That the caves of the Vale of Clwyd were inhabited by hyænas and other animals at a period, when man existed in the Vale of Clwyd, before the deposition of the middle and upper glacial deposits, but whether before the oldest glacial deposits, there is no evidence to show.

That the Vale of Clwyd like the valleys of the Ribble and the Mersey was deeper before the deposition of the glacial deposits than at the present time. That the valleys and plains of Lancashire, Cheshire, and the coast of North Wales were filled up with various Drift deposits.

That the existing valleys of Lancashire, Cheshire, and the coast of North Wales, have been excavated by the action of running water since the deposition of the Upper Boulder Clay.

That the great peat beds fringing the coasts of these districts are later than the period of denudation of those valleys in the Glacial Drifts.

That the period of the Roman occupation of Britain was later than the growth of the peat.

NOTES ON THE CLASSIFICATION OF THE PALÆOZOIC POLYZOA.

BY GEORGE ROBERT VINE.

The classification of Palæozoic Polyzoa, whether as Cyclostomata, Busk, Cryptostomata, Vine, or Trepotomata, Ulrich, is still incomplete. This arises from two causes, it may be from more causes still, but I wish to confine my remarks specially to two points only :—

- I. The want of a suitably definite nomenclature, descriptive of the structural elements of the Zoarium, Recent and Fossil ; and
- II. The want of ready agreement on the part of Palæontologists, as to what should, and what should not be admitted as Polyzoa, or Bryozoa.

Within the last few years the Palæozoic Bryozoa have been critically studied, both by means of the mass, and by sections of the species described, and at the present time we are in a better position to judge of the possibilities of future research, than we were at the beginning of the decade that is now drawing to a close. Since the

commencement of my British Association Reports on Fossil Polyzoa in 1880, new investigators have entered the field, and if the good old proverb is true, 'many minds, many modes,' the results will be that the varied methods now adopted by Palæontologists, will ultimately enable us to look at the Palæozoic Polyzoa from different standpoints, so as to have an allround view of the same, rather than from one standpoint only. In my recently published paper, "Notes on Classifications of Cyclostomatous Polyzoa, old and new,"* I have done my best to gather together into one focus, much, if not all that has been suggested respecting the classification of the Mesozoic Polyzoa, and in the present paper I wish to do the same for the Polyzoa of the Palæozoic horizons. In the present case it will be wiser to deal with the suggested subdivisions separately, and in order of time.

In his valuable introduction to "American Palæozoic Bryozoa,"† Mr. E. O. Ulrich has given very elaborate details respecting the general structure of the Monticuliporidæ, and of "a great number of undoubted Bryozoa belonging to the sub-order Cyclostomata," which should be studied carefully by future investigators. Mr. Ulrich includes in his Bryozoa group, as do American authors generally, the whole of the Monticuliporidæ. These, however, are placed amongst the corals by English authors, such as Duncan and Nicholson. In the not-far-off future some species at least of the Monticuliporidæ will have to be retained as Bryozoa, in spite of the now general disposition to place them elsewhere, or we shall have to modify, considerably, our ideas respecting many of the Polyzoa of Mesozoic and Tertiary horizons. In the present paper I have excepted the Monticulipora until our British Silurian examples have been more carefully studied.

I.—CYCLOSTOMATA BUSK. 1857, Published in 1859.

"Cell tubular: orifice terminal, of same diameter as the cell, without any moveable apparatus for its closure, consistence calcareous." Monograph of the Crag Polyzoa.

There is not, so far as I am aware, any insuperable difficulty of

* Proc. Yorks. Geol. & Polyt. Society, Part III, Vol. IX, 1888.

† Jour. Cinc. Soc. Nat. Hist., Vol. V., pp. 121-149.

including the whole of the recent, semi-recent, and Mesozoic Polyzoa, under a description so well worded as the above. Most of the species that have come under my own observation may be definitely described as Cyclostomatous. The cells are tubular, the orifices in most cases are terminal, and though not all of the same diameter as the cell, the orifices are certainly without any "moveable" apparatus, still there were cell "closures" in Cyclostomatous, as well as in Cheilostomatous Polyzoa. It is not altogether then the preciseness in the above definition that causes any difficulty to the Palæontologist, whenever his investigations carry him beyond the Mesozoic horizons. For accurate descriptions of species here, however, the diagnosis is either too incomplete or too obscure, and this is felt to be the case by every naturalist who has taken the Palæozoic Polyzoa in hand.

I have already referred to the labours of Mr. Waters on the semi-fossil, and fossil Cyclostomata,* but it will be necessary to refer to them again for the purpose of formulating a satisfactory nomenclature for speculative as well as for working students.

The Cyclostomatons "*Cell*" (Busk) "*Zoecium*" (Hincks) "is the chamber in which the polypide is," or was lodged. It is wholly calcareous, and its structural elements are few and characteristic. If we take the "cells" of two species, *Crisia* and *Hornera*, and analyse them, we shall find material for formulating a definite working nomenclature, suitable for Palæontological investigations; then, if some few of the Palæozoic species are submitted to the test, it will soon be found whether the ancient cell corresponds with the characteristic recent cell in all, or in any, of its elements. If not, then the question naturally arises as to whether it is wise to confine ourselves to one division for the Polyzoal group of organisms, or whether it will be necessary to establish other divisions in which many of the Palæozoic species can be satisfactorily placed.

In the cell of *Crisia*, (*cornuta*, *eburnea*, or *denticulata*) there are certain "punctures" evenly or sparsely distributed, which do not appear to have been separately studied either by Mr. Busk, or Mr. Hincks, but the punctures are partly referred to as characteristic of

* Proc. Yorks. Geol. and Polyt. Soc., pt. iii., vol. 9, 1888.

species both by Busk, and Hincks. In *Crisia eburnea* these "punctures" are thinly distributed, having a circular mouth, and on the sides of the cell we get a longitudinal aspect of the same, seen, however, to much better advantage whenever the walls of the cell are broken. The "punctures" penetrate the substance of the cell wall from the surface, opening, apparently on the inner side of the tube. In the more highly calcareous cells of *Hornera foliacea* similar punctures to those of *Crisia* may be observed, only they are larger, and even under a lower objective the punctured tubes show a longer section on account of the thickness of the cell-wall. In the dissepiments which connect the branches of the *Zoarium* the openings of punctures are larger, but many of these appear to be of a different character to those of the smaller openings in the cell walls.

Mr. A. W. Waters' in his admirable paper on "Fossil Cyclostomatous Bryozoa from Australia,"* refers to the punctured surfaces of the Cyclostomata, and he suggests a possible homology between some of the lateral interzoecial tubes and the rosette plates of the Chilostomata. Mr. Waters refers also to the almost general constancy of the size of these punctures in preparations he had made of Tertiary Cretaceous, and even Palæozoic species, "The structure is well shown, he says, in sections, figured by J. Beissel, especially in pl. x., fig. 127 in his paper, Ueber die Bry. der Aachener Kreide.† . . . These, I take it (the surface punctures) are the homologues of the much larger pores in the front of nearly all Chilostomata, which there also cause the Zoecial ornamentation," p. 677, op. cit. I have already referred to the interzoecial pores in the walls of the cell when sectioned, but Mr. Waters affords an illustrated instance, (pl. xxxi., fig. 24, op. cit.) in *Heteropora pelliculata*, Waters, in which a diaphragm, or plate, seemingly perforated in the centre, occurs in the middle of the pore-tube, and thus it seems entirely to correspond to the simplest of the rosette plates among the Chilostomata," p. 677, op. cit. Mr. Waters also refers to the "surface pores" in other genera, such as *Entalophora*, &c. . . "but in some genera, such as *Hornera*, some *Idmoneæ* . . . both living and

* Quart. Jour. Geo. Soc., Vol. 40 (1884), pp. 674-697.

† Nat. Verh. Holl. Maat. Weten. Haarlem, xxii., (e) Deel.

fossil there are, over part of the surface at any rate, and sometimes over all, larger openings giving a peculiar ornamentation to the surface ; these larger surface openings do not, however, enter directly as such into the Zoœcial tube, but at the base there are one or more minute openings leading to the Zoœcial cavity," p. 678, pl. xxx., fig. 8., op. cit. In *Idmonea radians*, Mr. Waters says, "these large exterior openings occur at the junction of the Zoœcia," and Mr. S. O. Ridley in his paper on the Zoological collections made during the survey of H.M. Ship Alert,* refers to *Idmonea milneana* D., Orb., in which the "dots" (Busk, *Cyclostomata*, 1875, p. 12) of Busk's description are certainly *raised*." It is not improbable, then, that these "dots" or "punctures" may have a morphological meaning, not as yet thoroughly understood, but their study has yielded, to me at least, results that will be utilised further on, and we shall meet with another character in species of the *Heteropora*, that was partially referred to by Busk in the Crag Polyzoa.

In his paper on "The Closure of the Cyclostomatous Bryozoa,"† Mr. Waters has furnished us with details of another structure, also available to the Palæontologist, especially so when dealing with Palæozoic species, and allied to, and possibly correlative with this structure are the so-called "teeth" in carboniferous *Fenestella*,‡ but perhaps not analogous with the "hair-like teeth which occur in several species of *Lichenopora*, which have globular terminations." (Bry. Bay of Naples, p. 276).

We are indebted to Mr. E. O. Ulrich for many hints while comparing the various species subjected to his scrutiny, that will be valuable to the student ; but it seems remarkable that some of these, drawn from the previous researches of D'Orbigny have been so frequently overlooked, or perhaps misinterpreted. The study of minute structures however in other groups are yielding ample results to the investigator, and I see no reason why the same comparative

* Proc. Zool. Soc., London, Jan. 4, 1881, pp. 44-61. See also Tet. Cyclos., New Zealand Quart. Jour. Geol. Soc., Aug., 1887.

† Linn. Soc. Jour. Zoology, Vol. XVII, p. 884, pp. 400-404, Pl. XVI.

‡ Remarks on some *Fenestellidæ*, A. W. Waters, Transac. Geol. Soc., Manchester, 1878.

study of the minute parts of the cell should not yield similar advantages to the student of ancient organic forms.

It is very certain then that some of the Palæozoic Polyzoa at least may be safely placed, according to the structural elements under the division Cyclostomata, but there are others which could not with any degree of satisfaction to the Systematist be so placed, and for the inclusion of these, two independent divisions have been established by myself and Mr. E. O. Ulrich, of America, which will now be separately considered.

Sub-Order. CRYPTOSTOMATA VINE. 1880-1.

Zoöecia sub-tubular, in section slightly angular. Orifice surrounded by a vestibule, or otherwise concealed.

As there has been a little misunderstanding about my labours when trying to classify Palæozoic Polyzoa, it may be as well to give a personal explanation of my own special work, or so much of it as will include the above sub-division. In my second report on Fossil Polyzoa, "British Association 1881," I reviewed all that was known in Great Britain about Palæozoic Polyzoa, and in that report special details will be found showing the position I occupied with respect to the then known British species. A few years previous to this Prof. H. A. Nicholson wrote several articles on American Devonian, and Silurian species,* and about the same time Mr. Robert Etheredge, jun.,† and the Messrs. Young, of Glasgow University,‡ published papers on carboniferous species. My knowledge of these Palæozoic forms was drawn from Murchison's *Siluria* (Lonsdale) Phillips' *Geology of Yorkshire*, and M'Coy's publications, together with the new work of these later writers. In compiling my British Association Report, I went over all the type specimens of the Palæozoic species in the School of Mines. At that time no one in England had wholly committed themselves to a new classification. Many authors followed either Morris's arrangement in his catalogue of British Fossils, or formulised suggestive divisions *en passant*. My earliest labours, for which Dr. Duncan and others blamed me, were directed towards modernising the classification so as to be more in

* *Geological Magazine*, 1874. † *Explanation of Sheet 23, Scotch Geol. Survey*.

‡ *Quart. Jour. Geol. Soc.*, 1874, and *Ann. Mag. Nat. Hist.*, 1874.

accordance with Hincks and Smitt. These authors suggested that all future grouping of the Polyzoa should be based on the character of the "cell," or *Zoecium*, rather than upon the mode of growth of the "colony" or *Zoarium*. In his work on British Marine Polyzoa Mr. Hincks says, "there is evidence ('I quote my own words from Brit. Assoc. Report, p. 2 of Report), however, (as I learn on the excellent authority of Mr. R. Etheredge, jun.), of the existence of a few Chilostomatous genera at least, within this epoch (Palæozoic), and probably the group is represented in the Silurian division of it,' a conclusion, which after the most careful research, I am unable to agree with."* In dealing with the Palæozoic genera, however, I was obliged to accept the dictum of other authors, hence I took Lonsdale's, Nicholson's and Messrs. Young's estimate as to what external characters were found in *Fenestella*, *Ptilodictya* and *Glauconome*, and worked accordingly, but none of the remarks which I offered in the reports were wholly founded upon the labours of others. Types of the various genera were sectioned, but not, perhaps, fully understood in all their details of structure. I was not at that time, 1879 and 1880, aware of the rich harvest of Palæozoic forms which was then being catalogued, and which have since been described by Mr. E. O. Ulrich, of Cincinnati. Had I been aware of these I should have been more careful before committing myself to a peculiarly British, rather than a general classification. I hope, therefore, future students of Palæozoic Polyzoa will bear these remarks in mind while reading over the observations I offer on my own and Mr. Ulrich's labours.

In the year 1881 Mr. G. W. Shrubsole, of Chester, began the compilation of his paper on *Glauconome*, and as he had had some communications with Mr. R. Etheredge, jun., besides myself, respecting Palæozoic forms, Carboniferous and Silurian, I suggested to him the necessity of a new arrangement of the so-called Cyclostomatous forms. Mr. Shrubsole's idea was to suppress the upper Silurian name

* In the report, details will be found of all the supposed species whose affinities were somewhat doubtful. Since this was written I have been compelled to modify this opinion, and in all probability examples both of Chilostomatous and Ctenostomatous Polyzoa existed in Palæozoic strata.

Glaucanome Goldfuss, and retain the term for Carboniferous, as well as Cambrian, or Bala species. He adopted this, and I also favoured the suggestion, hence the paper presently to be referred to, came to grief before it was printed in the Journal of the Geological Society. For years Mr. Shrubsole and myself had been working amicably together, and I suggested that if he made the paper a joint one I would allow him to do the descriptive part, and I would furnish him with details of a new sub-order for publication. Accordingly, on June 21, 1882, a paper entitled "The Silurian Species of *Glaucanome*, and a suggested classification of the Palæozoic Polyzoa," was read. The paper, as written, was never published, and an abridged report only was inserted, two years after, in the Journal of the Geological Society, 1884. There was, however, an abstract publication of the original paper inserted in the "Abstracts of the Proceedings of the Geological Society of London," No. 424, sessions 1881-82, p. 109 (June).^{*} From the pages of the above work I now quote. "The authors discussed the history of our knowledge of the genus *Glaucanome*, and especially of the Silurian species. They then characterised the genus, to which they refer only the Bala species, formerly regarded as identical with *G. disticha*, Goldf., but which they describe as *G. Sedgwickii* Shrub. *Glaucanome disticha*, Goldf., from the Wenlock of Dudley, is taken as the type of a new genus *Arcanopora*.

The authors then remarked upon the characters on which the classification of the Polyzoa is founded, drawn from the study of recent forms, and stated that throughout the Cainozoic and Mesozoic series no Polyzoa are known which cannot be referred to these recognised groups. Many Palæozoic forms are in a different case. The orifices seen on the surface are not, in many instances, the mouths of the cells, but those of what the authors call *vestibules* beneath which the true cell mouth is concealed. For these types they propose to found a new sub-order under the name of Cryptostomata, and characterised by having the Zoæcia sub-tubular, or in section, slightly angular, and the orifice surrounded by a vestibule or otherwise con-

^{*} See Note on *Glaucanome disticha*, from the Bala beds, &c., by G. W. Shrubsole; also in the Geol. Magazine, August, 1882, pp. 381-382.

cealed. The families referred to this group are the Ceramoporidæ, Philodictyidæ, and Arcanoporidæ.”*

In my Fourth British Association Report on Fossil Polyzoa, 1883, I did my best to classify the whole of the then known Fossil species up to the chalk. All my ideas were based on the “Cell” and its arrangement in the branch, and, with the exception of the following which I now consider as erroneous, such as placing *Ceripora interporosa*, *C. similis*, Phillips, and *Hyphasmapora Buskii*, Eth. under the Genus *Heteropora*, I do not think the classification has been as yet superceded so far as British species are concerned.

In the sub-division *Cryptostomata*, and under the Family name *Arcanoporidæ* Vine, “*Zoarium* multiform, *Zoœcia* tubular or semitubular, orifice of cell obscured by vestibule, true orifice of cell unknown,” I placed the following genera :—

Genus *Ptilodictya*, Lonsdale. Type *P. Lonsdalei*, Vine.

„ *Arcanopora*, Vine. „ *Flustra? parallela*, Ph.

„ *Glaucanome*, Goldf. „ *G. disticha*, Goldf.

[NOTE.—My chief reason for shifting the type of *Arcanopora* from *Glaucanome disticha* to *Flustra? parallela* was on account of the similarity of the “hidden cells,” irrespective altogether of the character of the interspaces between the cells. The Geological Society objected to the destruction of *G. disticha* as indicated in the abstract already given, consequently this species remains the only British type of *Glaucanome*.]

In October, 1882, four months after the abstract of our papers was published, nearly ten months after it was written, the first of Mr. Ulrich's Papers on American Palæozoic Bryozoa appeared. This and subsequent papers were published in the Journal of the Cincin. Soc. of Nat. History. From the first I hailed the publication with pleasure, but although I have differed from Mr. Ulrich in his estimate as to what are and what are not Bryozoa or Polyzoa, no offence on my part was contemplated. In his first paper, p. 151,†

* Proc. Chester Soc. Nat. Sc., Ph. iii., 1883; and Silurian species of *Glaucanome*, &c., by G. W. S. and G. R. Vine. Abridged, Quart. Jour. Geol. Soc., 1884, pp. 329-332.

† Jour. Cin. Soc. Nat. His., Vol. V.

Mr. Ulrich established a new sub-order which he named and described as follows :—

SUB-ORDER TREPOSTOMATA, ULRICH.

“This sub-order is proposed for the reception of the majority of the Palæozoic, and many of the more recent Bryozoa. The principal distinguishing features of the sub-order are :—(1.) That the Zoarium is composed of slender fasciculate tubes, which do not (as is the case in the *Cyclotomata*,) gradually enlarge as they approach the surface, but remain throughout nearly of the same diameter ; and (2.) That at a certain point in the course of the tubes to the surface, they bend outward, more or less abruptly, and change in character.” Five families in particular Mr. Ulrich places in this sub-division. They are :—

1. Family Ptilodictyonidæ, Zittel emend, Ulrich.
2. „ Stictoporidae, Ulrich.
3. „ Monticuliporidae, Nicholson.
4. „ Fistuliporidae, Ulrich.
5. „ Ceramoporidae, Ulrich.

In the first family is placed the Genus *Ptilodictya*, Lonsdale, and in the second the Genus *Cystodictya*, Ulrich, but both are differently characterized in the descriptions. In the *Ptilodictya* the external features are diagnosed, but in *Cystodictya* the external and internal features are characterized. “Sections show that the inter-tubular spaces are occupied by a vesicular tissue.”* It is very evident therefore, that Mr. Ulrich accepted for his generic divisions very different characters from myself, he the structure of the *Zoarium*, I the character of the Cell only, and there could be no offence in placing my name *Arcanopora*, as a synonym of *Cystodictya*,† Ulrich, if the priority had been Mr. Ulrich’s instead of my own. My placement, then, of two different Genera, *Flustra ? parallela*, Phillips, in close companionship with *Ptilodictya* is not the result of ignorance, but rather on account of the partially hidden cell, and so on with *Glaucanome disticha*, Goldfuss. If, therefore, we are to depend upon the structure of the interspaces, all of which were well known to me

* Ulrich, op. cit., p.152.

† Jour. Cincin. Soc. Nat. Hist., April, 1884.

long before I wrote, for our generic divisions then Mr. Ulrich is right and I am wrong ; but if the cell or *Zoecia* is to form the basis of our suggested divisions, then our work must be left to the convenience or the inclinations of future workers.

Since my labours commenced, the so-called *Ceramopora megastoma*, M'Coy,* has been removed from the Polyzoan group to the Cœlenterata, and in all probability *Ceripora interporosa*, Phillips, will have to submit to the same fate. What other species will have to be removed I can partially anticipate, but the removal of these at least is justifiable on account of their peculiar structural elements.† Mr. Ulrich however, still regards these as well as the Monticuliporidæ generally, as belonging to the Bryozoan group.

We have, then, three sub-divisions, under which the Palæozoic Polyzoa may be placed, but whether it will be wise to retain the whole, remains for future workers to decide. My belief is that all may be safely retained, but so far as the grouping of the Palæozoic Polyzoa is concerned, a little more latitude must be observed, because we deal with more primitive structures than in the grouping of Mesozoic, Tertiary, or Recent species.

I have already, in my Fourth British Association Report on Fossil Polyzoa (1883), given the history of the general grouping of Fossil species, ranging from the Silurian to the Upper Cretaceous Rocks ; and, as already referred to, I have recently reviewed in this Journal the Cyclostomata of the Jurassic Rocks, I shall now show the tendency of modern systematic classification as regards Palæozoic species.

In his "Scheme of classification of the American Palæozoic Bryozoa,"‡ Mr. E. O. Ulrich arranges the Cyclostomatous group as follows :—

SUB ORDER CYCLOSTOMATA, BUSK.

I. FAMILY TUBULIPORIDÆ, BUSK.

Genus Stomatopora—Bronn : ranging from the Trenton.

,, Proboscina, Audouin.

* Review of the Diastoporidæ, Quart. Jour. Geol. Soc., 1880.

† See a Paper by Nicholson & Foord, Ann. Mag. Nat. Hist., Ser. V., Vol. XVI, 1885.

‡ Journ. Cincin. Soc. Nat. History, Vol. v., 1882, p. 149.

Genus *Berenicea*, Lam.

„ *Rhopalonaria*, Ulrich.

II. FAMILY THEONOIDÆ, BUSK.

„ *Scenellopora*, Ulrich.

III. FAMILY ENTALOPHORIDÆ, REUSS.

„ *Mitoclema*, Ulrich.

IV. FAMILY FENESTELLIDÆ, KING.

„ *Fenestella*, Lonsdale.

„ *Polypora*, M'Coy.

„ *Septopora*, Prout.

„ *Fenestralia*, Prout.

„ *Phyllopora*, King.

„ *Archimedis*, Lesueur.

„ *Lyropora*, Hall.*

V. FAMILY ACANTHOCLADIDÆ, ZITTEL.

„ *Penniretepora*, D'Orb. = ? *Glauconome*, Lonsdale.

VI. FAMILY ARTHROMENIDÆ, ULRICH.

„ *Arthronema*, Ulrich.

„ *Arthroclema*, Billings.

In a later publication† Mr. Ulrich remarks, “More extended investigations of the large group of Palæozoic Bryozoa . . . have shown me that the classification (as given above) is in some respects faulty, and yet more incomplete.” In two groups Fenestellidæ, King, and Acanthocladidæ, Zittel, Mr. Ulrich places no fewer than twenty genera, and he states that the same synopsis will be adopted in his work on the Bryozoa of the State of Illinois (Geol. Surv. of Ill., Vol. viii., not yet published, Aug. 1888). A few remarks on some of the genera retained by Mr. Ulrich may be of use to students of British Palæozoic Polyzoa, for it is useless to pretend that any of our rocks will ever yield such a wealth of forms, generic or specific, as the American Palæozoic Rocks have already yielded.

In our own Palæozoic Rocks we have abundant evidence of the presence of the following genera :—

* Possibly three other Genera *Carinopora*, *Cryptopora*, Nich. and *Ptelopora*, M'Coy.

† Contributions to American Palæontology, Vol. i., May, 1886.

<i>Stomatopora</i> ,—	several species, but Upper Silurian only.
<i>Berenicea</i> ?	Probably in Silurian rocks.
<i>Rhopalonaria</i> ,	Upper Silurian and Carboniferous.
<i>Entalophora</i> ,	Species, Upper Silurian.
<i>Fenestella</i> ,	Silurian to Permian.
<i>Polypora</i> ,	Silurian and Carboniferous.
<i>Septopora</i> ,	„ „
<i>Stictopora</i> ,	= <i>Ptilodictya</i> , Lonsdale and Vine, Upper Silurian.
<i>Phyllopora</i> ,	Lower Silurian and Permian.
<i>Ptilopora</i> ,	Carboniferous.
<i>Goniocladia</i> ,	„
<i>Thamniscus</i> ,	Upper Silurian, Carboniferous and Permian.
<i>Pinnatopora</i> ,	Lower Silurian and Carboniferous.
<i>Glaucanome</i> ,	Lonsd., Upper Silurian.
<i>Acanthocladia</i> ,	Permian.
<i>Synocladia</i> ,	Permian.

Mr. Ulrich retains *Hemitrypa*, Phillips, but Mr. G. W. Shrubsole* has already shown, from the examination of type species, that so far as British examples are concerned, *Hemitrypa* is an untenable genus, and cannot stand. The whole of these genera are given as Cyclostomatous in the 1882 paper of Mr. Ulrich, but I cannot say whether he will retain the same sub-division for the emended grouping. So far as my own experience goes, only a few of the genera given above can be so placed, but before a satisfactory arrangement can be made, typical species of every genus will have to be described by sections, both of the Cells and of the Zoarium, in accordance with the now general mode of dealing with minute structures in other groups of fossil organisms.

II. SUB-ORDER CRYPTOSTOMATA, VINE.

In my fourth Report, (British Association, 1883). I gave a description of the minute structures of a species of so-called *Ptilodictya*, Lonsdale. It is well known that Lonsdale indicated that his genus and species were similar to, if not identical with *Flustra lanceolata*, Goldf. In all probability this was an error, as the small specimens selected by me for *P. Lonsdalei* do not correspond with Goldfuss's

* Quart. Jour. Geol. Soc., 1879, pp. 281-2.

species otherwise than in its feather-like arrangements. In a note Lonsdale says "This coral is considered by Goldfuss to be a *Flustra*,* but it is placed by Milne Edwards among the doubtful species of that genus, (2nd Ed. Lamk, pt. ii, p. 219). From *Eschara* it differs in not having a central partition. I have ventured to propose the above name taken from the feather-like arrangements of the middle and lateral cells."† Only one species is placed in the genus by Lonsdale, *P. lanceolata*, Lonsd., and he remarks "Small fragments of probably young specimens of this species are occasionally found in the shales of Wenlock limestone." It is from fragments so abundantly distributed in the Wenlock shales that I selected the types of my species *P. lonsdalei*. The *Eschara scalpellum*, Lonsd., is present in the Wenlock shales also, though not so abundant. It is certainly not an *Eschara*, neither is it a *Ptilodictya*, in the same sense as the type species of Lonsdale or Goldfuss. In my classification I except this species as I am still doubtful where to place it. The *Ptilodictya interporosa*, Vine, according to the arrangement of Mr. Ulrich, is a *Stictoporella*, and not a *Ptilodictya*, hence we have only the two species *P. lanceolata*, Lonsd., Dudley limestone, and *P. lonsdalei*, Vine, in our British rocks, if the British species are retained as *Ptilodictya*, Lonsd., and not as *Stictopora*, Hall.

The careful study of British species, at that time including *Eschara scalpellum* as a *Ptilodictya*, led me to remark of Phillips' *Flustra? parallela* = *Vincularia*, id. M'Coy, "I . . . prefer to leave the *Flustra* which Phillips describes with the *Ptilodictya* as *P. parallela*, and this reference is founded upon original investigation of various specimens of *Ptilodictya*, &c."‡ This might have been an

*NOTE.—*Flustra*, according to the definition of Goldfuss and Linnæus, is as follows:—FLUSTRA, Linn., stirps foliacea, flexiles, lapidescens, cellularium seriabus in utraque pagina, e basis frontis radiantibus quasi contexta.—Petrifac, p. 32. FLUSTRA, somewhat stony, submembranaceous, and flexible, on a thin crust, consisting of contiguous cells, set in many regular series, on one or both surfaces; cells sessile, short, oblique, with a terminal, irregular, frequently dented, or ciliated margin.—Brown's Zoologists' Text Book, 1st Ed. 1833, p. 566.

† Silurian System 1839, p. 675. Redefined by M'Coy, Brit. Pal. Foss. 1847, (= *Stictopora*, Hall).

‡ Brit. Assoc. Report on the Carb. Polyzoa, 1880, p. 2 of Report.

error of judgment on my part, but no great sin at a time when so little was known about our British species. Since then my knowledge has been widened, and I owe to Mr. Ulrich's friend, and my own, Mr. J. M. Nickles, ample American material from the Cincinnati rocks, to show that the location may have been a bad one. I quote my own remarks, and I will later on reproduce my original illustrations, which were drawn for the purposes of the Report in 1879. The structure therefore which formed the basis of the character of *Cystodictya*, Ulrich, were known to, but not fully appreciated by me at the time I wrote. In the same report,* however, I separate the *Sulcoretopora Robertsoni*, Young & Young, from *F. ? parallela*, remarking that *S. Robertsoni* is destitute of the non-poriferous, rugose, and striated margins of *F. parallela*. It is upon the presence of this particularly constant character that I refer Phillips' species to *Ptilodictya*." This correction of my former work was needful, and I make no apology for its introduction here. The remark however does not apply to my nomenclature of the minute structures of *P. lonsdalei*, Vine, which I used as the basis of the sub-division CRYPTOTOMATA.

"*Zoæcia* tubular, sub-tubular, in section (occasionally) slightly angular. *Orifice* of cell surrounded by vestibule, concealed."

I am not prepared at present to say what species will be included in the group, but I wish the student to bear in mind that my arrangement is based upon the "cell" rather than upon the surroundings of the cell, and that I still retain *Ptilodictya lonsdalei* (*Stictopora* ?) and its peculiar structures as typical of the division.

III. SUB-ORDER TREPOSTOMATA, ULRICH.

There are several species in British Silurian Rocks that may be conveniently placed in this sub-order, notably the Pseudo-Polyzoan forms referred to in the Fourth British Association Report (p. 45 of Report). Many of these species are still awaiting description and illustration, but I have preferred to keep them in abeyance till the report of Mr. E. O. Ulrich is published ; but the groups *Monticulipora* and *Fistulipora* have been so ably handled by Prof. Nicholson

* Ibid, p. 8 of Report.

and A. H. Foord,* that I feel it would be mere folly on my part to suggest polyzoal affinities for species that have been placed in the genera indicated, by these competent authorities.

In his review of the "Bryozoraires,"† Dr. M. Gustave Dolfus suggests that the general classification of the Bryozoa is indispensable to a good description of species, and after reviewing the work that has been accomplished by Hincks, Smitt, Busk, Waters, Pergens and others, he gives a resume of what has been done by M. Koschinsky and M. Waagen, the first on the ancient tertiaries, (Eocene), of Bavaria, the other on the Fenestellidæ of the Carboniferous rocks of India. I have not seen M. Waagen's work, but Dr. Dolfus furnishes, in the review referred to, some account of the grouping of Palæozoic Polyzoa by this author. The arrangement is different from that ordinarily received, but I give it on the authority of M. Dolfus (op. cit. p. 186).

Family 1.—Fenestrellinæ.	1839, Fenestrella, Lonsdale.
	1858, Fenestralia, Prout.
	1859, Septopora, Prout.
	1857, Lyropora, Hall.
	1844, Ptilopora, M'Coy.
	1883, Helicopora, Claypole.
	1842, Archimedis, Lesueur.
Family II.—Polyporina.	1844, Polypora, M'Coy.
	1849, Phyllopora, King.
	1849, Synocladia, King.
	1876, Dendricopora, Koninck.
Family III.—Goniocladinæ.	1876, Goniocladia, Etheridge, jun.
	1875, Ramipora, Toulou.
Location Doubtful.	? Disticheia, Sharp.
	1874, Carinopora, Nicholson.
	1874, Cryptopora, Nicholson.
	1876 ? Protoretetopora, Koninck.
	=? Phyllopora, King.

* *Annals and Mag. Nat. Hist.*, Dec., 1885, pp. 406-517,

† *Extrait de l'annuaire geologique universel*. Tome iii., 1887.

In Dr. Lindstrom's "List of the Fossils of the Upper Silurian Formation of Gotland,"* the following species are placed after the Brachiopoda, under the head "Bryozoa," p. 13.

1. *Monticulipora fibrosa*, Goldf.
2. ,, *petropolitana*, Pander, var.
3. ,, *ostiolata*, Hall.
4. ,, *Fletcheri*, Edw. and Haime.
5. ,, ? *pulchella*, Edw. and Haime?
6. *Chætetes Bowerbankii*, Edw. and H.
7. *Trematopora solida*, Hall.
8. *Discopora squamala*, Lonsdale.
9. *Cladopora repens*, Linn.
10. ,, *sparsa*, Hall.
11. ,, *seriatoporides*, E. and H.
12. *Cœnites juniperinus*, Eichw.
13. ,, *orientalis*, Eichw.
14. ,, *linearis*, Ed. and H.
15. *Ptilodictya lanceolata*, Goldf.
16. ,, *tessellata*, His.
17. *Retepora reticulata*, His.

It would be unfair to the author if I did not make some reference to the labours of Mr. James Hall, of the New York State Museum, of which he is the principal Palæontologist. In the year 1847 the first volume of the Palæontology of New York was published. In it the author describes and illustrates (pl. iv.) several species of Polyzoa or Bryozoa from the Chazy and Trenton Limestone, which he names *Retepora*, *Gorgonia*?, *Stictopora*, *Escharopora* and *Intricaria*. Other volumes followed in successive years, the last one, VI., appearing quite recently, in all of which new, or little known Bryozoa, are described and figured. Since Mr. Hall began his labours on the Bryozoa new methods of procedure have been introduced into the study of the group, consequently conflicts between the favourers of the new or the old methods have been frequent, and at times, severe. It has not been my happy lot to side with either

* Stockholm, 1885. Privately printed. See also Dr. Lindstrom's paper
Ann. Mag. Nat. Hist. Ser. iv., Vol. xviii., p. 5., et. seq.

party, and in these notes I have done my best to be fair all round. If, then, I take two horizons of Mr. Hall's, which have been fully catalogued, the Upper and the Lower Helderberg groups, I shall be able to give a pretty full synopsis of the generic, but not the family grouping of the author.

LOWER HELDERBERG GROUP.*=Upper Silurian.

Of the grouping in this horizon Mr. Hall says "The fossils in this enumeration are designated as Corals and Bryozoans, the line of demarcation between the two classes in the genera CHÆTETES, TREMATOPORA and CALLAPORA being at the present time not satisfactorily determined." Mr. Hall further states that the revision of his previous paper (1874), together with the description of the new species here included, gives an expression of our knowledge of these groups of fossils up to 1878.

Genus Aulopora, Goldfuss	Five species.
„ Vermipora, Hall	Three „
„ Striatopora, Hall	One „
„ Michelina, De Koninck	One „
„ Favosites, Lamarck	Six „
„ Chætetes, Fischer	Six „

The whole of these genera are described as "Corals" by Mr. Hall, and the following as "Bryozoans."

Genus Trematopora, Hall	Nine	species.
„ Callopora, Hall	Thirteen	„
„ Lichenalia, Hall	Three	„
„ Ceramopora,† Hall	Four	„
„ Paleschara, Hall	Three	„
„ Stictopora, Hall	One	„
„ Escharopora, Hall	Four	„
„ Fenestella‡ Lonsdale	Twenty-five	„ and Vars.
„ Ichthyorachis, M'Coy	One	„
„ Thamniscus, King	Five	„

* 32nd Annual Report on the State Mus. Albany, 1880.

† This includes *Berenicea maxima*, Hall, 26th Rep., N. Y. S., Mus., 1874.

‡ Including the so-called "Hemitrypa" species.

1881. UPPER HELDERBERG GROUP,=Devonian.

In this paper the "Bryozoans of the Upper Helderberg and Hamilton formations" are described. Mr. Hall in a note says that he has "included a few forms of CHÆTETES, which from their structure can scarcely be separated from FAVOSITIDÆ, while the differences between this genus and TREMATOPORA is hardly determinable by any well-marked characters. Under the FENESTELLIDÆ, I have not recognized the genus POLYPORA, though describing species with from two to four ranges of cells on the branches. The numerous examples of this variation have rendered the distinctions between the genera obsolete."

Genus Chætetes, Fischer	Four	species.
„ Trematopora, Hall	Six	„
„ Callopora, Hall	Three	„
„ Lichenalia, Hall	Nineteen	„
„ „ Sub-genus Phractopora,	One	species.
„ Thallostigma, n.g.	Three	species.
„ Stictopora, Hall	Nine	„
„ Intrapora, n.g.	One	„
„ Thamnopora, n.g.	One	„
„ Prismopora, n.g.	Two	„
„ Scalaripora, n.g.	Two	„
„ Glauconome, Goldfuss.	Three	„
„ Thamniscus, King	Two	„
„ Cystopora, n.g.	One	„
„ Clonopora, n.g.	Two	„
„ Crisina, D'Orbigny	One	„

Genus Fenestella (Miller), Lonsdale, Sixty-three species,

Including Fourteen bracheted (Hemitrypa).

In addition to the above lists I have by my side a carefully compiled MS. Catalogue of Palæozoic Bryozoa, by my friend J. M. Nickles, in which he enumerates, including Hall's species up to 1887, the names, together with a few synonyms, of nearly 1,500 species, American and Foreign. It is very certain that this amazing wealth demands the closest scrutiny, and to deal with all the *minutiæ* which links together group with group, is beyond my powers. To

attempt classifying such vast masses of mixed forms on the old lines of a varying Zoarium, or on the possession of a more or less number of cells to the branch, as in the *Fenestella*, is a task I leave to others. Yet so far as our own *Polypora* are concerned it seems to me not a wise grouping to found a family name *Fenestellidæ*, on account of the banding together by dissepiments of the branches of a form, regardless altogether of the structure of the cells and the Zoarium. I am well aware that in the rocks of the Niagara group, and also in our Dudley limestone there are species with alternating branches, bearing two and three rows of pores, yet so far as I have been able to study the forms superficially, both the branches and the cells differ from those of *Polypora*. My material of the species is however too limited to warrant a more critical opinion.

At the beginning of this paper I specified two wants—

- 1st, a suitably definite nomenclature descriptive of the structural elements of the Zoarium ; and 2nd, a ready agreement on the part of Palæontologists as to what should, and what should not be, admitted as Bryozoa.

In the details given above, I think I have justified this necessity in dealing with Palæozoic forms. It now remains for me to carry the work a step forward by asking, in the interests of Palæontology, plainly—What are Polyzoa ? What are the marks in the Zoœcia or Zoarium which distinguishes the group from all other groups ? I do not ask in the interests of either biology or of ordinary natural history, because both the Biologist and the Naturalist can resort to the living animal or to well-sectioned tissues for the solution of nearly all their difficulties. Besides special memoirs we have the introduction to Hinck's British Marine, and Dr. Allman's Monograph of the Fresh Water Polyzoa. These works, however, do not sufficiently describe the Zoarium of the more calcareous Cyclostomata so as to be of use to the Palæontologist, but good work has been attempted nevertheless. Mr. Waters* very accurately describes my own views on the subject as well as proposes to me a problem which still awaits solution, but of which this paper is the first instalment. He says,—“ Although it would be impossible here to give a

*Fossil Cyclostomata from Australia, Quart. Jour. Geol. Soc., Vol. 40, pp. 679-680.

complete history of all that has been attempted in the way of arrangement, we must mention the efforts of Dr. H. Hamm.* Dr. Hamm, however, in his new classification and on very slender basis creates fourteen new genera of fossil Cyclostomata. "It is not new genera or families that are wanted; the real difficulty is to deal with and show the connection of those now used." Further on (p. 680) Mr. Waters says "Mr. Vine has brought together in the British Association Reports a vast amount of material bearing upon the classification of the Cyclostomata up to the age of the Cretaceous. . . . For my own part I much doubt if we are yet in a position to frame anything approaching to a natural and final classification of the older forms, but this opinion may arise from my extremely small acquaintance with Palæozoic Bryozoa; but neither do I think we have nearly arrived at that point with the recent and neo-zoic forms, and until this is the case we can hardly expect to be quite sure about the older ones; and I have often urged upon my friend Mr. Vine that more information concerning the minute structures would be most valuable from so good a worker." In answer to the question what are Polyzoa—

Mr. Hincks says† "The Polyzoa are almost universally composite animals, forming colonies of considerable extent, which are the products of repeated continuous gemmation." In every Polyzoon we distinguish two fundamental elements, the ZOÆCIUM and the POLYPIDE. These are the primary Zooids in every colony." Professor H. A. Nicholson says‡ "All the Polyzoa live in an associated form in colonies . . . each 'Polyzoarium' (or colony) consists of an assemblage of distinct but similar Zooids arising by continuous gemmation from a single primordial individual. The colonies . . . are in many respects closely similar to those of many of the Hydroid Polypes The 'Polyzoarium' or 'Cœnecium' however of a *Polyzoon* differs from the Polypidom of a composite Hydroid in the *general* fact that the separate cells of the former do not communicate with one another, otherwise than by the continuity of the external

* Die Bry. des Mastr. Ober-Senon. 1 Th. Cyclos, Berlin, 1881.

† Introduction Brit. Marine Polyzoa, pp. i and iii.

‡ Manual of Palæontology. Vol. I, p. 414, Ed. 1879.

integument, whereas the Zooids in the latter are united by an organic connecting medium or *cænosarc*." Mr. Hincks describes the "Rosettenplate" of Reichert as a "diaphragm, pierced by one or more minute orifices, occurring in the walls of the adjacent cells amongst the Cheilostomata . . . by means of which, communication is maintained between all the cells of a colony. . . ." I have already quoted a passage from Mr. Waters' paper on the Cyclostomata, in which the following remark may be found, but I give it again in connection with the above. In *Heteropora pelliculata*, Waters, there is a plate or diaphragm "seemingly perforated in the centre, it occurs in the middle of the pore-tube, and thus it seems entirely to correspond to the simplest rosette-plates of the Cheilostomata."* Mr. Busk observed "The Polyzoa are always associated into compound growths, made up of a congeries of individuals, which though distinct, yet retain some degree of inter-communication." From all this we glean the fact that in recent species of Polyzoa, a means of inter-communication do exist between cell and cell, both in the Cyclostomata and the Cheilostomata, and inferentially we may conclude that such means might have existed in the cells of true fossil forms of Polyzoa as well.

As regards the affinities of the Polyzoa, much diversity of opinion exists. In his work on Palæontology† Professor Owen says "The *Bryozoa* are allied to the compound *Ascidia*, but not one of the Ascidian Molluscoids quit the ovum as a gemmule swimming by means of cilia, and no Bryozoon quits the ovum in the guise of a cercarian or tadpole, to swim abroad by the alternate inflexions of a caudal appendage The Bryozoa, whether regarded as the highest organised Polypes, or as the lowest organised mollusca, or as an intermediate type, are treated of in systematic Palæontology in the position here assigned to them. The practical Palæontologist finds himself compelled to arrange and study the Bryozoa along with the corals, if only on account of the difficulty he, in *many* cases, experiences of determining which class of Polypi his specimens belong to," Mr. Hincks condenses the opinions of several naturalists in a

* Quart. Jour. Geol. Soc., Vol. 40, p. 677.

† Edition 1860, p. 27, &c.

few brief paragraphs in his work on "British Marine Polyzoa," p. cix. "They have been ranked among the worms by Leuckart, Gegenbaur, Schneider, and Ehlers, the two latter authors placing them near the *Gephyræa*; Barrois, though doubtful, inclines to connect them with the Rotifera; Reichert would approximate them to the Coelenterates; Milne Edwards, Agassiz, Allman, Huxley, Ray Lankester, and others, either refer them to the Mollusca or place them in a dependency of this sub-kingdom, the Molluscoida. . . . I shall confine myself in a great measure to a statement of the grounds on which I hold that the Polyzoa are essentially Molluscan."

Unfortunately for science, the promise shadowed forth in the preface to the monograph of the Silurian Fossils of the Girvan District in Ayrshire was not fully carried out. In the preface to the first Fasciculus, Messrs. Nicholson & Etheredge, jun. state (p. viii):—"The only point about the corals worth mentioning is, that we have thought it advisable, in the meanwhile, to retain such forms as *Chaetetes* and *Fistulipora*, in the *Actinozoa*, rather than keep them back till we come to deal with the *Polyzoa*. It may ultimately be shown that these forms should properly find their place among the latter, but this view cannot be regarded as proved, and there are considerable difficulties in the way of its adoption." The Polyzoa, so far as I am aware, have never been described as yet from the Girvan district.

In his work on the Genus *Monticulipora* (Ed. 1881), Professor H. A. Nicholson has entered fully into all the characteristics of the development, affinities, and systematic position of *Monticulipora* (pp. 56-78), and I believe that a close study of this part by the student of Fossil Polyzoa will dispel many loose ideas respecting the Zoological position of the group. Many of Professor Nicholson's remarks are based on Foreign, rather than British species, and my pretty full knowledge of Silurian forms, founded upon thousands of examples from the Wenlock Shales, compels me to draw a line at true *MONTICULIPORA*, and not to include in the group forms that may, with some propriety, be placed much nearer to Polyzoa than to *Monticulipora*. I take, therefore, no exception to Nicholson's generic characters, but I select the following as a special diagnosis:—

- (a) Corallum, composed of closely approximated tubular corallites.
- (b) Walls of Corallites, never absolutely amalgamated.
- (c) Walls imperforate, and septa entirely wanting.
- (d) Tabulæ always present, generally complete.
- (e) The presence of "Monticules" and "Maculæ"; areas elevated and depressed.

The above I consider a fair analysis of the Corallum, but Professor Nicholson has made us his debtor in his further studies of members of the group in his fresh contribution on the Genus *Fistulipora* M'Coy,* by adding a useful working nomenclature of parts of the Corallum, which will supersede the terms used in his "*Monticulipora*," and "*Palæozoic Corals*."

- (f) Autopores = "large corallites" of the above works.
- (g) Mesopores = "interstitial tubes" „
- (h) Acanthopores = "spiniform corallites"
- (i) Corallites, only used in a general sense when referring to the tribes of which the colony is made up.

As the true opposite of this nomenclature the following may be suggested as applicable to Polyzoa, and partially adopted from Mr. Hincks.

- I. Zoarium (= Polyzoarium). The composite structure formed by repeated gemmation.
- II. Zoecium (= cell). The chamber in which the polypide was lodged.
 - (a) Cell wall ornamented by foramina (= punctures, Busk).
- III. Cœnecium = the common dermal system of a colony.
- IV. Ectocyst (= ectoderm). The outer layer of the Cœnecium.
 - (b) Ectocystal tubes. Tubes nominally ornamental of the Cœnecium, but which penetrate this layer.
 - (c) Interectocystal tubes. Tubes horizontal to the Ectocyst.
- V. Endocyst. The inner layer; valuable to the Palæontologist as a reference whenever the Ectocystal tubes penetrate the substance of the Endocyst.

* Dr. H. A. Nicholson and A. H. Foord. *Ann. Mag. Nat. Hist. Ser. v.*, Vol. xvi., pp. 496-517.

VI. Funicular opening and Endosarcial passages. The opening at the bottom of the cell, and the interspaces between cell and cell.

VII. Gonocyst. The inflation of the surface of the Zoarium, in which the embryos are developed (Ovicell).

As this paper will be followed by others, wholly devoted to the structural characteristics of the Palæozoic Polyzoa, it may be well to refer to remarks in my first paper on *DIASTOPORIDÆ*,* “It is clear . . . that the Palæozoic representatives of the family Diastoporidæ differ very materially from the more recent members. If the whole are to be classified under one family name, a course highly advantageous to the study of Polyzoa, it will be necessary to take into consideration the more prominent characters, and place the species of the different formations under suitable genera,” consequently I suggested the following arrangement :—

Recent and Tertiary	Genus I.—	Diastopora, Johnston.
Secondary	„ II.—	To be re-worked.
Palæozoic (in part)	„ III.—	Ceramopora, Hall.
Palæozoic (in part)	„ IV.—	Berenicea, M'Coy's description restricted.

Since then *Ceramopora megastome*, Vine, has been re-worked by Mr. John Young † and Messrs Nicholson & Foord,‡ and the carboniferous form is now placed as a synonym of *Fistulipora* (*Calamopora*) *incrustans*, Phillips. I have no objection to the synonym, for it is in good company, and I refer to it now because the re-study of the form by these esteemed authors has brought out a most valuable structural feature in this species, and in *Fistulipora* generally. “This consists of a very peculiar modification of the walls of the autopores which give them quite a distinct *facies*. The autopores possess a strong fold which imparts a trilobate or floriform aspect to the cells.” The sinus is minutely described by the authors, and as it has a decided morphological significance, I refer the student to the closer study of the autopores of the Monticuliporidæ, taking as his guide the valuable paper on the Genus *Fistulipora*, M'Coy, by Nicholson & Foord.

* Quart. Jour. Geol. Soc., Vol. XXXVI, 1880, pp. 356-361.

† Annals and Mag. Nat. Hist., Dec. 1882, pp. 427-431, and Trans. Geol. Soc., Glasgow, 1883, pp. 244-250.

‡ Ann. Mag. Nat. Hist., Ser. V., Vol xvi, p. 500.