
3a.
3.
4.
4a.

PLATE VIII.

EDRIOASTER BIGSBYI (page 82).

Figure 1. Upper side of a specimen partly embedded in stone.

" 1*a*. A polished section through the mouth and two of the grooves, showing that the pores penetrate through.

" 2. Fragment of a crushed specimen, showing two of the rays.

" 2*a*. A portion of figure 2 enlarged to show the pores.

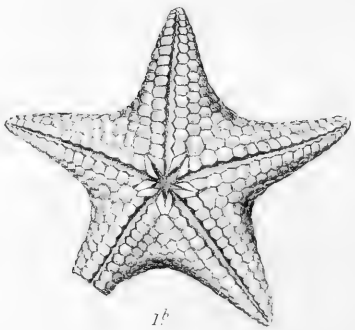
AGELACRINITES DICKSONI (page 84).

Figure 4. The original specimen discovered by Dr. Bigsby, now in the Museum of Practical Geology, Jermyn Street, London.

" 4*a*. The same enlarged.

" 3. View of a different specimen, in collection Geological Survey of Canada.

" 3*a*. The same enlarged.

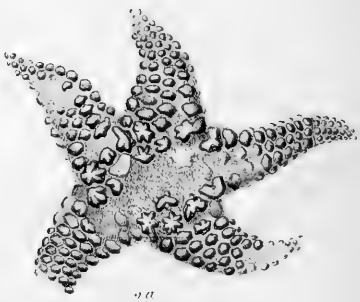


1b

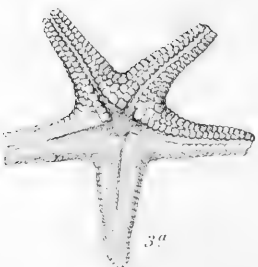
1a

2c

2b



2a



3a

3b

PLATE IX.

PALASTERINA STELLATA (page 76).

Figure 1*a*. The specimen natural size.

" 1*b*. The same enlarged.

PALASTERINA RUGOSA (page 77).

Figure 2*a*. Dorsal view of a specimen from the Hudson River group, Anticosti.

" 2*b*. Fragment of another individual.

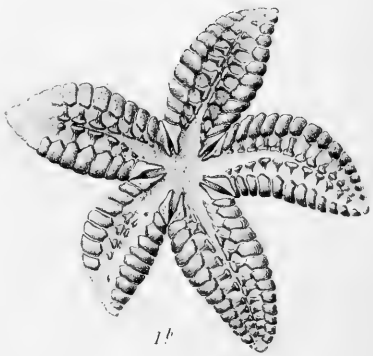
" 2*c*. One of the plates enlarged.

PETRASTER RIGIDUS (page 80).

Figure 3*a*. Ventral view of an imperfect specimen.

Fig. 3*a* appears to be the dorsal side of an individual of this species with the plates along the centre of the rays removed.

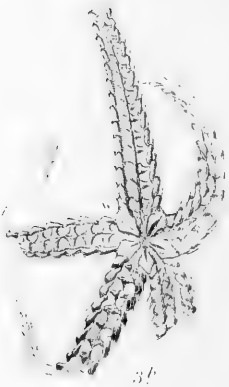
1a



1b

3a

3c

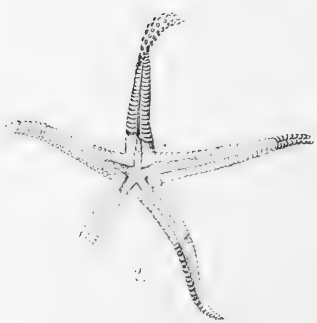


3b

4b

3d

4c



2

4a

PLATE X.

STENASTER SALTERI (page 78).

Figure 1*a*. Ventral view of a specimen collected at Belleville.
" 1*b*. The same enlarged.

STENASTER PULCHELLUS (page 79).

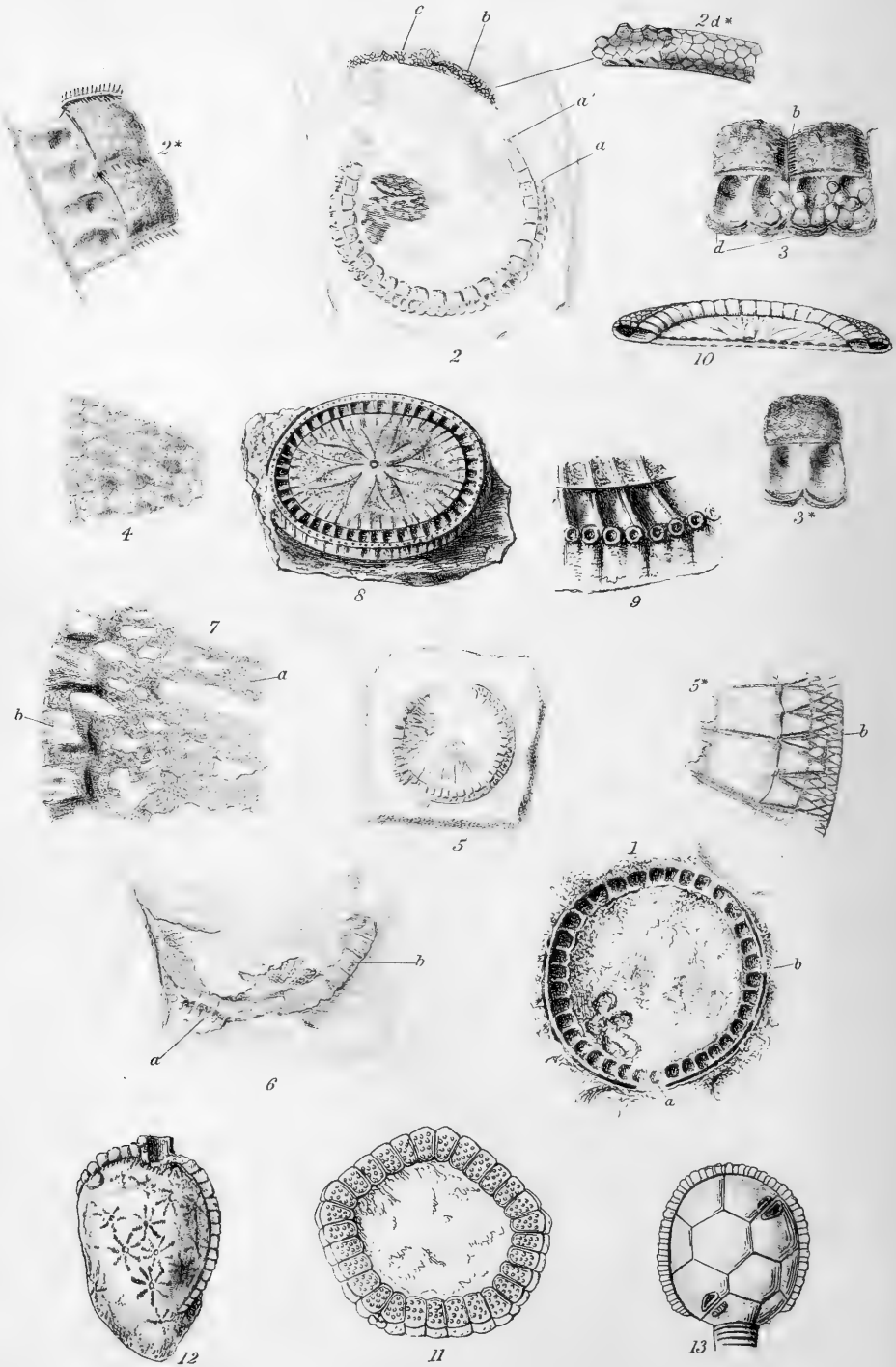
Figure 2. Ventral view of the only specimen collected.

TÆNIASTER SPINOSUS (page 81).

Figure 3*a*. Ventral view of a small specimen.
" 3*b*. The same enlarged.
" 3*c*. Another specimen, with the rays bent upwards.
" 3*d*. The same enlarged.

TÆNIASTER CYLINDRICUS (page 81).

Figure 4*a*. Dorsal view of a specimen.
" 4*b*. Ventral view of a different specimen.



J.De C. S. and J.W Salter del.

J.De C.Sowerby. sc.

PLATE X. (bis.)

CYCLOCYSTOIDES HALLI (page 86).

Figure 1. Impression of the marginal plates in a fragment of limestone.

" 2. A different specimen, shewing twenty-six of the marginal plates. *c* and *b*, the tube. 2*d**, tube enlarged. 2*, marginal plates enlarged.

" 3. Marginal plates enlarged.

" 4. A portion of the disc enlarged.

" 5. A small specimen nearly perfect. 5*, portion of margin enlarged.

" 6. Portion of a specimen partly destroyed by the application of acid.

" 7. Part of 6 enlarged.

CYCLOCYSTOIDES DAVISII (page 89).

Figure 8. Cast of a specimen with margin perfect.

" 9. Portion of margin magnified.

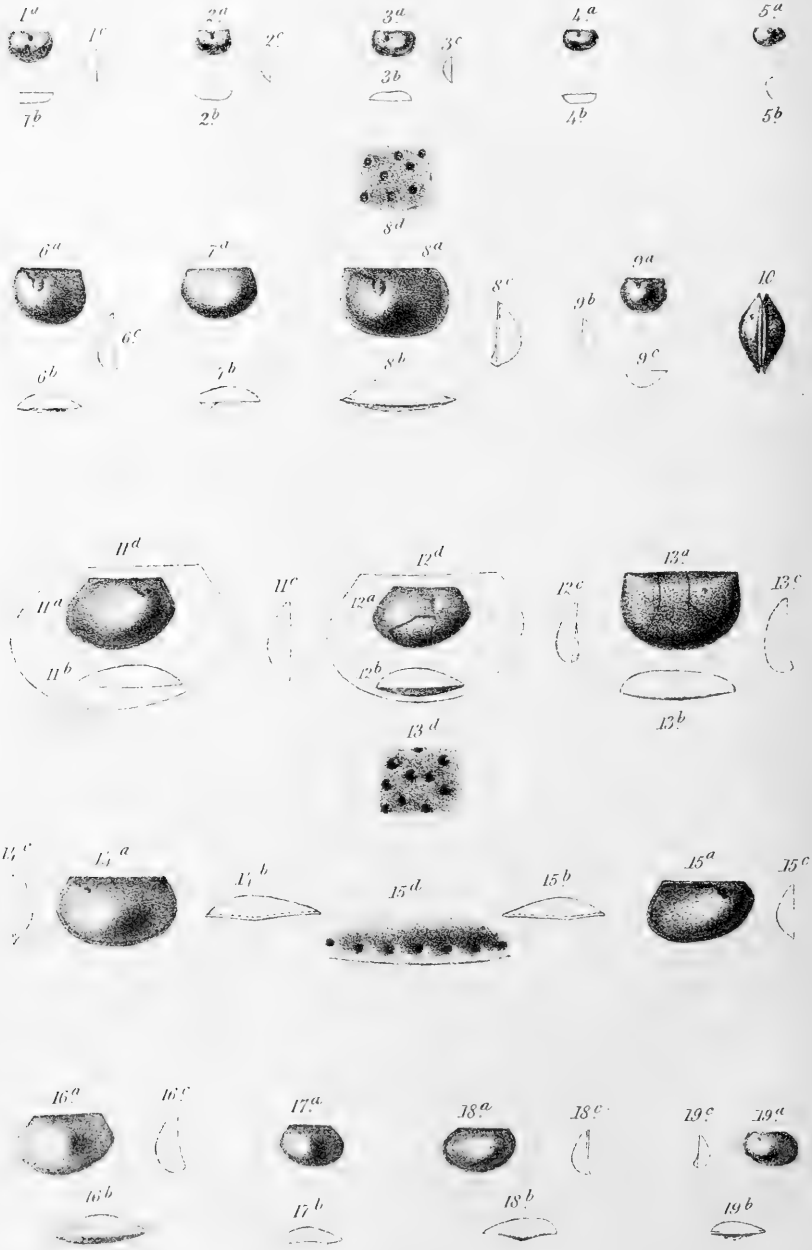
" 10. Ideal section of *Cyclocystoides*.

" 11. Pentagonal Star-fish.

" 12. *Amygdalocystites florealis*.

" 12. *Pseudocrinites magnificus*.

The three latter figures are given for comparison.


1a
1c
1b
2a
2c
2b
3a
3c
3b
4a
4b
5a
5b
8d
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6c
6b
7a
7b
8a
8c
8b
9a
9b
9c
10
11d
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11c
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13b
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14c
14a
14b
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16a
16c
16b
17a
17b
18a
18c
18b
19c
19a
19b

PLATE XI.

(Page 91—102.)

Fig. 1. *B. Logani* (var. *reniformis*) ; magnified 4 times : *a*, right valve ; *b*, dorsal view ; *c*, anterior view. From Hawkesbury.

Fig. 2. *B. Logani ;* magnified 4 times : *a*, left valve ; *b*, dorsal, and *c*, posterior view. From Hawkesbury.

Fig. 3. *B. Logani ;* magnified 4 times : *a*, left valve ; *b*, ventral, and *c*, posterior view. From Grenville.

Fig. 4. *B. Logani ;* magnified 4 times : *a*, right valve ; *b*, dorsal view. From Hawkesbury.

Fig. 5. *B. Logani* (var. *lepeditoides*) ; magnified 4 times : *a*, right valve ; *b*, anterior view. From Grenville.

Fig. 6. *Leperditia Canadensis* (var. *nana*) ; magnified 4 times : *a*, left valve ; *b*, ventral, and *c*, posterior view. From Grenville.

Fig. 7. *L. Canadensis* (var. *nana*) ; magnified 4 times : *a*, right valve ; *b*, ventral view. From Grenville.

Fig. 8. *L. Canadensis* (var. *labrosa*) ; magnified 4 times : *a*, left valve ; *b*, ventral, and *c*, anterior view ; *d*, portion of surface of *a*, very highly magnified (× 75).

Fig. 9. *L. Canadensis* (var. *nana*) ; magnified 4 times : *a*, left valve ; *b*, dorsal, and *c*, anterior view. From Grande Isle.

Fig. 10. *L. Canadensis* (var. *nana*) ; dorsal view of the united valves (nearly closed) ; magnified 4 times. From Grande Isle.

Fig. 11. *L. Canadensis* (var. *Louckiana*) ; *a*, right valve, magnified two diameters ; *b*, ventral view ; *c*, anterior view ; *d*, outline, magnified 4 times. From Louck's Mill.

Fig. 12. *L. Canadensis* (var. *Pauquettiana*) ; *a*, right valve, magnified 2 diameters ; *b*, the ventral, and *c*, the anterior view, showing the inner flange of the ventral edge ; *d*, outline, magnified 4 times. From Pauquette's Rapids, Allumette Island.

Fig. 13. *L. Anna ;* magnified 4 times : *a*, right value ; *b*, ventral, and *c*, anterior view ; *d*, portion of surface of *a*, highly magnified (× 25). From St. Anne's.

Fig. 14. *Isochilina Ottawa ;* magnified 4 times : *a*, left valve ; *b*, anterior, and *c*, ventral view. From Grenville Canal.

Fig. 15. *I. gracilis ;* magnified 4 times . *a*, right valve ; *b*, anterior view, and *c*, ventral, *d*, magnified portion of the marginal rim. From White Horse Rapids.

Fig. 16. *L. Canadensis* (var. *Josephiana*) ; natural size : *a*, right valve ; *b*, ventral, and *c*, anterior view. From St. Joseph's Island.

Fig. 17. *L. Canadensis* (var. *Anticostiana*) ; natural size : *a*, left valve ; *b*, ventral view. From Anticosti.

Fig. 18. *L. amygdalina ;* natural size : *a*, right valve ; *b*, ventral, and *c*, anterior view. From L'Orignal.

Fig. 19. *L. amygdalina ;* natural size : *a*, left valve ; *b*, ventral, and *c*, anterior view. From L'Orignal.