A MONOGRAPH

OF THE

SILURIAN FOSSILS OF THE GIRVAN DISTRICT IN AYRSHIRE

WITH SPECIAL REFERENCE TO THOSE CONTAINED IN THE "GRAY COLLECTION"

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SILURIAN FOSSILS OF THE GIRVAN DISTRICT IN AYRSHIRE

WITH SPECIAL REFERENCE TO THOSE CONTAINED IN THE "GRAY COLLECTION"

BY

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PROFESSOR OF NATURAL HISTORY IN THE UNIVERSITY OF ST ANDREWS

AND

ROBERT ETHERIDGE, JUN., F.G.S.

ACTING-PALÆONTOLOGIST TO THE GEOLOGICAL SURVEY OF SCOTLAND

FASCICULUS I.

(RHIZOPODA, ACTINOZOA, TRILOBITA)

WILLIAM BLACKWOOD AND SONS
EDINBURGH AND LONDON
MDCCCLXXVIII

GENERAL PREFACE.

The present work is the first Fasciculus of a detailed descriptive catalogue of the fossils of the Silurian area of Girvan, in Ayrshire. The district in question has long been known to be occupied by a great and complicated series of Silurian rocks, the disentanglement and correlation of which has presented exceptional difficulties to the stratigraphical geologist. It has also long been known that the Girvan deposits were largely fossiliferous, but the organic remains have, up to this time, been only very partially worked out, in spite of the excellent descriptions of various forms which have been published by M'Coy, Salter, Sir C. Wyville Thomson, Mr Davidson, Professor John Young, and others. As will be seen, indeed, from the bibliographical list which follows, a large number of valuable papers have been written, dealing with fossils derived from the Girvan area; but these memoirs only treat of limited portions of the subject; while they are to be found in separate and often hardly accessible publications.

Under these circumstances, it appeared to us that a systematic descriptive account of the fossils of the Girvan district would be of value to the geological student, and would be likely to solve some important problems in both palæontology and geology. We therefore made application to the Royal Society

for assistance from the Government grant, and we take this opportunity of expressing our gratitude for the sum of seventy-five pounds, which was allotted to us. This sum was of course insufficient to defray the cost of the first Fasciculus; but without this assistance we could not have commenced the work in a satisfactory manner; and we have to record our best thanks to our friend Robert Gray, Esq., F.R.S.E., to whose generosity we owe further aid.

Apart, however, from matters of this kind, our greatest debt of gratitude was due to Mrs Robert Gray, without whose co-operation the present work could not have seen the light. By giving us the free and uncontrolled use of her cabinet, Mrs Gray has put us in possession of the most complete series extant of the Silurian fossils of Ayrshire, and has thus enabled us to undertake a systematic review of the interesting and important organic remains of the Girvan area. In this connection, we have only to add that our further thanks are due to our friend Charles Lapworth, Esq., F.G.S., who has kindly presented us with some interesting specimens collected by himself in this region. Lastly, a visit to the ground in person has resulted, not only in giving us a direct knowledge of the rocks from which our specimens have been derived, but also in considerably increasing the available material for our work.

PREFACE TO THE FIRST FASCICULUS.

In the present Fasciculus we have dealt with the *Protozoa*, the Corals, and a portion of the *Crustacea* of the Girvan district, so far as we are at present acquainted with them. In the case of well-known and thoroughly understood forms, on which our specimens throw no new light, we have contented ourselves with simply recording the occurrence of the species, accompanying this with any observations which the Ayrshire examples might call for. In the case of new or imperfectly understood forms, we have always given as full a description as our materials would allow, availing ourselves as far as possible of illustrations in elucidation of the text.

In connection with the Protozoa, the description of *Saccammina* is from the pen of Henry B. Brady, Esq., F.R.S., on whose unimpeachable authority this interesting type of the *Foraminifera* can now be asserted to have been in existence in Lower Silurian times. For this and much other kind assistance from the same source, we are glad to have this opportunity of publicly expressing our obligation.

As regards the Corals of the Girvan area, we had unusual difficulties to confront. Though the total number of specimens available for examination was very large, the great majority of these were in such a state of preservation that their external

characters could only be made out imperfectly, if at all. This necessitated the sectioning of a great number of examples, as well as the preparation of an extensive series of microscopic slides. For this reason, also, the figures which we have given are more largely concerned with the minute internal structure, and less with external features, than has been usual in works dealing with fossil corals. In spite of these disadvantages, the results obtained have been very satisfactory, the coral-fauna proving to be one of high interest. The only other point about the corals worth mentioning is, that we have thought it advisable, in the meanwhile, to retain such forms as *Chætetes* and *Fistulipora* in the *Actinozoa*, rather than to 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 Trilobites, so far as we have at present investigated them, do not call for any particular remarks. On the whole, we are able to support the determinations of previous writers; and it appears probable that more good work has been accomplished and published in the direction of this order than of any other, by those who have, up to the present time, investigated the Girvan fauna. We hope to complete the Trilobites and other orders of Crustacea in our second Fasciculus, when we intend giving a short chapter upon their relations with the Trilobite faunæ of other areas, and particularly their bearing upon the age of the various subdivisions of the Girvan series.

In connection with the Trilobites, we are under obligations to R. Etheridge, Esq., F.R.S., and G. Sharman, Esq., of the Museum of Practical Geology, who have rendered us material assistance in the comparison of some of our specimens with those in the valuable collection of that institution. We are

also indebted to Dr J. C. Purves, for suggestions on many points.

As regards the plates, we have only to say that those dealing with the corals were drawn by one of us, and that the others were drawn, and all were put upon the stone, by Mr Charles Berjeau, F.L.S., whose skill as a scientific artist is too well known to need any praise from us, and whose reputation certainly will not suffer from these specimens of his handiwork. Unless otherwise stated, the specimens figured form a part of the "Gray Collection."

St Andrews and Edinburgh,
October 1878.

A MONOGRAPH

OF THE

SILURIAN FOSSILS OF THE GIRVAN DISTRICT.

BIBLIOGRAPHY.

1849. SALTER, J. W.—Note on the Fossils from the Limestone on the Stinchar River, and from the Slates of Loch Ryan. *Quart. Jour. Geol. Soc.*, v., pp. 13-17, t. 1.

Mentions the occurrence of seven species in the Stinchar River Limestones, and describes six of them—viz., *Pleurotomaria Moorei*, Salter; *P. latifasciata*, Portlock (?); *Murchisonia scalaris*, Salter; *Euomphalus* (?), sp. ind.; *Orthis confinis*, Salter; *Illænus Davisii*, Salter.

1850. M'COY, Prof. F.—On some New Genera and Species of Silurian Radiata in the Collection of the University of Cambridge. *Annals and Mag. Nat. Hist.*, 2d ser., vi., pp. 270-290.

Describes *Strephodes Craigensis*, M'Coy, Craighead; *Petraia æquisulcata*, M'Coy, Mulloch Quarry; *Palæopora favosa*, M'Coy, Craighead and Mulloch Quarry.

Ibid.—On some New Silurian Radiata, *loc. cit.*, pp. 474-477.

Describes *Palæopora subtilis*, M'Coy, Mulloch Quarry.

1851. M'COY, Prof. F.—On some New Silurian Mollusca. *Annals and Mag. Nat. Hist.*, 2d ser., vii., pp. 45-63.

Describes *Orthoceras politum*, M'Coy, Glenwhapple; *Bellerophon subdecussatus*, M'Coy, Mulloch Quarry; *Trochus Moorei*, M'Coy, Dalquharran.

Ibid.—id., 2d ser., vii., pp. 387-409.

Describes *Cytheropsis Aldensis*, M'Coy, Aldens; *Hemithyris angustifrons*, M'Coy, Mulloch Quarry; *H. nasuta*, M'Coy, Craighead Quarry; *Orthisina Scotica*, M'Coy, Craighead Quarry and Colmonell; and *Holopella tenuicincta*, M'Coy, Mulloch Quarry.

1851. Salter, J. W.—List of some of the Silurian Fossils of Ayrshire. *Quart. Jour. Geol. Soc.*, vii., pp. 170-178, plates 8-10.

Mr Salter gave an exhaustive list of the fossils from the Girvan district, obtained from twelve localities. His list comprised the following new species: *Diplograpsus bullatus*, *Nidulitus favus*, *Pleurorhynchus dipterus*, var. *rhomboideus*, *Maclurea magna*, M'Coy, *Orthoceras Barrandei*. In addition to these, several already known species are noticed.

1851. Sedgwick, Rev. Prof.—On the Geological Structure and Relation of the Frontier Chain of Scotland. *Brit. Assoc. Report for* 1850, pt. ii., pp. 103-107; with List of the Organic Remains by Prof. M'Coy.

The rocks of the Girvan district are divided into two subdivisions, a north and south Girvan group. A copious list of fossils, arranged under localities, is given. (This paper was also published in the *Edinb. N. Phil. Jour.*, li., p. 250.)

1852. M'Coy, Prof. F.—Contributions to British Palæontology; some New Lower Palæozoic Mollusca. *Annals and Mag. Nat. Hist.*, 2d ser., x., pp. 189-195.

Describes *Murchisonia cancellatula*, M'Coy, Mulloch Quarry; *M. simplex*, M'Coy, Dalquharran; *Maclurea macromphala*, M'Coy, Craighead; *Ecculiomphalus Scoticus*, M'Coy, Mulloch Quarry.

1852. M'Coy, Prof. F.—British Palæozoic Fossils, fas. ii., p. 351.

In this valuable work there will be found a list of fossils arranged alphabetically in localities, and preserved in the Woodwardian Museum, Cambridge. For the descriptions of the species the work may itself be referred to; we shall have occasion to notice many of the forms in question.

1853. Salter, J. W.—Figures and Descriptions illustrative of British Organic Remains. *Mem. Geol. Survey United Kingdom*, Dec. vii., No. 2, p. 11.

Describes *Cheirurus gelasinosus*, Portlock, from the "limestone of Ayrshire."

Ibid.—Id., Dec. vii., No. 5.

Describes *Cyphaspis megalops*, M'Coy, and gives as one locality sandstones of Mulloch Quarry, on the authority of M'Coy.

1854. Morris, Prof. J.—A Catalogue of British Fossils, comprising the Genera and Species hitherto described; with reference to their Geological Distribution, and to the Localities in which they have been found. 2d edition, London, 8vo.

1857. Thomson, Sir C. Wyville.—On some Species of *Acidaspis* from the Lower Silurian beds of the South of Scotland. *Quart. Jour. Geol. Soc.*, xiii., pp. 206-210, t. 6.

Describes four species of *Acidaspis* from the schists at the base of the "Graptolite and Orthoceratite flags" of Penwhapple Glen, Girvan district, which the author considers to be of Upper Bala age—*Acidaspis Lalage*, *A. hystrix*, *A. callipareos*, and *A. unica*.

1864. Salter, J. W.—Figures and Descriptions illustrative of British Organic Remains. *Mem. Geol. Survey United Kingdom*, Dec. xi., No. 1, p. 8.

Describes *Agnostus trinodus*, Salter, and gives as one locality Penwhapple Burn, Girvan district.

Ibid.—*Id.*, Dec. xi., No. 5, p. 4.

Describes *Staurocephalus* (?) *unicus*, Wy. Thomson, Penwhapple Glen, Girvan District.

Ibid.—A Monograph of British Trilobites, pt. 1, 4to.

Describes the following species from the Girvan district: *Phacops Stokesii*, Milne-Edw.; *Cheirurus bimucronatus*, Murchison, Mulloch Quarry; *C. octolobatus*, M'Coy, Penwhapple; *C. gelasinosus*, Portlock, Craighead limestone.

1864. Thomson, Sir C. Wyville.—Figures and Descriptions illustrative of British Organic Remains. *Mem. Geol. Survey United Kingdom*, Dec. xi., No. 6.

Describes an entirely new form of Trilobite, under the name of *Salteria primæva*, Wy. Thomson.—Schists forming the base of the "Graptolite and Orthoceratite flags," Penwhapple Glen, Girvan district.

1865. Salter, J. W.—A Monograph of British Trilobites, pt. 2.

Describes, from Girvan localities, *Staurocephalus globiceps*, Portlock; *Calymene Blumenbachii*, Brongniart, Mulloch Quarry.

1866. Davidson, T.—A Monograph of the British Fossil Brachiopoda, pt. vii. The Silurian Brachiopoda, No. 1.

Describes from Girvan localities the following: *Lingula attenuata*, Sow.; *Discina perrugata*, M'Coy; *D. oblongata*, Portl.; *D. crassa*, Hall; *Siphonotreta micula*, M'Coy.

1867. Murchison, Sir R. I.—Siluria, 4th ed., London, 8vo, pp. 155-157.

A general outline of the Geology is given, and the occurrence of certain fossils on the Stinchar and Girvan rivers, and at Mulloch Hill, Saugh Hill, and other localities, is mentioned.

1867. Salter, J. W.—A Monograph of British Trilobites, pt. iv.

Describes from Girvan localities—*Illænus Bowmani*, Salter, Girvan; *I. Thomsoni*, Salter, Mulloch Quarry; *I. Macallumi*, Salter, Mulloch Quarry.

1867. Davidson, T.—A Monograph of the British Fossil Brachiopoda, pt. iii. The Silurian Brachiopoda, No. 2.

Describes *Meristella angustifrons*, M'Coy; *Atrypa reticularis*, Dalman; *A. imbricata*, J. de C. Sow.; *A.* (?) *hemisphærica*, J. de C. Sow.; *A.* (?) *Scotica*, M'Coy; *Pentamerus oblongus*, J. de C. Sow.; *Rhynchonella cuneata*, Dalman.

1868. Geikie, Prof. A.—On the Order of Succession among the Silurian Rocks of Scotland. *Trans. Geol. Soc. Glasgow*, iii., pt. 1, pp. 74-95.

The Carrick limestones are noticed, and referred to the Caradoc or Bala group; so also is the Craighead limestone, and again the beds at Ardwell, Piedmont Glen, and Penwhapple Burn. The shelly sandstones of Drummuck, Mulloch, and Saugh Hill are placed as Llandovery. From all the foregoing localities lists of fossils are given.

1868. Jones, Prof. T. Rupert.—Notes on the Palæozoic Bivalved Entomostraca, No. viii. *Annals and Mag. Nat. Hist.*, 4th ser., ii., pp. 54-62.

Describes *Cythere Aldensis*, M'Coy, from Aldens, to the south-west of Girvan. The species is placed in the genus *Cythere*, rather than *Cytheropsis*, with which it had been previously associated.

1868. Gray, R.—Note on Silurian Fossils from Girvan. *Proc. Glasgow Nat. Hist. Soc.*, i., pt. 1, p. 101.

A list, comprising many of the genera found in the district, is given.

Ibid.—Note on a Series of Silurian Brachiopoda, from the neighbourhood of Girvan, *loc. cit.*, p. 124.

The following are mentioned: *Lingula Ramsayi*, *L. attenuata*, and *Discina perrugata*.

1868. Young, J.—Remarks on four species of Silurian Brachiopoda, new to Ayrshire, *loc. cit.*, p. 169.

Notices *Siphonotreta micula*, *Orthis galea*, *O. alata*, and *Lingula Ramsayi*.

1868. Young, Prof. J., M.D.—On New Forms of Crustacea from the Silurian Rocks at Girvan. *Proc. Nat. Hist. Soc. Glasgow*, i., pp. 169-173.

Describes as a new species *Cheirurus trispinosus*, from Penkill, and as a new genus and species *Solenocaris solenoides*.

1868. Gray, R.—On the occurrence of *Ischadites Kœnigi* in the Silurian Rocks of the Girvan District, *loc. cit.*, p. 197.

First discovery of this species in the rocks in question.

1868. Young, J.—Note on a new Brachiopod Shell, *Triplesia Grayæ*, Davidson, discovered in the Silurian Strata of the Girvan valley by Mrs Robert Gray, *loc. cit.*, p. 207.

1868. Bigsby, Dr J. J.—Thesaurus Siluricus. The Flora and Fauna of the Silurian Period, &c. London. 4to.

A detailed and tabulated list of Silurian fossils generally, amongst which will be found a record of the Girvan forms.

1869. Gray, R.—Note on *Leptæna Youngiana*, Davidson, a new Silurian Brachiopod Shell from the Girvan District; and also on the Occurrence of *Leperditia* in the same, *loc. cit.*, pt. ii., pp. 230, 231.

1869. Davidson, T.—A Monograph of the British Fossil Brachiopoda, pt. vii. The Silurian Brachiopoda, No. 3.

Describes *Rhynchonella nasuta*, M'Coy; *R. nucula*, Sow.; *R. Thomsoni*, Davidson; *R. Salteri*, Dav.; *Triplesia Grayæ*, Dav.; *Atrypa* (?) *incerta*, Dav.; *Orthis Bouchardii*, Dav.; *O. elegantula*, Dalman; *O. Girvanensis*, Dav.; *O. vespertilio*, J. de C. Sow.; *O. calligramma*, Dalman.

1869. Geikie, Prof. A.—Lists of Fossils, determined by Mr R. Etheridge, from (*a*) the Craighead limestone, (*b*) the Ladyburn (Drummuck) section, and (*c*) from the lower Llandovery Rocks of Kirk Hill, Girvan district. *Mem. Geol. Survey Scotland*, Expl. sheet 14 (pp. 9-10).

Eleven species are mentioned from the first locality, six from the second, and eight from the third.

Ibid.—Lists of Fossils, determined by Mr R. Etheridge, (*a*) from the Aldens limestone, and (*b*) from Ardmillan Brae, in the Girvan district. *Mem. Geol. Survey Scotland*, Expl. sheet 7 (pp. 9-10).

From the first locality nine species are mentioned, and from the second forty-five and a few doubtful ones.

1871. DAVIDSON, T.—A Monograph of the British Fossil Brachiopoda, pt. vii. The Silurian Brachiopoda, No. 4.

Describes *Orthis turgida*, M'Coy; *O. confinis*, Salter; *O. insularis*, Eichwald (?); *Strophomena rhomboidalis*, Wahl.; *S. retroflexa*, Salter; *S. antiquata*, Sow.; *S. corrugatella*, Dav.; *S. grandis*, Sow.; *Leptæna Youngiana*, Dav.; *L. quinquecostata*, M'Coy; *L. sericea*, Sow.; *L. tenuicincta*, M'Coy.

1873. ETHERIDGE, R., with Prof. J. YOUNG and R. ETHERIDGE, jun.—List of Fossils collected by the Geological Survey from the Silurian Rocks of the south-west of Ayrshire. *Mem. Geol. Survey Scotland*, Expl. sheet 3 (pp. 29-34).

The Fossils are arranged under thirty-one localities.

1873. LAPWORTH, C.—On the Silurian Rocks of the south of Scotland. *Trans. Geol. Soc. Glasgow*, iv., pt. 2 (pp. 164-174).

In the appendix to this paper will be found 'Lists of the Fossils of the various subdivisions of the south Scottish Silurians,' the ninth paragraph of which relates exclusively to the Girvan series.

1875. YOUNG, J.—Notes on the Genera of Extinct Fossil Shells, *Bellerophon* and *Porcellia;* their classification amongst the Mollusca, and their distribution in the Silurian and Carboniferous strata of the west of Scotland. *Proc. Nat. Hist. Soc. Glasgow*, 1875, ii., pt. 1, p. 16.

States that four species of *Bellerophon* occur in the Girvan Silurian beds.

Id.—Note on a small collection of Fossil Brachiopoda from the neighbourhood of Girvan. *Loc. cit.*, p. 21.

Records the occurrence of *Atrypa incerta*, *Rhynchonella æmula*, *R. Thomsoni*, *R. Weaveri*, *Orthis Bouchardii*, *O. vespertilio*, *O. calligramma*, var. *Scotica*, *O. elegantula*, *Triplesia Grayæ*, *Strophomena imbrex*, *Leptæna Youngiana*, *L. tenuicincta*, *L. sericea*, and *Strophomena Grayi*.

YOUNG, Dr J.—Note on a new species of Crustacean, belonging to the genus *Solenocaris*, from Silurian strata near Girvan, and on fragments, probably the appendages of a Trilobite or Limuloid Crustacean. *Loc. cit.*, p. 66.

1876. LAPWORTH, C.—On Scottish Monograptidæ, pt. 8. *Geol. Mag.*, Dec. 2, 1876, iii., pp. 544-552.

Describes *Cyrtograptus Grayæ*, a new species from the Penwhapple Glen beds, near Girvan.

1876. YOUNG, J.—Notes on a series of Fossils from the Silurian Rocks of the Girvan Valley. *Proc. Nat. Hist. Soc. Glasgow*, ii., pt. 2, p. 166.

Notes the occurrence in the Gray collection of *Bellerophon dilatatus*, *Murchisonia obscura*, *Holopella obsoleta*, *Scalites angulatus*, *Lingula quadrata*, *Orthis biforata*, *Rhynchonella Salteri*, *Orthis Girvanensis*, and *Acidaspis Brightii*.

Id.—Note on a series of Trilobites of Caradoc age from the Silurian strata of the Girvan Valley. *Loc. cit.*, p. 179.

Notes the identification of the following species in the Gray collection — viz., *Illænus Bowmani*, *I. Thomsoni*, *I. Barriensis*, *Cybele verrucosa*, *Staurocephalus* (?) *unicus*, *Proetus latifrons*, *Cheirurus latifrons*, *Zethus rugosus*, and *Odontopleura ovata* (?)

Id.—Note on a series of Graptolites from the Silurian strata of the Girvan Valley. *Loc. cit.*, p. 182.

The following are stated by Mr Young to be in the Gray collection from Penwhapple Glen—viz., *Graptolithus priodon*, *G. Sedgwickii*, *G. colonus*, *Cyrtograptus Grayianus*, Lapworth; and *Dicranograptus tardiusculus*, Lapworth.

Id.—Note on Crinoid remains from the Silurian strata of the Girvan district. *Loc. cit.*, p. 216.

Obtained from two localities, Craighead and Balcletchie.

Young, Prof. J.—Note on a Silurian Fossil from the Girvan district. *Loc. cit.*, p. 223.

The specimen was referred to Salter's genus *Pterotheca*.

1876. Armstrong, J., with J. Young and D. Robertson.—Catalogue of the Western Scottish Fossils. Glasgow. 8vo (pp. 12-22).

Gives a list of fossils, zoologically arranged, of the Girvan district, with localities, compiled from various sources.

1877. Davidson, T.—Notes on four species of Scottish Lower Silurian Brachiopoda.—*Geol. Mag.*, Dec. 2, iv., pp. 13-17, t. 2.

Describes *Siphonotreta Scotica*, Dav., Craighead Quarry; *Lingula quadrata*, Eichwald, Craighead Quarry; and *L. Canadensis*, Billings, Balcletchie, near Girvan.

1877. Woodward, Dr H.—A Catalogue of British Fossil Crustacea, with their Synonyms, and the Range in Time of each Genus and Order. London. 8vo.

1877. Nicholson, Prof. H. A., and R. Etheridge, jun.—On *Prasopora Grayæ*, a New Genus and Species of Silurian Corals. *Annals and Mag. Nat. Hist.*, 4th ser., xx., pp. 388-392.

A small, peculiar, button-shaped little coral, having much the external appearance of a *Favosites*. The internal structure is, however, unique, and quite different from that of the latter. Abundant at Craighead Quarry.

1878. Etheridge, R., and E. T. Newton.—A Catalogue of the Cambrian and Silurian Fossils in the Museum of Practical Geology. London. 1878. 8vo.

Many species from the Girvan ground are given, with their localities.

Etheridge, R., jun.—Notes on Silurian Fossils from Ayrshire. (*Proc. R. Physical Soc. Edinb.*, 1878, iv., pt. iii., pp. 164-177, t. 2.)

Describes as new species *Turrilepas Scotica* and *Acidaspis Grayæ*; and as a new genus and species *Pinnocaris Lapworthi*.

LOCALITIES AT WHICH FOSSILS HAVE BEEN COLLECTED IN THE GIRVAN DISTRICT, AND REFERRED TO IN THE SUCCEEDING PAGES OF THIS WORK.

1. High Mains, about 6 miles N.E. of Girvan.
2. Kirk Hill, near last locality.
3. Littleburn, S.W. of High Mains.
4. Quarry at pond, S.W. of Rough Neuk, about 6 miles N.E. of Girvan.
5. Quarry at Rough Neuk.
6. Roadside, near Old Fort at Kirk Hill.
7. Quarry on roadside, east of last locality.
8. Littleburn, Quarrel Hill, near Auldthorn, about 6 miles N.E. of Girvan.
9. Drummuck Burn, about 4 miles N.E. of Girvan.
10. Lady Burn, above Drummuck.
11. Lady Burn, opposite Threave.
12. Craighead Quarry, about 3 miles N.E. of Girvan.
13. Craigens, near Kirk Hill, about 5½ miles N.E. of Girvan.
14. Ardmillan Brae, about 2½ miles S.W. of Girvan.
15. Piedmont Glen, S. of Girvan.
16. Laggan Burn, S.E. of Girvan.
17. Ardwell Shore, about 4 miles S.W. of Girvan.
18. Penwhapple Glen, E. of Girvan.
19. Saugh Hill, about 1½ mile E. of Girvan.
20. Camregan Plantation, about 2 miles E. of Girvan.
21. Balcletchie, about 4 miles E. of Girvan.
22. Tramitchell, about 3 miles S.E. of Girvan.
23. Barbae, nearly 3 miles S.E. of Girvan.
24. Pinmacher, about 2½ miles S. of Girvan.
25. Letterpin, nearly 4 miles S. of Girvan.
26. Auchensoul, about 5 miles S.E. of Girvan.
27. Aldons, on the Stinchar R., about 5 miles S. of Girvan.
28. Head of burn passing Bargany Pond, about 6 miles east by north of Girvan.
29. Hillside opposite Blair farm, about 8½ miles N.E. of Girvan.
30. Quarry on roadside near Knockgardner, about 10 miles N.E. of Girvan.
31. Mulloch Hill, 4½ miles N.E. of Girvan.
32. Penkill, 3½ miles N.E. of Girvan.
33. Colmonell, on the Stinchar R., about 7 miles S. of Girvan.
34. Braes, about 1½ mile E. of Girvan.
35. Knockdolian Mountain, near Colmonell, on the Stinchar R., S. of Girvan.
36. Cuddystone Glen, about 1 mile S. of Girvan.
37. Knockgerran, about 4½ miles E. of Girvan.
38. Shalloch Mill, on sea-shore, 1½ mile S. of Girvan.
39. Burn a little south of Shalloch Mill (Graptolites, &c.)
40. Ardmillan shore, 2½ miles S. of Girvan.

DESCRIPTION OF THE SPECIES.

PLANTÆ.

ORDER ALGALES.

Genus CHONDRITES, Sternberg, 1833.

CHONDRITES, *sp.*

(Near *Chondrites verisimilis*, Salter, Mem. Geol. Survey, Scotland, No. 32, p. 134, t. 2, f. 1 and 2.)

Obs.—A single, small, and imperfect fragment is in the Gray collection, which has all the appearance of a *Chondrites*, and very near the above species. The probability of this fact is increased by the occurrence at another locality in the Girvan area of a form which cannot be distinguished from *C. verisimilis*, Salter. The specimen in question was found by Mr A. Macconochie, near Bargany Pond, about six miles north-west of Girvan, and is in the collection of the Geological Survey of Scotland.[1] In the 'Catalogue of Western Scottish Fossils,'[2] by Messrs Armstrong, Young, and Robertson, *C. verisimilis* is relegated to the Annelida, a step to which we must express our unqualified dissent, as an inspection of Salter's figure will at once show that it can have no possible connection with that class.

Locality.—Penkill, in a fine-grained, slightly micaceous shale, (Gray collection).

[1] Etheridge, Mem. Geol. Survey, Scot., Expl. 3, p. 34.
[2] Glasgow, 1876, p. 15.

SUB-KINGDOM PROTOZOA.

CLASS RHIZOPODA.

Genus NIDULITES, Salter, 1851.

Nidulites, Salter, Quart. Jour. Geol. Soc., 1851, vii. 174.
„ Morris, Cat. Brit. Foss., 1854, 2d ed., p. 362.
„ Bigsby, Thesaurus Sil., 1868, p. 4.
„ Salter, Cat. Camb. and Sil. Foss., Woodwardian Mus., Cambg., 1873, p. 72.

(Compare *Cyclocrinus*, Eichwald, Lethæa Rossica, i. 637; *Pasceolus*, Billings, Logan's Geol. Survey Report, Canada, for 1856, p. 342; Pal. Fossils, Canada, p. 390, f. 366, 367; Cat. Sil. Foss. I. of Anticosti, p. 69; *Sphærospongia*, Salter, Pal. Niti in the N. Himalaya, 1865, p. 48; Cat. Camb. Sil. Foss., Woodwardian Mus., Cambg., 1873, p. 40.)

(*a*) *Gen. char.* — Body pyriform or sphæroidal (?), pedunculate, with an outer integument of hexagonal calcareous plates, articulated (or fused ?) by their edges. Each plate is deeply convex, with the convexity directed to the hollow interior of the sphere, into which it further sends a small central papilla or styliform projection, leaving a pit in the cast. The edges of the plates are prominent, thus closely resembling honeycomb. Plates to a certain extent variable in size, decreasing towards the contracted base. Apertures, none (?). Traces of an enclosing sac or investment. Perfect condition of organism unknown.

(*b*) *History.*—Mr Salter described *Nidulites* as oval or round plates, about two inches in diameter, spreading from a centre of attachment into a flattened irregularly wavy form, the entire surface of both the upper and under sides being covered with hexagonal cups. The edges of the latter were stated to be smooth and even with the general surface, their bases rounded, and usually with a central puncture or pit. A narrow space was always found to exist between the two series of cups, which Mr Salter considered to be occupied in the perfect organism by a membrane giving attachment to the

cups, probably by means of the punctures before mentioned. The lower surface of the cups themselves appears to have been somewhat wrinkled. Their bodies were supposed by Mr Salter to be the egg-ribbons of marine Gasteropoda, probably of a genus nearly allied to *Natica*, an idea suggested to him by Professor Milne-Edwards. Mr Salter adds that one condition of *Nidulites* was figured by Professor M'Coy as a specimen of the latter's *Palæopora favosa*.

Professor Morris in his 'Catalogue' placed *Nidulites* amongst the "Incertæ sedis," expressing thereby his appreciation of the difficulties in assigning to it any definite systematic position.

In the palæontological notes attached to the third edition of Sir R. Murchison's 'Siluria,' furnished by Mr Salter, *Nidulites* is in one place doubtfully referred to the Polyzoa,[1] whilst in another his original theory is given up, and Mr Salter evidently conceived that it might possibly be an Amorphozoön.[2] He states that he had not met with any upper plate or covering to the cells, which appear to have been quite open.

In the 'Palæontology of Niti,'[3] Salter remarks upon the relation of *Nidulites* to his genus *Sphærospongia*, and the probable sponge nature of both of them.

In the Cambridge Catalogue,[4] Salter again compares *Nidulites* to his genus *Sphærospongia*.

(*c*) *Obs.*—*Nidulites favus* is only known to us in the condition of casts. It occurs in the form of irregularly oval, globular, or pyriform masses, when at all approaching the complete outline, or as flat expansions when in a fragmentary state. The true test, shell, calyx, or skeleton, by whichever name the reader may think fit to call it, is never met with, but we either have a globular body consisting of a series of moulds in the form of hexagonal cups, or, on the other hand, concave or flattened expansions, consisting of rounded hexagonal promi-

[1] Siluria, 1867, 3d ed., p. 188. [2] Ibid., p. 208.
[3] Pal. of Niti in the Northern Himalaya, &c. Calcutta, 1865, 8vo, p. 48.
[4] P. 72.

nences, often ranged in quincunx. Whenever these two conditions are found in apposition, a narrow space is always left between them, which, according to Salter's view, was occupied by a connecting membrane or lamina, but which we conceive to represent the position of the actual calcareous skeleton. It must also be borne in mind that Mr Salter believed the cups were placed back to back, adhering to the membrane represented by the space in question—a conception which we think resulted from an examination of a number of examples crushed together. The convex casts of the hexagonal cups are often, but by no means in every case, provided with central papillæ, which are themselves the casts of pits existing in the cup-moulds; but, as in the case of the papillæ or styliform processes, their presence is not constant. In the masses of the convex casts there is a tendency in the respective hexagons for the surface to peel off in concentric layers. When the cups are filled with matrix to a similar level, and the observer is looking down on the specimen, the appearance of a series of roughly hexagonal plates is presented.

The slight irregularities visible in the form of the globose or pyriform body of *Nidulites* lead us to suspect that the test possessed a certain amount of flexibility when in the living state. We have not seen an individual perfect in outline, but the figures given on Plate IX. leave little doubt as to the true form of the organism; neither do we doubt that there existed a peduncle or short stem, especially when we take into consideration its remarkable resemblance to its allies *Pasceolus*, Billings, and *Sphærospongia*, Salter. This is to a great extent borne out by a specimen from Haverfordwest, in the Museum of Practical Geology, which shows, at a point we take to be the crushed-in base, the remains of a peduncle, with, spreading out from it on all sides, the remains of an enclosing membrane or epidermal integument. A single specimen in the Gray collection shows this to a small extent. In the examination of a large series of *Nidulites* fragments, our great endeavour has been all along to obtain some definite insight into the charac-

ters of the true skeleton; but, with the exception of one specimen, our efforts have been quite unsuccessful. The specimen in question has enabled Mr F. G. Cuttell to prepare us a microscopic section showing the space previously mentioned as occurring between the cups and their casts occupied by carbonate of lime, but merely as an infilling, and not as the actual skeleton, since it consists of crystalline calcite.

(*d*) *Affinities.* — The nearest affinities of *Nidulites* are probably with *Cyclocrinites*, Eichwald, and *Receptaculites*, Defrance, but its relationships are extremely obscure. Two other forms to which *Nidulites* is even, perhaps, more closely allied, are *Sphærospongia*, Salter, and *Pasceolus*, Billings.[1] It is necessary for us to enter somewhat more into details connected with these genera before closing our remarks on *Nidulites*.

The genus *Pasceolus* (fig. 1 *a* and *b*) was described by the late Mr Billings as a body possessing "an ovate or globular form covered with an integument of small polygonal plates (?), and with one or more circular apertures. . . . At one end there is a narrow prolongation, which, most probably, constituted the pedicle by which the body was attached to the bottom. . . . A little below the mid-height of the body there is a small circular elevation which appears to mark the place of an orifice. . . . No sutures can be distinguished, and the form of the plates can only be made out as so many obscure convexities on the outside. . . . The cast shows the place of the sutures most distinctly, and that the plates were deeply concave on the inside. . . . The whole surface of the cast of the fossil is covered with small convex elevations. . . . Many of these elevations have a small round knob in the centre, with an obscure ridge radiating to the middle of each of the sides."[1] Mr Billings at one time referred *Pasceolus* to the Tunicata, but in his second description he considers its true zoological position to be "quite undecided."[2]

[1] Pal. Foss. Canada, i. 390, 391.

[2] Ibid., p. 392.

Messrs A. E. Verrill and W. H. Niles have referred,[1] and so, indeed, has Mr Billings,[2] to the resemblance of *Pasceolus* to *Cyclocrinites*, Eichwald.

Professor Verrill states that the exterior of *Pasceolus* "was formed by a shell of considerable thickness, composed of small hexagonal and pentagonal plates or prisms, having the outer

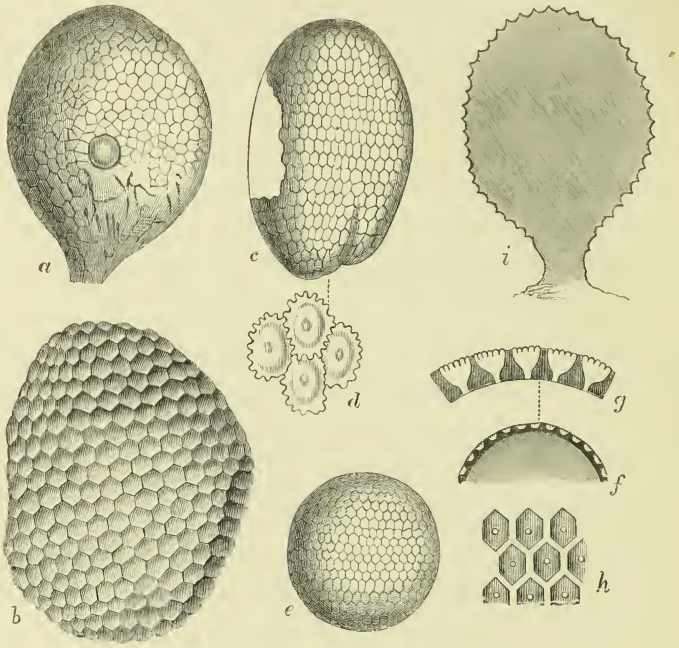

Fig. 1.—*a*, *Pasceolus Halli*, Billings, of the natural size, from the Middle Silurian of Anticosti. *b*, *Pasceolus globosus*, Billings, from the Trenton Limestone of Ottawa, of the natural size. *c*, *Sphærospongia mellifiua*, Salt., from the Silurian of India, of the natural size. *d*, Four of the integumentary plates of the same, enlarged. *e*, *Cyclocrinus Spaskii*, Eichwald, from the Silurian of Esthland, natural size. *f*, Part of a vertical section of the same, of the natural size, showing the thickness of the integument. *g*, Part of the test, enlarged. *h*, Portion of the mould of the inner surface of the same, enlarged. *i*, Diagrammatic representation of a vertical section of *Nidulites favus*, Salt., the central cavity being supposed to be filled with the matrix. (*a* and *b* are after Billings, *c* and *d* are after Salter, and *e*, *f*, *g*, and *h* are after Roemer.)

surface marked with raised radiating lines. Moreover, some of the specimens had the lateral openings well preserved, and surrounded by six plates differing in form from the rest." From this we gather that Verrill considered *Pasceolus* to be a

[1] Proc. Nat. Hist. Soc. Boston, 1864-66, x. p. 19.

[2] Pal. Foss., i. 392.

Cystidean : indeed, his colleague, Mr Niles, supported him in this view, and definitely referred *Pasceolus* to *Cyclocrinites*, Eichwald. It will be noticed that in Professor Verrill's description, a considerable advance is made in the structure of *Pasceolus* : we have prisms introduced, and the lateral openings surrounded by six plates, dissimilar to the others forming the test. To these criticisms Billings replied at some length,[1] dissenting from the views expressed by the above authors. He further pointed out that *Pasceolus Halli* is covered with a thin, translucent, horny, wrinkled integument, and also noticed its relationship to the form at present under consideration, in these words—"It may be that these bodies are akin to Salter's *Nidulites*."[2]

We now pass on to *Cyclocrinus* (fig. 1, *e-h*), small globular bodies, covered with hexagonal or pentagonal plates, and placed by Eichwald in the Cystoidea. Each of the plates has a tubercle in the centre, as before described in some conditions of *Pasceolus*, and similar obscure radiating ridges; the apex is provided with an orifice, considered to be oral, and the opposite extremity is provided with a small pedicle. There is also an incrustation present in one of the figured specimens, probably analogous to that mentioned by Billings in *Pasceolus Halli*. The latter author, although admitting the possibility of Cystidean affinities, shows that some of the essential structures of that order are wanting in *Cyclocrinus*. Eichwald further states that the plates of his genus rest on a common calcareous base, which passes between them, and fills the interstices.[3]

Dr F. von Roemer[4] has supplemented Eichwald's figures by giving a section of *Cyclocrinus* (fig. 1 *f*), in which are the plates of the test represented in the form of small cups with delicate styliform processes; and in another figure, which we suppose represents a cast of the cup-like plates, the place of the processes is represented in each by a median puncture. By Roemer *Cyclocrinus* is referred to the Receptaculitidæ. From

[1] Cat. Sil. Foss. I. of Anticosti, 1866, p. 71. [2] Ibid.
[3] Lethæa Rossica, i. p. 638. [4] Lethæa geognostica, 1876, Atlas, t. 3, f. 21, *a-e*.

the points we have brought forward, it is quite clear that even on Mr Billings's diagnosis there is a close resemblance between *Pasceolus* and *Cyclocrinus*, and if we accept the remarks of Messrs Verrill and Niles, there is a still closer one; however, if *Cyclocrinus* really possesses an apical aperture, then, as Billings has truly said, "it must be a distinct genus from *Pasceolus*."[1] Unfortunately we have no material at our disposal to enable us to express an opinion; we can only notice the relation of the two genera, one to the other, and to *Nidulites*.

We have now to consider the third genus, *Sphærospongia*, Salter (fig. 1 *c* and *d*), with which we are acquainted only from figures and descriptions given by Mr Salter. It was proposed in the "Geology of the Neighbourhood of Edinburgh,"[2] and described in the 'Palæontology of Niti,' the type of the genus being the large *Sphæronites tesselatus*, Phill. *Sphærospongia*, then, is an oval or pyriform body, hollow within, composed of a series of hexagonal or pentagonal plates, with sinuous margins, united laterally, and each bearing a central pit or depression. The walls are strengthened internally by longitudinal bars or ribs. The internal structure has been illustrated by Mr Pengelly.[3] Mr Billings has remarked[4] upon the resemblance between *Pasceolus* and *S. tesselatus*, Phill.[5]—viz., the same semi-pyriform outline and mammillated hexagonal plates. Mr Pengelly's figure, if it be the same fossil as the latter, represents the interior, with a network of vertical and longitudinal ribs.

Nidulites agrees with *Pasceolus* and *Sphærospongia* in the ovate, globular, or pyriform body, and probable pedicle, in the form of the plates composing the test, and, so far as the former is concerned, in the presence of the papillæ in the casts of the concave plates. There is, however, this very marked difference: in *Pasceolus* the plates are described as concave or cup-like, with the concavity directed towards the interior of the

[1] Cat. Sil. Foss. I. of Anticosti, p. 71.
[2] Mems. Geol. Survey, Scot. No. 32, p. 136.
[3] Geologist, 1861, iv. 340, 341.
[4] Pal. Foss. Canada, p. 392.
[5] Pal. Foss. Devon., t. 59.

body; but in *Nidulites* just the contrary occurs,—the plates are concave externally, and convex towards the hollow interior. The result of this is, that whereas the styliform processes of the cup-like plates in *Nidulites* are exhibited as papillæ on the whole concave casts of the organism, in *Pasceolus* they are seen on the convex cast of the interior of the body, producing in the perfect organism a very marked and peculiar structural difference. Moreover, if there are "circular apertures" or "circular elevations" in *Pasceolus*, there are none, nor any trace of any, so far as our observation has gone, in the numerous specimens of *Nidulites* examined by us. The absence of openings, again, will at once separate the latter from *Cyclocrinus*, if there exists one in the summit of that genus, as described by Eichwald, and another on the sides with modified plates, as observed by Verrill and Niles, who make *Cyclocrinus* and *Pasceolus* identical. On the other hand, with the aid of Roemer's well-executed figures, we observe that the feature which served as a point of departure between *Nidulites* and *Pasceolus* has, in the case of the former and *Cyclocrinus*, quite an opposite effect—in other words, the plates of the test are convex towards the hollow interior, and are prolonged inwards as a styliform process in a similar manner. This would produce in external casts similar papillæ to those seen on the surface of that particular condition of *Nidulites*. There is no trace of radiating striæ on the casts of *Nidulites*, as shown in *Cyclocrinus* and described in *Pasceolus*.

We are unfortunately precluded from doing more than calling attention to these facts. Much progress yet requires to be made in our knowledge of *Pasceolus*, *Cyclocrinus*, *Sphærospongia*, and *Nidulites*, before their exact relation to one another, and to the lower sections of Palæozoic Invertebrates, can be determined. That they are all congeneric we think there is little doubt, but which is identical with which it is at present quite impossible to tell; but so far as *Nidulites* is concerned, the balance of evidence appears to indicate *Pasceolus* and *Sphærospongia* (as typified by *S. hospitalis*, Salter) as its nearest connections. As regards the systematic position

of these forms, we are inclined to consider them very near to *Receptaculites*.

Nidulites favus, Salter.

(Pl. IX. figs. 15-22.)

N. favus, Salter, Quart. Jour. Geol. Soc., 1851, vii. 174, t. 9, f. 16, 17.
Palæopora favosa (pars), M'Coy, Brit. Pal. Foss., 1851, p. 15, t. 1 C, f. 3, *c* and *d* (excl. f. 3, *a* and *b*).
N. favus, Morris, Cat. Brit. Foss., 1854, 2d ed., p. 362.
,, ,, Huxley and Etheridge, Cat. Foss., Mus. Pract. Geol., 1865, p. 34.
,, ,, Salter, in Murchison's Siluria, 1867, 4th ed., pp. 188, 208, 509, foss. 30.
,, ,, Bigsby, Thesaurus Sil., 1868, p. 4.
,, ,, Salter, Cat. Camb. and Sil. Foss., Woodwardian Mus., Cambg., 1873, p. 72, fig.

Spec. char.—The characters of the species are essentially those given under the generic heading, and need not be repeated here.

Obs.—Prof. M'Coy described *N. favus* as a condition of his *Palæopora favosa*, and both mentioned and figured all the essential characters of the form as then known. Examination enables us to quite corroborate Mr Salter in the separation of the two species, for *P. favosa* is a common fossil at Craighead Quarry, near Girvan, and we have examined many specimens of it.[1]

A single individual, with the cups very much smaller in size, would almost induce us to found a new species for its reception, were it not that in one of the most complete representations[2] known to us of the very closely allied, if not identical, genus *Pasceolus*, the plates, or cups, become gradually smaller in size towards the base (of attachment?). The specimen in question, therefore, may be only a portion of the larger *N. favus*, although we are inclined to an opposite view. Should this example from Balcletchie ultimately prove to be distinct, we would propose for it the name of *Nidulites parvus*, Eth. and Nich.

Loc. and Horizon.—Mulloch Hill, in a fine-grained buff to

[1] See *post*, under *Lyopora favosa*. [2] Illinois Survey Report, iii. t. 5, f. 2ª.

liver-coloured sandstone of Upper Silurian age. (Gray *Coll.*) It is of frequent occurrence in a somewhat similar rock at Haverfordwest, N. Wales, of Llandovery age. *N. favus* has also been met with at the following further localities in the Girvan district: High Mains, Kirk Hill, Roughneuk Quarry, Craighead Quarry, Craigens, Barbae, and Letterpin (Geological Survey, collected by the late Mr R. Gibbs, and Mr A. Macconochie).[1]

Genus ISCHADITES, Murchison, 1839.

Ischadites, Murchison, Sil. Syst., 1839, pp. 697, 698.
„ Eichwald, Lethæa Rossica, 1860, v. 435.
„ Salter, Mem. Geol. Survey, 1866, iii. 282.
„ Bigsby, Thesaurus Siluricus, 1868, p. 3.
„ Salter, Cat. Camb. Sil. Foss., Woodwardian Mus., Cambg., 1873, pp. 40, 100.

Gen. char. — Globular, pedunculated bodies; surface subdivided by a number of direct or wavy ridges, crossing one another at oblique angles, into a series of rhomboidal or lozenge-shaped spaces; the peduncle terminating in a series of branching and diverging root-fibres; rhomboidal spaces subdivided by two lesser ridges crossing them at their greater and lesser diameters. Aperture situated at the apex.

Obs.—So far as we are aware, very little has been done to elucidate this genus. Many authors have united it with *Receptaculites*, Defrance, but although admitting that they appear to be very closely connected, and perhaps identical, we retain the name until the form has been more thoroughly worked out, and its characters better defined. The necessary material for this purpose is not accessible to us, and we cannot, therefore, offer more than a general opinion just now. *Ischadites* was considered by König to be an Ascidian allied to his genus *Leucophthalmus;*[2] by Salter[3] to be a regular sponge with vertical and transverse bundles of fibres resembling his genus

[1] Etheridge, Young, and Etheridge, Mem. Geol. Survey, Expl. 3, 1873, pp. 29-33; Armstrong, Young, and Robertson, Cat. W. Scot. Foss., 1876, p. 13.
[2] Icones Fossilium Sectiles, p. 1. [3] Mem. Geol. Survey, Scot., No. 32, p. 136.

Sphærospongia, and having roots[1] and an aperture like the recent genus *Grantia;* whilst by the larger majority of writers *Ischadites* has been, as stated above, referred to *Receptaculites*. The late Mr Billings stated[2] that the sculpture of *Ischadites* and of his *Receptaculites Canadensis* was quite similar.

According to Salter, the genus occurs in the Upper Llandeilo, Caradoc, Woolhope, Wenlock, and Ludlow beds.

The following are the British species known :—

I. antiquus, Salter, Mem. Geol. Survey, 1866, iii. 282; Upper Llandeilo, N. Wales.
I. Grindrodi, Salter, Bigsby's Thesaurus Siluricus, 1868, p. 4; Woolhope, &c.
I. Königii, Murchison, Sil. Syst., 1839, p. 697; Wenlock and Ludlow; Dudley, Malvern, &c.
I. micropora, Salter, Cat. Camb. Sil. Foss., Woodwardian Mus., Cambg., p. 40; N. Wales.
I. tesselatus, Salter, MS., Siluria, 1867, 4th ed., p. 509; Caradoc.

Ischadites Königii, Murchison.

I. Königii, Murchison, Sil. Syst., 1839, p. 697, t. 26, f. 11.
Receptaculites Neptuni (pars), D'Archiac and De Verneuil, Trans. Geol. Soc., 1842, 2d ser., vi., pt. 2, p. 407.
„ „ C. F. Roemer, das Rhein, Ubergangs. 1844, pp. 59, 60.
„ „ Bronn, Index Pal. Nomen., 1849, p. 1079.
„ „ Morris, Cat. Brit. Foss., 2d ed., 1854, p. 363.
I. Königii, Salter, in Murchison's Siluria, 4th ed., 1867, p. 509, t. 12, f. 4.
„ „ Gray, Proc. Nat. Hist. Soc., Glasgow, 1868, i. 169.
„ „ Bigsby, Thesaurus Sil., 1868, p. 3.
„ „ Salter, Cat. Camb., Sil. Foss., Woodwardian Mus., Cambg., 1873, p. 100.
„ „ Armstrong, Young, and Robertson, Cat.W. Scot. Foss., 1876, p. 13.

Obs.—The Gray collection contains two specimens of *Ischadites*, both fragmentary, and without the original integument preserved. The larger of the two specimens is probably an example of *I. Königii*, whilst the second appears to us to have areolæ possessing more the characters of *I. antiquus*, Salter; it shows the top and the so-called aperture. Neither of the

[1] Pal. of Niti, 1865, p. 48. [2] Pal. Fossils of Canada, i. 384.

specimens affords characters sufficient for description. *Ischadites* was first indicated as a Girvan fossil by Mr R. Gray, F.R.S.E.

Loc. and Horizon. — Balcletchie, near Girvan, in a fine-grained shale of Upper Silurian age. Penkill, in a fine greenish-coloured conglomerate, also of Upper Silurian age (smaller specimen). Gray *Coll.*

Genus SACCAMMINA, Sars.

(Vidensk.-Selsk, Förhandl., 1868.)

Saccammina Carteri, H. B. Brady.

(Pl. IX. fig. 23.)

Saccammina Carteri, H. B. Brady, Ann. and Mag. Nat. Hist., ser. iv., vol. vii. p. 177, Pl. XII., 1871. Also, in Monograph of the Carboniferous and Permian Foraminifera, Pal. Soc., p. 57, Pl. I., figs. 1-7, and Pl. XII., fig. 6, 1876.

Having obtained from the "Craighead Limestone," at Tramitchell, some small fossils which we believed to be referable to the above species, we submitted them to our friend Henry B. Brady, Esq., F.R.S., one of the greatest of living authorities upon the fossil and recent *Foraminifera*, and he not only confirmed our determination, but kindly furnished us with the subjoined notes upon this interesting form, as well as upon the microscopical characters of the limestone in question. The other Microzoön referred to by Mr Brady as probably allied to the recent genus *Hyperammina* we have thought it well to describe provisionally under the name of *Girvanella problematica*, a title which does not imply its absolute identity with the living form :—

"Of the specimens of limestone which I have examined some are very dark-grey, others lighter coloured and brownish. The polished surfaces of the latter often show blue-grey patches, as though the brown tint were due to some alteration in chemical composition. The rough weathered surface of the stone is studded with fossil remains of one sort or other, chiefly the projecting fractured ends of the stems of encrinites; but there

are in addition certain rounded bodies varying in size from 1-20th to 1-8th of an inch in longer diameter. These are generally too much worn, and otherwise altered, to give any satisfactory indications of their nature or origin; but transparent sections of the rock leave no sort of doubt that they are segments of *Saccammina Carteri*, a well-known Carboniferous Rhizopod.

"In the Carboniferous limestones *Saccammina* is sometimes so abundant that the rock may fairly be said to be built up of its remains: in other cases it is sparsely distributed, the segments are few and far apart, but individually they are of larger size. At Elfhills, in Northumberland, where the fossil was originally discovered, both these conditions exist, a thin bed near the surface being crowded with the fusiform segments; whilst in a much thicker bed, lower down in the series, they are few and far between.

"The Girvan limestones, such of them as I have seen, bear considerable resemblance to the lower of these two formations; but the specimens of *Saccammina*, as indeed of all the fossils, have undergone even more change in the process of mineralisation than is usual in the Carboniferous rocks. The chambers are completely filled with crystalline carbonate of lime, which has become so incorporated with the substance of the shell-wall as to obliterate its principal structural features, so that in transparent sections of the limestone, the segments often appear only as colourless rounded patches, without any trace of the original investment. At times the peripheral portions are slightly denser, and less transparent, than the rest of the patch, whilst an occasional specimen still shows the outline and thickness of the shell-wall with comparative distinctness. So far as can be observed, the *Saccammina* of the Girvan limestone agrees precisely in size, form, and structure with that of the Carboniferous beds.

"Under the most favourable conditions it is not easy to identify the Microzoa of compact sub-crystalline limestones; and from the fragments of minute fossils which appear in the

sections of the Girvan rock there is scarcely anything to be gathered. One organism, however, deserves a passing notice from the frequency with which it is met with. It is found in the form of little masses of thin, fine, arenaceous tubes—either a continuous tube of nearly even diameter coiled irregularly on itself, or possibly of more than one, intertwined. The masses are exceedingly minute, and they are too obscure for detailed description, but they are of interest in connection with certain organisms of the genus *Hyperammina* recently obtained from the deep-water dredgings of the Challenger expedition. One of these, of which the description and figures are not yet published (*H. vagans*, Brady, MS.) often occurs in a condition very similar to these little bodies, though usually of much larger size. When quite perfect the recent species has a swollen primordial chamber, but it is very rarely, indeed, that complete specimens are met with. I know of no other organism, recent or fossil, that these little masses of tubes so closely resemble."

Genus GIRVANELLA, Nich. and Eth., jun. *Gen. nov.*

Gen. char. — Microscopic tubuli, with arenaceous or calcareous (?) walls, flexuous or contorted, circular in section, forming loosely compacted masses. The tubes apparently simple cylinders, without perforations in their sides, and destitute of internal partitions or other structures of a similar kind.

Obs.—We have founded the above provisional genus for the minute fossils alluded to above, to which, for convenience' sake, we shall attach the following specific title—

Girvanella problematica, Nich. and Eth., jun. *Sp. nov.*
(Pl. IX., fig. 24.)

Spec. char. — Tubes from 1-600th to 1-700th of an inch in diameter, not observed to taper, twisted together in loosely reticulate or vermiculate aggregations of a rounded or irregular shape, which seem to be mostly from 1-20th to 1-10th of an inch across.

Obs.—Minute bodies having the above structure are very abundant in the "Craighead Limestone" in certain beds, and seem to deserve notice and a name. Their presence can sometimes be recognised by the naked eye, in the form of small irregular patches of a brownish or greyish colour; but we have only been able to examine them by means of transparent slices of the stone, and we know nothing of their external characters. Microscopic examination shows them to consist of small detached aggregates of twisted or flexuous cylindrical tubes, which are clearly hollow, and are presented to us with such a variable section as to show that they were irregularly contorted. Many are cut right across, and show only the divided ends of the tubes; others are shown in short lengths of varying extent. Here and there two or three tubes run side by side, but they unquestionably were independent of each other, never actually attached by their walls; and they are always so loosely reticulated together that the interstices of the mass are filled up with transparent calcite, readily distinguishable from the more opaque and granular matrix which surrounds them.

As to the affinities of these curious bodies we are inclined to regard them as Rhizopods. Our friend John Murray, Esq., suggested to us that they might possibly be of the same nature as certain Rhizopod-tubes obtained by the Challenger Expedition, and about to be described by Mr H. B. Brady under the name of *Rhizammina algæformis;* and they certainly have a curious resemblance to these. The last-named authority, however, as before stated, thinks that they are more nearly allied to forms like *Hyperammina vagans* "with an unlimited length of fine, thin, arenaceous tube, which curls, twists, coils, and plaits itself in every conceivable way" (H. B. Brady, in a letter to the authors).

Form. and Loc.—Very abundant in parts of the "Craighead Limestone," at Tramitchell, near Girvan. (*Coll.*, H. A. Nicholson.

SUB-KINGDOM CŒLENTERATA.

CLASS ACTINOZOA.

Genus LYOPORA, Nich. and Eth., jun. *Gen. nov.*

Gen. char. — Corallum composite, massive, composed of tubular, sub-cylindrical, or hexagonal corallites, which are more or less completely fused with one another. Walls of the corallites extraordinarily thick and dense, destitute of mural pores. Columella absent. Septa rudimentary, few in number, having the form of irregular obtuse ridges on the interior of the wall. Tabulæ complete. No cœnenchyma.

Obs.—We have found ourselves compelled to establish the new genus *Lyopora* for the reception of the very singular corals described by Prof. M'Coy under the name of *Palæopora* (?) *favosa* (Ann. and Mag. Nat. Hist., ser. 2, vol. vi. p. 285), the same name being subsequently given to it, without the note of interrogation (Brit. Pal. Foss., p. 15). In both the descriptions quoted, M'Coy expresses the opinion that this coral should probably be regarded as a new genus, and this surmise we are fully able to sustain. The reference of the coral under consideration to the genus *Palæopora*, M'Coy (=*Heliolites*), was the result of a reliance upon appearances which are wholly illusory, its affinities with *Heliolites* being of the slightest possible character. The total absence of "cœnenchymal tubuli," as conclusively demonstrated by thin sections, is sufficient proof of this, and M'Coy's belief in the existence of such tubules appears to be really based only upon the occasional existence of small interspaces, of an entirely irregular character, at the angles of junction of the corallites, or sometimes in the substance of the thick walls of these tubes. Microscopic examination also renders it quite certain that M'Coy was in error in supposing that a columella was present, no traces of such a structure existing. He does not state specifically whether he

had observed this organ in specimens preserved in the limestone; but we should be disposed to think that his belief in the occurrence of a columella was really based upon the bodies which he describes as the *casts* in sandstone of *Palæopora favosa;* these bodies in reality being (as noted by Salter, Quart. Jour. Geol. Soc., vol. vii., p. 174) unquestionably casts of the singular *Nidulites favus*, and having, therefore, no connection with the present form.

In superficial aspect, as remarked by M'Coy, the corals of this genus closely resemble *Favosites;* but they are fundamentally distinguished therefrom by the immense thickness of the wall, the absence of mural pores, and the presence of rudimentary septa. The genus, in fact, is apparently most closely allied to those forms of *Columnaria*, Goldfuss (as this is usually understood), in which the septa are imperfect and marginal; but it is sufficiently separated by the enormous development of the walls of the corallites, the comparative irregularity of these tubes, and the more incomplete condition of the septa.

The only other genus with which the present could be confounded, and the resemblance between the two is very remote, is *Pachypora*, Lindström. In the latter, however, apart altogether from differences of size, form, and mode of growth, the thickening of the walls of the corallites is by the deposition of successive concentric layers of carbonate of lime, and mural pores are present.

Lyopora favosa, M'Coy, *sp.*

(Pl. II., figs. 1-1 *c*.)

Palæopora (?) *favosa*, M'Coy, Ann. and Mag. Nat. Hist., ser. 2, vol. vi. p. 285, 1850.
„ *favosa*, M'Coy, Brit. Pal. Foss., p. 15, Pl. I. C, fig. 3, 1851.
Heliolites (*Palæopora*) *favosus*, Salter, Quart. Jour. Geol. Soc., vol. vii. p. 170, 1851.

Spec. char.—Corallum composite, massive, spheroidal, hemispheric, pyriform, or irregular in shape; the corallites subcylindrical, elliptical, hexagonal, or irregular in outline, firmly

united with one another. Calices usually circular or hexagonal, averaging a line and a half in diameter, the lip coarsely granular. Walls imperforate, extraordinarily thick, the interspaces between any two contiguous calices being occupied by dense calcareous tissue, of from three-quarters of a line to more than a line in thickness, sometimes with minute and entirely irregular vacuities. Septa rudimentary, often wanting in individual calices, varying in number from two or three up to ten or twelve or more, always abortive, and represented only by rough and blunt ridges on the interior of the wall. Visceral chamber crossed by strong, solid, complete tabulæ, distant from a line to a line and a quarter from one another.

Obs.—In their great work on British Fossil Corals, Milne-Edwards and Haime express the opinion that this species is really founded upon ill-preserved specimens of *Heliolites interstincta*, Wahl. (Brit. Foss. Corals, p. 250). It should be remembered, however, that this opinion was not based upon any inspection of actual specimens, and that it was to a large extent justified by the very misleading figures of the internal structure of the species given by M'Coy (Brit. Pal. Foss., Pl. I. C, figs. 3 *a* and 3 *b*).[1] On the other hand, the careful examination of a large number of specimens, both macroscopically and by means of microscopic sections, has thoroughly satisfied us not only of the validity of the species, but also of its belonging to a special generic type. So great, indeed, are the discrepancies in the respective observations of M'Coy and ourselves as to the structure of this coral, that we were at first disposed to think that we must be in error in supposing that our form was that originally described as *Palæopora* (?) *favosa*. M'Coy, however, only gives two localities for his fossil—viz., in the limestone of Craighead, near Girvan, where it is said to be "extremely abundant," and in the sandstone of Mulloch Quarry, where it is said to occur in the state of casts. The

[1] These figures have similarly misled Lindström, who, in a list of Silurian Corals from Sweden (Öfversigt. af Kongl. Vetenskaps Akad. Förhandl., 1873), describes a *Heliolites* under the name of *Heliolithes favosus*, M'Coy.

supposed casts of the latter locality are undoubtedly referable to *Nidulites favus*, so that we have only the specimens from the limestone to deal with; and as the form which we consider to be *Palæopora* (?) *favosa*, M'Coy, not only occurs abundantly at Craighead, but is the only coral which could possibly be supposed to agree with M'Coy's description and figures, we cannot doubt the identity of the two.

As regards its general form, *Lyopora favosa* appears to be very variable, but it occurs most commonly as pyriform or subhemispheric masses (Pl. II., fig. 1), which are rooted at one point, and seem to have the whole of the rest of the surface covered with the calices, the corallites thus diverging from a basal point or from a median line. No epitheca seems to have existed. The size of ordinary specimens varies from an inch or less in height and breadth up to half a foot or more. The calices are rarely well preserved, but even in worn examples their margins are rendered tubercular by the rudimentary septa. The most conspicuous feature in the minute structure of the species is certainly the great thickness of the walls of the corallites, as shown both in tangential and vertical sections. Microscopic examination of such sections (Pl. II., figs. 1 *b*-1 *e*) conclusively proves the total absence of both "mural pores" and "cœnenchymal tubules," and the figures of the latter given by M'Coy (*loc. cit.*) cannot, therefore, be accepted as otherwise than apocryphal. The calcareous walls of the corallites (Pl. II., fig. 1 *e*) are in fact quite compact, usually fused completely with one another, or sometimes allowing the junction between contiguous tubes to be detected, and occasionally showing minute irregular spaces, which are undoubtedly only due to imperfect deposition of the sclerenchyma. The tabulæ are remote, approximately horizontal, and unusually thick; and though best seen, of course, in vertical sections, they are often displayed in portions of tangential sections, either owing to the plane of the section cutting some of the corallites obliquely, or to its absolutely coinciding with the plane of a tabula. Lastly, the septa (Pl. II., 1 *a* and 1 *e*) vary much in number, appearing

most commonly to be from ten to fifteen, but they are always mere blunt inward projections of the wall.

Form. and Loc.—Abundant in the limestone and calcareous shales (Lower Silurian) of Craighead, near Girvan. (*Coll.*, Mrs R. Gray and H. A. Nicholson.)

Genus TETRADIUM, Dana, 1846.

(Wilkes's Expl. Exped. Zoophytes, p. 701.)

Gen. char.—Corallum massive, sub-hemispheric or irregular in form, composed of long prismatic corallites, in close contact, but not amalgamated by their walls, and not arranged in superimposed strata in the typical forms. No mural pores; septa distinct, few in number, typically four, short, not reaching the centre of the visceral chamber, seeming as if formed by inflections of the wall. Calices generally petaloid, as are the corallites in transverse section. Tabulæ numerous, complete. Increase by fission of the old tubes.

Obs.—The genus *Tetradium* is a small and peculiar one, which, as we have elsewhere suggested (Ann. Nat. Hist., ser. 4, vol. xx., p. 163), may perhaps be placed in the neighbourhood of *Halysites*, though it has certain resemblances to *Chætetes*. It is easily recognised, in typical examples, by the peculiar shape of the long imperforate tubular corallites, which, in transverse section, appear to be petaloid, owing to the presence of generally four or five short septa, formed by inflections of the wall. The accompanying engraving (fig. 2) shows the minute structure of the corals of this genus, as displayed in transverse and vertical sections.

Though common in the Lower Silurian of North America, the genus *Tetradium* was not recognised as occurring in Britain, till we pointed out (*loc. jam cit.*) that a peculiar form belonging to it was present in pebbles of Silurian limestone contained in the Old Red conglomerates of Habbie's Howe, in the Pentland Hills, near Edinburgh. These pebbles are

peculiar in being often composed of a coarsely oolitic limestone; and at the time that we described the form of *Tetradium* in question, we were unable to point to any limestone of similar characters as occurring in place in the Silurian series of

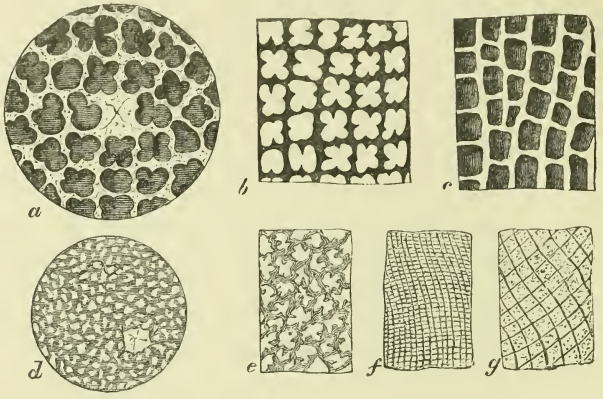

Fig. 2.—*a*, A small portion of a transverse section of *Tetradium minus*, magnified about ten diameters. The section is a transparent one; and the visceral chambers of the corallites, being filled up with the matrix, appear black, whilst the walls are composed of crystalline calcite; in the centre of the section is a vacant space filled with calcite (a water-canal?). *b*, Portion of polished transverse section of same, not so highly magnified; in this section the visceral chambers appear as light spaces, and the walls are dark. *c*, Portion of a longitudinal section of the same, showing tabulæ. *d*, Portion of a transparent transverse section of *Tetradium Peachii*, Nich. and Eth., jun., magnified about twenty diameters. Near the bottom of the section a water-canal (?) is seen cut across. *e*, Portion of transverse section of the same, magnified still further. *f*, Portion of the longitudinal section of the same, magnified about fifteen diameters. *g*, Portion of the same, enlarged still further.

Scotland. Since then, however, we have found that a similar oolitic limestone, of Silurian age, is developed in at least two localities near Girvan—viz., plentifully at Tramitchell, and to a less extent at Craighead; and we have further had the satisfaction of finding that the limestone at the latter place is largely made up of masses of the same *Tetradium* (*T. Peachii*) as that of the pebbles of the Habbie's Howe conglomerate. We can hardly doubt, therefore, that these pebbles were derived originally from the existing Craighead limestone of Girvan, or from some former extension of this bed.

Tetradium Peachii, Nich. and Eth., jun.

(Pl. I., fig. 3, and Pl. II., figs. 1-1 *b*.)

Alveolites (?), sp., R. Eth., jun., Proc. Roy. Phys. Soc. Edinb., 1874-75, p. 51.
,, (?), *Peachii*, R. Eth., jun. (MS.), Coll. Geol. Survey of Scotland, Mus. Science and Art, Edinb.
Tetradium Peachii, Nich. and R. Eth., jun., Ann. and Mag. Nat. Hist., ser. 4, vol. xx. p. 166.

Spec. char. — Corallum massive, very irregular in shape, often more or less lobulate on the surface, composed of excessively minute, closely approximated corallites, from 1-25th to 1-35th of a line in diameter. The corallites are amalgamated by their comparatively thick walls, irregularly circular or oval in outline, running parallel with one another in straight, slightly curved, or undulating lines. Very often the corallum consists of successive layers of corallites disposed in a concentric manner round one or more centres. Septa generally present, mostly three or four in number, short, looking as if formed by an inflection of the wall of the corallite, to the transverse section of which they communicate a petaloid aspect. Tabulæ usually numerous and complete.

Obs.—As before remarked, this singular form is extremely abundant in the Silurian limestone of Craighead, near Girvan, and the specimens from this locality are in a much better condition for microscopic examination than those from the pebbles in the Habbie's Howe conglomerate. We are therefore now able to confirm our former reference of the species to the genus *Tetradium*, and we are in the position to describe some additional points in its minute structure. As seen at Craighead, *Tetradium Peachii* occurs both in the limestone and in its associated shales, and presents itself in the form of wholly irregular masses, of very variable size. Small masses from the shale range from three lines to an inch and a half in diameter, and are generally more or less spheroidal or oval in shape. When not obscured by matrix, the surface is often more or less con-

spicuously mammillated or botryoidal (Pl. I., fig. 1 *b*), but in no case have we succeeded in detecting the calices by a simple examination of the weathered surface with a lens. Specimens from the limestone rarely weather out to any extent, and yield to fracture as if they formed part of the rock itself. They form masses often two or three inches in diameter, which are easily recognised by their whitish or light-brown colour, and by their dense texture; and which not uncommonly show on broken surfaces an arrangement in concentric layers of growth, similar to that observed in the specimens from the Habbie's Howe conglomerate, and reminding one of some of the more compact forms of the Stromatoporoids.

Even in the Craighead specimens, the minute structure of *Tetradium Peachii* can only be made out by transparent slices, examined with the microscope. Transverse sections (Pl. I. 3), when they are at all accurately at right angles to the corallites, show that these possess the characteristic form of the tubes in this genus. Extraordinarily minute as the corallites are — generally about 300 in the space of an inch—they usually show the characteristic petaloid form and the four short septa of *Tetradium*. The septa, however, vary from one to five, and in many of the corallites they can only be detected with difficulty, apparently owing to the fact that the section does not pass through the tubes at right angles to their long axis. In long sections (Pl. II., figs. 1 and 1 *a*), the corallites are seen to generally possess more or less wavy walls, and to increase by fission, and the chief new point that we have noticed is that the tabulæ are very variable in their occurrence. In the Habbie's Howe specimens the tabulæ seem to be rarely wanting, and they are usually very numerous and close-set (*see* fig. 2, *f* and *g*). In the Craighead specimens tabulæ of a similar character are sometimes present (Pl. II., fig. 1); but they may be only present in a portion of a mass, and in many sections (Pl. II., fig. 1 *a*) they cannot be detected at all. This, however, is only in accordance with what we know commonly to occur in *Favosites* and other similar forms, in which the

tabulæ often seem to have been completely or partially destroyed during fossilisation. Lastly, in many of the specimens from Habbie's Howe, we have noticed that the corallum is perforated by irregular tubes, perhaps of the nature of water-canals, varying from 1-40th to 1-50th of an inch in diameter; but we have not detected similar structures in the examples from Ayrshire.

The rediscovery of this peculiar coral at Girvan is a point of particular interest. Whence the limestone blocks and pebbles containing *T. Peachii*, contained in the Habbie's Howe conglomerate, originated, was to us, as to all others who had examined them either *in situ* or in the laboratory, an unsolved problem; for on appealing to Professor Geikie, F.R.S., we found that he was unacquainted with such a limestone at any other locality known to him in Scotland. Although the abundant occurrence of *T. Peachii* in the Craighead limestone, accompanied as it is at times by the well-marked oolitic structure so common in some of the Pentland Hill pebbles, would justifiably lead one to suppose that we had here met with the point of origin of the pebbles in question, still this is not altogether borne out by the other coral forms which accompany *T. Peachii* at the latter locality. We here meet with, in the same blocks, such forms as *Halysites* (*H. catenularia*, Linn.?), *Plasmopora* (*P. petalliformis*, Lonsd.?), *Favosites* (2 or 3, sp.), one of the latter very near *F. Hisingeri*, Ed. and H., *Heliolites* (*H. interstincta*, Linn.?). These corals have been very carefully examined by one of the writers and Dr J. C. Purves, and although there may be some little doubt as to the exact specific identifications arising from the mode of preservation of the specimens, we have little hesitation in placing reliance on them.

Form. and Loc.—Very abundant in the limestone (Lower Silurian) of Craighead, near Girvan. (*Coll.*, Mrs R. Gray and H. A. Nicholson.) Also in pebbles of limestone of Silurian age contained in the Old Red Sandstone conglomerate of Habbie's Howe, Pentland Hills, near Edinburgh. (*Coll.*, J. Henderson, R. Etheridge, jun., and Geol. Surv. Scot.)

Genus Favosites, Lamarck, 1816.

(Hist. des An. sans Vert., vol. ii. p. 204.)

Favosites Girvanensis, Nich. and Eth., jun., *sp. nov.*

(Pl. I., figs. 2-2 *c*.)

Spec. char.—Corallum diminutive, discoidal or sub-hemispheric in shape, with a flat or convex base, which is covered by a concentrically wrinkled epitheca. Diameter varying from half an inch to rather more than an inch, and the height from three to eight lines. Corallites prismatic, thin-walled, three- to six-sided, closely approximated, of unequal sizes, the average tubes being from a third to a fourth of a line in diameter, generally the latter, while the angles of junction of these are filled in by much smaller tubes. Mural pores not detected. Septa wholly absent. Tabulæ, when preserved at all, few and remote, distant from one another from one-third to one-half of a line. Walls of the corallites in longitudinal sections more or less undulated and wavy.

Obs.—This little *Favosites* occurs in plenty in the shales associated with the limestone at Craighead, near Girvan; and from the fact that its tubes exhibit wavy margins in longitudinal section, we were disposed at first to think that it might possibly be the young form of *Favosites aspera*, D'Orb. After examining and cutting some fifty specimens, however, we have come to the conclusion that it is really quite distinct from this form, and, indeed, from all other described species. We are very reluctant to add a new species to the already numerous and often imperfectly defined forms of *Favosites*, but the present species has peculiarities which preclude our placing it under any type known to us. That it is merely the young of some other form, as we at first imagined, is sufficiently disproved by the fact that of the large number of individuals known to us, no one exceeds one and a quarter inch in diameter, while most are considerably under the inch—no other larger form of the genus

Favosites being at present known to occur at all in the same beds. We are therefore bound to accept it as an adult form. Not only does its size become thus a specific character, but its discoidal form and concave base, with its concentrically striated epitheca (Pl. I., figs. 2 and 2 *a*), are equally so. In these last-mentioned features, *Favosites Girvanensis* agrees with the associated *Prasopora Grayæ*, nobis, as well as with small examples of *Chætetes petropolitanus*, Pand., to both of which it presents a very close superficial resemblance. The latter, however, does not occur at all (so far as we know) in the Craighead limestone, and even if it did, is quite distinct in its minute structure, the latter observation holding true of *Prasopora* also. As it occurs only in the shales associated with the Craighead limestone, *F. Girvanensis* shares with all the forms from this position the misfortune of almost never exhibiting any distinct structural features until it is sectioned; but its characters can be readily determined by microscopic examination. That it is a true *Favosites* is, in our opinion, sufficiently shown by the prismatic, thin-walled, closely-approximated tubes, the total absence of cœnenchyma and of septa, and the characters of the tabulæ when present. That we should have failed to detect mural pores does not invalidate this conclusion, as these structures can rarely be detected except in specimens showing the exterior of the tubes, and we possess none such. Nor does the variable condition of the tabulæ, and their commonly-occurring total absence, materially affect our views, since similar conditions are well known to obtain in apparently similarly preserved specimens of the larger forms of this genus. When present, however, the tabulæ are characteristic, in their comparatively small number, and the distance at which they are placed from one another (Pl. I., fig. 2 *b*). In all cases, also, the markedly wavy and undulated walls of the tubes (Pl. I., fig. 2 *c*) are highly characteristic. The other points which seem to us to adequately separate this form as a distinct species are the diminutive size, the constant discoidal form, the concave base, the concentrically wrinkled epitheca, the small size

of the corallites, and the presence of minute prismatic tubes intercalated between those of average size.

Form. and Loc.—Not uncommon in the shales associated with the limestone at Craighead, near Girvan. (*Coll.*, Mrs R. Gray.) We have also a single specimen from the Gray collection, which is labelled as coming from Penkill, near Girvan, the greenish mudstones of this locality being much higher in the Silurian series than the Craighead limestone.

Favosites Mullochensis, Nich. and Eth., jun., *sp. nov.*

(Pl. II., figs. 2-2 *b*.)

Spec. char.—Corallum small, forming ovoid or hemispherical masses, from half an inch to an inch in diameter. Corallites more or less pentagonal, with very thin wavy walls. The majority of the tubes large, from half a line to nearly a line in diameter, but having wedged in between them a few much smaller tubes. Mural pores apparently few and remote, not serially disposed. Septa wanting. Tabulæ few, very delicate, remote, from half a line to a line apart, generally represented only by short spines springing from the undulated walls of the tubes.

Obs.—This appears to be a genuine *Favosites*, though in some respects an abnormal one. We possessed only three specimens to work with, and in all of these, owing to the great thinness of the walls of the corallites, the internal structure had been to some extent obscured by fractures taking place during fossilisation, while in all the specimens the tubes had been largely filled up with the matrix, and were only infiltrated with calcite in their centre. When viewed in transverse section (Pl. II., fig. 2 *a*) the corallites are seen to be mostly of large size, though here and there a very small tube is intercalated between the others. The tubes are not strictly rectilinear, as in the most typical species of *Favosites*, but the walls are usually more or less curved, and often at places sharply bent and wrinkled — this latter feature perhaps due to changes

taking place showing mineralisation. In the only specimen in which we could detect mural pores, these openings are few, large-sized, and irregular in distribution. The most characteristic features of the species are seen in longitudinal sections (Pl. II., 2 *b*), and are displayed by all our specimens. These features are,—firstly, the fact that the walls of the tubes are conspicuously undulated; secondly, the presence of a very few extremely thin tabulæ; and thirdly, the fact that the majority of tabulæ are represented by short spines springing from the walls.

Form. and Loc.—In the dark-green mudstone (Upper Silurian) of Mulloch Hill. (*Coll.*, Mrs R. Gray.)

Favosites Gothlandica, Lamarck.

Favosites Gothlandica, Lamarck, Hist. des An. sans Vert., vol. ii. p. 206, 1816.
Calamopora Gothlandica, Goldfuss, Petref. Germ., Pl. XXVI., figs. 3 *a*, 3 *b*, 3 *c*, 3 *e* (cæt. exclusis), 1829.
Favosites sub-basaltica, D'Orbigny, Prodr. de Paléont., vol. i. p. 49, 1850.
,, *Gothlandica*, M'Coy, Brit. Pal. Foss., p. 20, 1851.
,, *Goldfussi*, D'Orbigny, Prodr. de Paléont, vol. i. p. 107, 1850.
,, *Goldfussi*, Milne-Edwards and Haime, Pol. Foss. des Terr. Pal., p. 235, Pl. XX., fig. 3, 1851.
,, *Gothlandica*, Milne-Edwards and Haime, Brit. Foss. Cor., p. 256, 1854.
,, *Niagarensis*, Hall, Pal. N.Y., vol. ii., Pl. XXXIV. A, bis, fig. 4, 1851.
,, *Gothlandica*, Billings, Can. Journ., new ser., vol. iv. p. 99, 1859.
,, *Gothlandica*, Nicholson, Report on the Palæontology of Ontario, 1874, p. 45.

(For a full synonymy of *F. Gothlandica* up to the year 1854, see Milne-Edwards and Haime in Brit. Foss. Cor., p. 256.)

Obs.—So far as the specimens which we have personally examined are concerned, the only undoubted examples of *Favosites Gothlandica*, Lam., are some that were detected by our friend Mr Charles Lapworth, F.G.S., in a limestone-band on the shore near Girvan. They are well preserved, and are in all respects identical with the typical examples of this species from the Upper Silurian and Devonian; but as they present no points of special interest, they need no further description here. They are associated with the next species (which we

believe to be *Alveolites Labechei*), and with casts of a small *Pentamerus*, and they are noteworthy as indicating the existence of a limestone near Girvan, of Llandovery or Wenlock age.

Form. and Loc.—Common in a coralline limestone-band on the sea-shore, not far from Shalloch Mill, near Girvan. (*Coll.*, Mr Charles Lapworth.)

Genus Alveolites, Lamarck, 1801.

(Syst. Anim. sans Vertebres., p. 375.)

Alveolites Labechei, Edw. and H.

Favosites spongites (pars), Lonsdale, in Murchison's Sil. Syst., Pl. XXV., bis, figs. 8, 8 *b* (cæt. exclusis), 1839.
Calamopora spongites, Eichwald, Sil. Syst. in Esthland, p. 197, 1840. (Not *Calamopora spongites* of Goldfuss.)
Alveolites Labechei, Milne-Edwards and Haime, Pol. Foss. des Terr. Pal., p. 275, 1851.
„ „ Milne-Edwards and Haime, Brit. Foss. Cor., p. 262, 1854.

Obs.—The limestone-band which we have referred to in the description of the previous species has yielded to the researches of Mr Lapworth specimens of an *Alveolites* which we feel no hesitation in identifying with *A. Labechei*, Edw. and Haime. Our examples do not show any surface-characters, but microscopic sections indicate that the internal structure is well preserved, and this is quite in accordance with that of specimens of the well-known Wenlock form, so that it will be unnecessary to occupy any space here with a detailed description.

Form. and Loc.—In a band of coralline limestone on the sea-shore, not far from Shalloch Mill, near Girvan. (*Coll.*, Mr C. Lapworth.)

Genus Fistulipora, M'Coy, 1849.

(Ann. Nat. Hist., ser. 2, vol. iii. p. 130.)

Gen. char.—Corallum very variable in form, encrusting, sub-massive, massive, or ramose, composite, of numerous com-

paratively large-sized corallites surrounded by a very varying number of smaller tubes (the latter corresponding to the "cœnenchymal tubules," so-called, of *Heliolites* and its allies). Septa wanting. Tabulæ well developed and complete, usually more numerous in the smaller than the larger tubes. No mural pores. Larger corallites typically circular, and usually with slightly exsert calices.

Obs.—Though it is not possible at present to limit the genus *Fistulipora* precisely, we may include under the above emended definition a number of Palæozoic corals, which for the most part present unusual difficulties in the way of their study. The superficial features of these forms—especially the presence of large-sized circular corallites, usually with slightly elevated calices, without septa, and surrounded by smaller circular or angular tubes—are sufficiently distinct to separate them readily from their allies, such as *Chætetes*. The absence of mural pores and of septa, and the presence of complete tabulæ in both sets of tubes, are the chief features in their internal organisation. We have no personal knowledge of forms with funnel-shaped tabulæ in the larger tubes —a character to which generic importance is assigned by M'Coy —nor have we ever observed the tabulæ to be confined to the smaller tubes, and wholly wanting in the larger ones.

We cannot enter here into a discussion as to how far *Fistulipora*, M'Coy, covers the ground occupied by the later genus *Callopora*, Hall (Pal. N.Y., vol. ii. p. 144, 1852). Our present impression, however, is that the two are incapable of separation, in which case M'Coy's name must be retained. Nor have we found it possible to accurately compare the species of *Fistulipora* which we are about to define with the very numerous forms of *Fistulipora* and *Callopora* which have been described by American palæontologists from Silurian and Devonian strata. There exist, in fact, no sufficient elements for such a comparison, since the American species are at present mostly known only by short verbal descriptions, rarely accompanied by figures, and for the most part without allusion

to the microscopic structure. Under these circumstances, we are therefore compelled to describe the following species as new.

Fistulipora favosa, Nich. and Eth., jun., *sp. nov.*

(Pl. II., figs. 3-3 *c*.)

Spec. char.—Corallum sub-massive, composed of numerous closely-approximated slender corallites, which diverge from an expanded base of attachment. Calices very markedly of two sizes, the larger ones circular or oval, and the smaller ones more or less angular, the former varying from 1-7th to 1-6th of a line in diameter, and the latter from 1-12th to 1-6th of a line. One or two rows of the smaller calices intervene between the larger, the latter being thus separated from one another by spaces varying from half their own width to the whole of their width. Septa wholly wanting. Tabulæ complete, strong, straight or slightly curved, from four to eight in the space of one line, generally fewer and more remote in the larger tubes than in the smaller ones. Though the openings of the larger corallites upon the surface are distinctly circular, all the tubes appear to be angular in cross-sections taken a little below the surface.

Obs.—The surface characters of this species are quite conclusive as to its being a true *Fistulipora* and not a *Favosites* (see Pl. II., fig. 3 *a*). The larger tubes, in fact, are always filled up near the surface with the dark matrix, which passes down to the first tabula, while the smaller and more closely tabulate intervening tubes are infiltrated with calcite; so that there is a most conspicuous difference between the two sets of tubes as examined at the surface. In thin sections, however, this difference to a large extent disappears, and the structure of the coral cannot readily be distinguished from that of a *Favosites* or a *Chætetes*. In transverse sections (Pl. II., 3 *b*), all the corallites are seen to be more or less angular, usually pentagonal, and the larger tubes are with difficulty recognised,

as they have lost their circular outline, and are usually infiltrated with lime, thus agreeing with the intervening tubules. A little care, however, will still distinguish the two sets of tubes; and the same distinction can also be carried out in long sections (Pl. II., fig. 3 *c*), where the larger tubes are recognised both by their comparative size and by their having fewer and more remote tabulæ than the smaller ones.

Upon the whole, *Fistulipora favosa* appears to be sufficiently characterised by its sub-massive form; the long corallites, not superimposed in successive layers; the round mouths of the larger tubes, combined with their angular section at points below the mouth; the presence of one or two rows of smaller angular tubes between the larger ones; and the existence of strong and complete tabulæ in all the tubes, but most numerously so in the small tubes.

The only individual of this species which we have examined is an ovoid mass, with a comparatively expanded base of attachment (Pl. II., fig. 3), its height being an inch and a half, and its greatest width rather more than an inch.

Form. and Loc.—Dark-green ashy beds of Balcletchie, near Girvan (? Lower Silurian). Gray collection.

Fistulipora (?) pilula, Nich. and Eth., jun., *sp. nov.*
(Pl. III., figs. 1-1 *b*.)

Spec. char. — Corallum small, completely ovoid or subglobular, from three to five lines in its longest diameter in the specimens examined by us. Corallites radiating from a central line and opening over the greater part of the surface, of different sizes, but not clearly divisible into two sets of different dimensions. Small tubes comparatively few, wedged in at the angle of junction of the larger ones, angular in form, the latter being rounded or sub-polygonal in section. The larger tubes have an average diameter of about one-fifth of a line, and the smaller ones are variable in size. Septa absent. Tabulæ numerous and close-set (12-15 in the space

of a line) in the smaller tubes, but very few and remote in the larger ones.

Obs.—As none of our examples show the characters of the surface, we do not feel certain whether this is a *Fistulipora*, or whether it should not rather be placed under *Chætetes;* and the characters presented by the microscopic sections are not conclusive upon this point. There is a great difference between the sizes of the tubes which compose the corallum, but it cannot be said that there is a series of large tubes surrounded and separated by another series of small tubuli. There is rather a series of large tubes, usually rounded or slightly angular, partially separated but never completely isolated by small angular tubes (Pl. III., fig. 1 *a*). The general aspect of cross-sections is certainly rather that of a *Fistulipora* of the type of *F. favosa* than of a true *Chætetes*, and longitudinal sections support this view. These (Pl. III., fig. 1 *b*) show a series of large tubes, in which tabulæ are wholly wanting or very sparingly developed, separated by much narrower tubes, in which tabulæ are very numerous and close-set. In no case do we find more than a single one of the smaller tubes separating any two of the larger ones. Increase is by fission of the old tubes. The only other characters which distinguish the species are those founded upon the small size of the corallum and its ovoid or globular shape; and these features seem to be constant, as eight individuals examined by us have all the same figure, and the largest does not exceed half an inch in diameter, the smallest being half the size of this.

Form. and Loc.—In the shales associated with the limestone, Craighead, near Girvan. (Gray collection.)

Genus Chætetes, Fischer, 1837.

(Oryct. du Gouv. de Moscou, p. 159.)

Chætetes, *sp.*

(Pl. III., figs. 2-2 *b*.)

Obs.—The Craighead limestone has yielded various fragments of a dendroid species of *Chætetes* (or *Monticulipora*) which appears to be well characterised, and which we cannot identify with any species of the genus known to us. We shall not, however, assign a new specific title to this form, as it is quite likely to prove identical with some already well-known species, when all the latter have been subjected to microscopic examination. We shall therefore content ourselves with simply appending a brief notice of the general characters and minute structure of the present form :—

Corallum (Pl. III., fig. 2) dendroid, from one to two lines in diameter, branching at short intervals. Calices sub-circular or polygonal, nearly equal-sized, about 1-6th or 1-7th of a line in diameter on an average, with here and there a much smaller tube, but without minute interstitial tubuli. Surface destitute of monticules. In cross-sections (Pl. III., fig. 2 *a*) all the tubes appear to be polygonal. In longitudinal sections (Pl. III., fig. 2 *b*) the tubes are seen to be vertical in the centre of the branches, and to be here crossed by well-marked, straight, and complete tabulæ, of which about ten or twelve occupy the space of one line. On approaching the surface, the tubes bend outwards, and widen somewhat, being crossed by curved and considerably more closely arranged tabulæ for some little distance below their mouths.

Though of the same general type as various well-known Silurian species (such as *C. pulchellus*, Edw. and H., and *C. Fletcheri*, Edw. and H.), we cannot identify the form above described with any previously recorded. The principal features which separate it from its nearest allies are the approximate equality of the tubes, and their regularly tabulate charac-

ter, together with the total absence of interstitial tubules, groups of large-sized tubes, or "monticules."

Form. and Loc.—In the shales associated with the limestone, Craighead, near Girvan. (Gray collection.)

Genus Prasopora, Nich. and R. Eth., jun., 1877.

(Ann. Nat. Hist., ser. 4, vol. xx. p. 38.)

Gen. char.—Corallum compound, forming small hemispheric or concavo-convex masses, composed of numerous prismatic corallites radiating from a wrinkled basal epitheca, and connected by smaller cœnenchymal tubules. Corallites with imperforate walls, destitute of septa, furnished with an exterior zone of vesicular tabulæ surrounding a vacant central tube, which may be crossed here and there by an occasional tabula. Calices showing a central aperture surrounded by a ring-like tabula. Cœnenchymal tubes much smaller than the corallites, prismatic, usually arranged in a single zone round each corallite, and crossed by numerous complete tabulæ. Corallites and cœnenchymal tubes in contact with one another, but not soldered together by their walls.

Obs.—The corallum in this genus is composite, and has the general form and aspect of the massive species of *Chætetes* (*Monticulipora*). Its general shape (fig. 3, B) is concavo-convex or hemispherical, the concave or flat base being covered by a concentrically wrinkled and striated epithecal plate (fig. 3, A). From the centre of this the corallites radiate in all directions, those in the middle of the corallum taking a nearly vertical course, while those near the margins are horizontal, or even deflexed, so as to run nearly parallel with the epitheca, corallites holding an intermediate position between these two points being bent at correspondingly intermediate angles. The corallum is made up of comparatively large-sized corallites interspersed with smaller "cœnenchymal" tubules; and the structure of these two elements is very different internally.

The corallites, as shown by microscopic sections, have a

unique internal structure. In *longitudinal* sections (*i.e.*, in sections parallel with their long axes) they are seen to be divided into a central tube and an exterior tabulate area (fig. 3, D). The central tube is either completely uninterrupted, or is occasionally traversed by a delicate transverse tabula (perhaps at intervals of a line or less), marking a temporary arrest in the process of growth. In some cases the central tube is filled with crystalline calcite; but it is often more or less completely occupied by an infilling of the surrounding matrix; and there are commonly little accumulations of the same material above each of the transverse tabulæ just alluded to. The central tube is surrounded by a zone of tabulæ which spring from the wall of the corallite, and are then bent downwards so as to become parallel to the long axis of the corallite, finally joining the tabula next below. There is thus formed a series of large circumferential vesicles, the convexities of which are directed upwards and towards the centre of the corallite. When divided fairly through the centre, the internal structure is seen to be as above; but when the section is excentric it passes through the exterior tabulate zone, and the cut edges of the vesicular tabulæ appear as cross lines, looking like ordinary tabulæ. As most of the corallites are curved, an ordinary longitudinal section divides them partly through the centre and partly excentrically, so that part of the tube shows the one set of appearances and part the other.

In order to examine the corallites in *transverse* section it is necessary to cut a slice tangential to the upper surface (slices cut tangential to the lower surface, owing to the deflection and approximate horizontality of the marginal corallites, exhibit oblique longitudinal sections of the tubes). In a properly prepared transverse section (fig. 3, C), the corallites are seen to be of a rounded or more generally hexagonal figure, with thick and well-defined walls. In the centre of each is a rounded or oval opening, representing the section of the central tube of the corallite, filled either with calc-spar or with the dark matrix of the enclosing rock. This opening is surrounded by one or

more curved lines, which are often tangents to the margin of the central aperture, or are concentric to it, or intersect one another. These lines are the cut edges of the tabulæ which form the exterior zone of each corallite, and they forcibly remind one of the somewhat similar appearance presented by

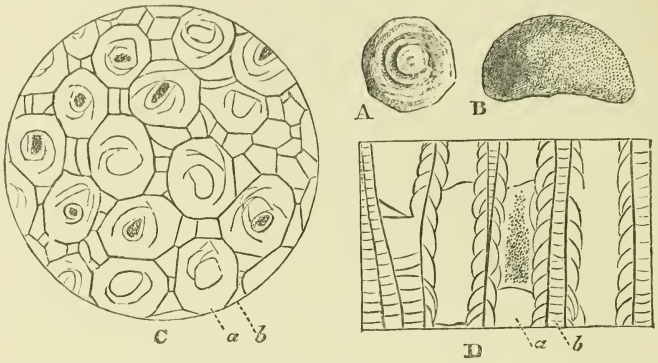

Fig. 3. A, Under surface of a small specimen of *Prasopora Grayæ*, natural size, showing the epitheca. B, Side view of another, larger specimen, of the natural size. C, Transverse section of the same, enlarged about twenty diameters. D, Longitudinal section, similarly enlarged : *a*, One of the corallites ; *b*, One of the cœnenchymal tubes. The dark shading in the microscopic sections indicates where the matrix is present.

transverse sections of the corallites of *Syringopora*, with their infundibuliform tabulæ. The corallites, in fact, in transverse section present a general resemblance to the bulb of an onion when cut across; and our generic name (Gr. *prason*, a leek) is in allusion to this. The central tube of the corallites is about one-third or often more of the total diameter; and the walls of the corallites are destitute of mural pores, and are not fused with one another or with the tubes of the cœnenchyma.

The cœnenchymal tubules are very variable in shape and size; but they are always much smaller than the true corallites, and are mostly oblong, triangular, or trapezoidal in shape (fig. 3, C). They are wedged in amongst the corallites, round which they are usually disposed in a single row; but the zone thus formed is rarely or never complete, each corallite coming into contact at different points with one, two, three, or even four contiguous ones. In some cases, also, there may be a double row of cœnenchymal tubes between the corallites. In internal

structure the tubes of the cœnenchyma possess none of the special characters which distinguish the true corallites, longitudinal sections showing them to be simply traversed by numerous close-set, complete tabulæ (*b*, fig. 3, D), generally slightly curved, with their convexities directed downwards. Transverse sections also show them to want the central tube of the true corallites, and to be irregular in form. Though we have retained the name of "cœnenchymal tubes" for these, we think it most probable that they are really of the nature of rudimentary corallites, which contained in the living state a series of small and specially modified zooids.

There are no traces of septa or of radial internal processes of any kind, either in the ordinary corallites or in the cœnenchymal tubes of *Prasopora*.

Affinities.—The only forms with which it is necessary to compare *Prasopora* are—(1) *Chætetes* and *Monticulipora;* (2) *Fistulipora* and *Callopora;* and (3) *Heliolites* and its allies.

The general appearance of the corallum in *Prasopora*, as before remarked, is very closely similar to that of massive examples of *Chætetes*, Fischer, and *Monticulipora*, D'Orb. From the forms included under these names, however, our genus is widely removed by the possession of a well-developed series of cœnenchymal tubules (very different in character from the minute tubuli found in many species of the two former groups), and by the internal structure of the corallites. No species of *Chætetes* or *Monticulipora*, so far as we know, exhibits anything to be compared with the external zone of vesicular tabulæ and the central tube of the corallites of *Prasopora*.

To *Fistulipora*, M'Coy, and the closely-allied or identical *Callopora*, Hall, the present genus is related by the fact that the corallites are surrounded by a greater or smaller number of cœnenchymal tubules. The two former, however, have the tubes of the corallites simply intersected by numerous complete tabulæ (said to be absent in some species of *Callopora*); and neither of them presents any approach to the peculiar structure

of the corallites of *Prasopora*, though it is in their neighbourhood that we may at present place the last-named genus.

Lastly, *Prasopora* resembles *Heliolites* and its allies in the fact that the corallites are surrounded by numerous transversely tabulate cœnenchymal tubules; but the total absence of septa and the peculiar structure of the corallites fundamentally separate the former from any member of the Helioporidæ. We may just add that the corallites of *Prasopora* in structure closely resemble those of *Roemeria* (the true *Calampora* of Goldfuss), but our genus is at once distinguished from this by the possession of "cœnenchymal tubules."

Prasopora Grayæ, Nich. and Eth., jun.

Spec. char.—Corallum forming small hemispheric or concavo-convex masses, generally from half an inch to three-quarters of an inch in diameter, and from a quarter to half an inch in height. Corallites more or less prismatic, from five to six in the space of one line (counting-in the intervening cœnenchymal tubules as well), thus averaging about 1-70th to 1-80th of an inch in diameter. Cœnenchymal tubules exceedingly variable in size and form, but rarely equal to half the diameter of the corallites. Epitheca and internal structure as described in the generic characters.

Obs.—Though we have now carefully examined considerably over a hundred specimens of this exceedingly interesting coral, we have nothing to add to the above description, as originally given by us. In both superficial characters and internal structure it appears to be extremely constant, and even its size varies very little. Out of the large series in Mrs Gray's collection the smallest example that has come under our notice is three and a half lines in diameter, and two and a half lines in height, while the largest is thirteen lines across, and six lines in height.

Form. and Loc.—Common in the shales associated with the limestone at Craighead, near Girvan. (Gray collection.)

Genus Halysites, Fischer, 1813.

(Zoognosia, 3d ed., vol. i. p. 387.)

Halysites catenulata, Linn.

Tubipora catenularia, Linné, Syst. Nat., ed. xii., p. 1270, 1767.
„ *catenulata*, Gmelin, Linné. Syst. Nat., ed. xiii., p. 3753, 1789.
Catenipora escharoides, Lamarck, Hist. des An. sans Vert., vol. ii. p. 207, 1816.
„ *tubulosa* and *C. escharoides*, Lamouroux, Exp. Méth., p. 65, 1821.
„ *labyrinthica* and *C. escharoides*, Goldfuss, Petref. Germ., vol. i. pp. 74 and 75, 1826.
Halysites attenuata, Fischer von Waldheim, Note sur des Tubip. Foss., p. 16, 1828.
Catenipora approximata, Eichwald, Zool. Spec., vol. i. p. 192, 1829.
Halysites escharoides, De Blainville, Dict. Sc. Nat. Atlas, Pl. XLIII., fig. 5, 1830.
„ *labyrinthica* and *H. escharoides*, Bronn, Lethæa Geognostica, vol. i. p. 52, 1835.
Catenipora labyrinthica, Milne-Edwards, in 2d ed. of Lamarck's Hist. des An. sans Vert. vol. ii. p. 322, 1836.
„ *escharoides*, Lonsdale, in Murchison's Silurian System, p. 685, 1839.
Halysites catenularia, Milne-Edwards and Jules Haime, Pol. Foss. des Terr. Pal., p. 281, 1851.
„ *catenulatus*, M'Coy, Brit. Pal. Foss., p. 26, 1851.
Catenipora escharoides, Hall, Pal. N.Y., vol. ii. pp. 44 and 127, 1852.
Halysites catenularia and *H. escharoides*, Milne-Edwards and Jules Haime, Brit. Foss. Cor., pp. 270 and 272, 1854.

(The above list comprises some of the most important references to this well-known coral. For a full synonymy up to date, *see* Milne-Edwards and Haime, Brit. Foss. Cor., pp. 270 and 272.)

Form. and Loc.—In cement-stones at Shalloch Mill, near Girvan, associated with *Dicellograptus Moffatensis* and other Lower Silurian (Caradoc ?) forms. (*Coll.*, Charles Lapworth.) As our specimens show no points of special interest, we have not thought it necessary to describe this familiar species. We have also a single specimen of the same from the greenish mudstones of Penkill, near Girvan, of Upper Silurian age. (Gray collection.)

Genus THECOSTEGITES, Milne-Edwards and Haime, 1849.

(Compt. Rend., t. xxix. p. 261.)

Thecostegites (?) Scoticus, Nich. and Eth., jun., *sp. nov.*

(Pl. IV., figs. 1-1 *b*.)

Spec. char. — Corallum composite, forming small masses, apparently not encrusting, composed of short cylindrical corallites, which diverge from the median line to open on the surface. The corallites are sometimes partially free, at other times in contact, but they widen out towards their mouths, where they are united by a continuous calcareous expansion, in which the calices are perforated. Calices mostly about half a line in diameter, but varying from ¼ to ¾ of a line, distant from one another from ¼ to ½ line, usually circular or oval, with slightly elevated lips, and furnished with a variable number of extremely short inward projections representing septa. Strong curved or flexuous tabulæ intersect the tubes at distances of from half a line to a line.

Obs.—The genus *Thecostegites*, Edw. and H., is only known by Devonian species; and it is defined by its authors as possessing a sub-massive encrusting corallum, with short cylindrical corallites, which are united by strong mural expansions, and are only free in the interspaces between these, the calices being circular, with rudimentary septa, and the tubes being crossed by horizontal tabulæ.

In Mrs R. Gray's collection we find two small specimens from the limestone at Craighead, which we are disposed to place provisionally in this genus; though it must be admitted that they do not agree in some important respects with the definition of *Thecostegites* above given, while the type has not previously been recognised in rocks of such ancient date. Our material, though well preserved as far as it goes, consists only of two small and imperfect specimens, the largest not an inch in length; and they do not exhibit the mural expansions which are said by Milne-Edwards and Haime to unite the

corallites, in places at any rate, in the genus *Thecostegites*. On the contrary, they are seen in longitudinal sections (Pl. IV., fig. 1 *b*) to have the walls of the corallites usually in contact. In places, on the other hand, the corallites are certainly not in contact, though it does not appear that they are here connected by epithecal outgrowths. However this may be, our form agrees with *Thecostegites* in the following points, which appear to us to be sufficiently weighty to justify our referring it to this genus as, at any rate, a provisional arrangement: (1.) The characters presented by the surface are very similar to those of *Thecostegites Bouchardi* (Pol. Foss. des Terr. Pal., Pl. XIV., fig. 1 *a*). Thus, the calices are slightly elevated, and are seen to rise from a continuous calcareous expansion, which separates them to a comparatively considerable distance (Pl. IV., fig. 1). So far as we can make out, the calcareous expansion in which the calices are pierced is formed by a thickening and coalescence of the corallites near their mouths; but our observations on this point are not decisive. (2.) Rudimentary septa are present. These can only be seen in microscopic sections transverse to the corallites; and they only exist as very short blunt inward projections, of variable number (Pl. IV., fig. 1 *a*). (3.) Strong and remote tabulæ intersect the corallites, though in our form these are oftener curved than straight (Pl. IV., fig. 1 *b*). (4.) Growth is by lateral gemmation, as clearly shown in long sections. (5.) Our species reminds us in many respects of an *Aulopora*, though wholly different in internal structure, and the same resemblance exists between the latter and one of the forms of *Thecostegites* described by Milne-Edwards and Haime (viz., *T. auloporoides*).

Should our reference of the Craighead specimens to the genus *Thecostegites* be confirmed by subsequent researches, we cannot doubt their entire distinctness from the species of this genus already known, and we have therefore given them a specific title. If finally established, the occurrence of the genus in rocks of Lower Silurian age will be a point of considerable interest.

Form. and Loc.—Rare in the shales associated with the limestone at Craighead, near Girvan. (*Coll.*, Mrs R. Gray).

Genus PINACOPORA, Nich. and Eth., jun., *gen. nov.*

Gen. char.—Corallum composite, coin-shaped, of extremely short corallites supported upon the upper convex surface of a free, discoidal, concavo-convex, concentrically-striated epitheca. Corallites of two sizes, regularly alternating with one another. Large-sized corallites disposed in obliquely decussating rows, each completely surrounded by a circle of very much smaller corallites ("cœnenchymal tubes"), rarely more than a single row of these latter, however, intervening between any given pair of the larger tubes. Large tubes furnished with twelve short septa, in the form of blunt spiniform projections; small tubes without septa. Large tubes furnished with one or two tabulæ, or rarely more, situated close to their base, the upper portion of the tube being open. Small tubes furnished with from two to four strong and complete tabulæ, which extend to close to their summits. Large tubes oval or circular in form; small tubes irregular in shape. No mural pores. No columella.

Obs.—The characters of this extraordinary genus are so peculiar that we shall consider them at some length,—a method of procedure which will enable us to dispense with more than a very brief notice of the single species upon which it is established. The specimens upon which we have founded the genus *Pinacopora* are only known to us as occurring in a single locality—viz., in the greenish mudstones of Mulloch Hill, of Upper Silurian age; and we possess an extensive series of these, from which we have been able to make out its structure in almost every particular. The corallum is compound and free, and has the form of a thin circular expansion, the under surface of which is covered with a thin, wrinkled, and concentrically-striated calcareous epitheca (Pl. III., fig. 3), which in nature and character entirely resembles the same

structure in such corals as *Chætetes petropolitanus*, *Prasopora Grayæ*, and other forms belonging to different types. The epitheca is always symmetrically concave, and its upper convex surface carries the corallites, which are remarkable for their extreme shortness, when we consider their comparatively large size. Thus, in a specimen one inch in diameter, the height of the corallites is only about half a line, while the diameter of the larger tubes is equal to their height. The corallites are of two kinds, large and small; or, in other words, to use the nomenclature of Milne-Edwards and Haime, the corallites are surrounded by "cœnenchymal tubes." In view, however, of the researches of Moseley upon *Heliopora*, we shall consider the smaller tubes to be really of the nature of corallites, tenanted, probably, in the living condition by a peculiar kind of zoöids. The larger and smaller corallites are symmetrically arranged upon the upper surface of the epitheca, the former being disposed in intersecting rows, and being isolated and separated from one another by the latter. In the only species of the genus known, the amount of the smaller tubes is not large, but there is always a single zone of them surrounding each of the large tubes (Pl. III., fig. 3 *d*). The large corallites, except in their shortness, are constructed upon the type of *Heliolites*, the resemblance between the two genera being especially manifest in the presence of short septa, apparently always twelve to each corallite when well preserved. The septa, however, are not so well developed as in *Heliolites*, being mere short blunt ridges (Pl. III., fig. 3 *d*). They are wholly wanting in the small tubes, as is also the case in *Heliolites*. Considering the extreme shortness of the corallites, the tabulæ may be said to be well developed, and they are always strong and complete. In the large tubes the tabulæ are confined to the bottom of the visceral chamber (Pl. III., fig. 3 *e*), and there is generally only one of them, though there may be two, or sometimes even three or four; though in the latter case they are very closely approximated. In the smaller corallites the tabulæ are more extensively developed, and they extend to close upon the summit of

the tubes (Pl. III., fig. 3 *c*). Lastly, the walls of the corallites are of considerable thickness, but wholly without mural pores, and the axis of the visceral chamber is never traversed by a columella.

As to the affinities of the genus *Pinacopora*, we are disposed to regard it as a member of the Alcyonarian family of the *Helioporidæ* of Moseley, and to place it in the neighbourhood of *Heliolites*, this being the only genus known to us with which it presents any relationship. It agrees, in fact, with *Heliolites* in the important feature that the corallum consists of a series of full-sized corallites, furnished with tabulæ, and with short septa, which are typically twelve in number; while these are surrounded and isolated by a series of smaller tubes, which are more closely tabulate, but are without septa. On the other hand, it differs from all known species of *Heliolites* in its forming a thin, concavo-convex, leaf-like plate; in the extraordinary shortness of its corallites; in the comparatively rudimentary condition of the septa; and in the small number of the smaller tubes, and the absence in them of anything like a regular or geometric form, while their tabulæ are remote and comparatively irregular.[1]

There is no other genus with which we find it necessary to compare *Pinacopora* in detail, but we may just notice the possibility that some of the forms upon which Hall founded the genus *Lichenalia* may perhaps turn out, when fully examined, to belong to the present genus, though others are probably of a different nature.

Pinacopora Grayi, Nich. and Eth., jun., *sp. nov.*

(Pl. III., figs. 3-3 *j*.)

Spec. char.—Corallum composite, in the form of a concavo-convex, leaf-like, calcareous expansion, of circular or oval form,

[1] The resemblance between *Pinacopora* and *Heliolites* is not conspicuously striking, except with one or two forms of the latter genus, such as *Heliolites dubia*, Fr. Schmidt, in which the larger tubes are closely applied to one another, and the cœnenchyma is reduced to a minimum.

varying from six to sixteen lines in diameter. Concave surface of the discoid corallum covered by a concentrically-striated calcareous epithecal plate. Upper convex surface of the disc completely covered with extremely short corallites, of two sizes, the height varying from two-thirds of a line to nearly a line. Large-sized corallites oval or nearly circular in shape, averaging about two-thirds of a line in diameter, completely open above, but occupied below by one, two, or rarely more, strong and complete tabulæ. Short septal ridges, typically twelve in number, also extend towards the interior of the visceral chamber. The larger corallites are regularly arranged in obliquely intersecting lines, and are completely surrounded by a zone of small tubes, averaging one-fifth of a line in diameter. These smaller tubes are very variable in shape, but they are furnished with strong and remote tabulæ to near their summits, and they are devoid of septa. Generally only a single row of small tubes intervenes between any given pair of large tubes, but there may be a partial duplication of this by the occasional development of additional tubuli in places.

Obs.—As there is only this single species in the genus, and as we have discussed the characters of the latter in detail, we need only add here a few remarks on the condition of preservation of the specimens with which we have worked. The cabinet of Mrs R. Gray contains a large and instructive series of examples from the mudstone of Mulloch Hill—the sole locality known for the species — and the following are the principal variations in the mode of their occurrence :—

(1.) In some specimens nothing whatever is to hand except the *cast* of the *under* surface of the epitheca.

(2.) In others, the polypiferous surface of the corallum is embedded in the stone, so that nothing is visible except the striated and concave under surface of the epitheca (Pl. III., fig. 3); but this has its structure preserved, and vertical sections of these specimens yield excellent results.

(3.) In others, again, we have the *cast* of the *upper* convex

surface of the epitheca (Pl. III., fig. 3 *a*), from which all the corallites have been broken off.

(4.) In other very instructive examples, while part of the epitheca is shown as a cast (as in the preceding), the rest of the original epithecal plate, along with the bases of the corallites, has been preserved (Pl. III., fig. 3 *b*), the upper portions of the latter being broken off.

(5.) In a fifth group of specimens, the actual calcareous corallum is wholly preserved, but, thin as it is, it has given way along a plane midway between the upper and lower surfaces of the disc. In such cases, one side of the split stone shows the convex upper side of the epithecal plate and the bases of the corallites which it supports; while on the other piece we have a corresponding concavity, which is occupied by the upper portions of the corallites, the actual mouths of which are embedded in the stone, and which the spectator thus looks at *from below* (Pl. III., fig. 3 *h*).

(6.) Lastly, there are many beautiful, and at first sight very puzzling, specimens in which we have *casts* of the upper or polypiferous side of the corallum (Pl. III., figs. 3 *f* and 3 *g*). These casts are circular or oval, and always concave, as corresponding with the convex upper surface of the coral upon which they are moulded. They exhibit a series of short columns, directed at right angles to the plane of the cast, about half a line in height, and the same in diameter, oval or circular in shape, arranged in intersecting lines, and indented on their sides with twelve vertical sulci. These columns are the casts of the large-sized corallites, and they are separated by interspaces which represent the zone of smaller tubes by which each of the latter is surrounded. These smaller tubes, being tabulate to close upon their summits, do not appear to have been penetrated by the surrounding matrix to any extent, so that one can only very indistinctly make out any projections in the cast, which might be considered as representing the cavities of these. We have named this interesting form in honour of our friend, R. Gray, Esq., F.R.S.E.

Form. and Loc.—Not uncommon in the mudstones (Upper Silurian) of Mulloch Hill. (*Coll.*, Mrs R. Gray.) We may add that we have seen specimens in the collection of Mr George Jennings Hinde of a species of coral from the "junction-beds" of Anticosti (base of Upper Silurian), which is undoubtedly congeneric with *Pinacopora Grayi.*

Genus Heliolites, Dana, 1846.

(Zooph., p. 541.)

Heliolites interstincta, Linn.

Madrepora interstincta, Linné, Syst. Nat., ed. xii., p. 1276, 1767.
Madreporites interstinctus, Wahlenberg, Nov. Acta Soc. Scient. Upsal., vol. viii. p. 98, 1821.
Porites pyriformis, Lonsdale, in Murchison's Silurian System, p. 686, 1839.
Palæopora interstincta, M'Coy, Brit. Pal. Foss., p. 15, 1851.
Heliolites interstincta, Milne-Edwards and Haime, Pol. Foss. des Terr. Pal., p. 214, 1851.
„ *pyriformis*, Hall, Pal. N.Y., vol. ii. p. 133, 1852.
„ *interstincta*, Milne-Edwards and Haime, Brit. Foss. Corals, p. 249, 1854.
(For full synonymy up to date, see Milne-Edwards and Haime's Monograph of British Fossil Corals, p. 249.)

Obs.—We have a few specimens which we are enabled to identify with this widespread and familiar form. All but one of our examples are simply in the condition of casts; but one small specimen from another locality (Penkill) is infiltrated with carbonate of lime, and was therefore in a condition suitable for microscopic examination. All the specimens, however, appear to be clearly referable to *Heliolites interstincta*, with which they agree in possessing large calices about three-quarters of a line in diameter, separated by spaces of about half a line, which are occupied by polygonal corallites of from 1-6th to 1-8th of a line in diameter.

Form. and Loc.—In the condition of casts in the dark-green mudstones of Mulloch Hill. Also at Penkill, near Girvan, the strata at both these localities being of Upper

Silurian age. (*Coll.*, Mrs R. Gray). We have no doubt that our specimens are specifically identical with those quoted by Salter under the name of *Heliolites subrotundus*, Fougt (= *Porites pyriformis*, Lonsd.), as occurring at Mulloch (Quart. Journ. Geol. Soc., vol. vii. p. 171).

Heliolites Grayi, Milne-Edwards and Haime (?).

(Pl. IV., figs. 4 and 4 *a*, and Pl. V., fig. 1.)

Heliolites Grayi, Milne-Edwards and Haime, Pol. Foss. des Terr. Pal., p. 217, 1851.
„ „ Milne-Edwards and Haime, Brit. Foss. Cor., p. 252, 1854.

Spec. char.—Corallum forming irregularly-branched or sublobate masses, which when of large size are clearly formed by the superposition of successive layers of corallites upon one another. In branched specimens the branches are cylindrical or flattened, sometimes palmate or lobulate, from four to about seven lines or more in diameter. The larger masses are irregularly lobed, and sometimes attain a diameter of one to two inches. The corallum appears to have been rooted at the base, and to have had all its free surface covered with the calices. The larger calices are half a line in diameter, or very slightly less, and they are separated by interspaces of from one-third of a line to half a line. The smaller tubes ("cœnenchymal tubes") are minute, four or five of them occupying an interspace between any pair of large tubes, and they appear to be irregular, or somewhat vermiculate in shape. There are twelve septa, with broad bases, and narrow interseptal chambers, in each of the larger tubes. Tabulæ unknown.

Obs.—The Craighead limestone has yielded a considerable number of specimens of coral with the characters above given, which we identify, with a little hesitation, with the *Heliolites Grayi* of Edwards and Haime. In most respects our specimens agree well with those ascribed to *H. Grayi* by its describers. It has the same peculiar mode of growth, and is often (though by

no means always) in the form of thick lamellar branched expansions, while its larger calices have the same diameter and the same number of thick triangular septa. Edwards and Haime, however, give as a specific character that the larger calices are "limited by a small, well-marked, circular ridge," formed by the exsert edge of the septa; but we cannot lay much stress upon the apparent absence of this in our forms, as with hardly an exception their surface-characters are absolutely undeterminable, and in the best of our specimens are exceedingly badly preserved. Upon the whole, therefore, we are tolerably confident that we are right in regarding the Craighead specimens as identical with the unique *Heliolites Grayi*, Edw. and H., of the Wenlock Limestone.

On the other hand, we entertain a little doubt as to the true generic position of this species, in spite of its close superficial resemblance to *Heliolites*. Could we rely with safety upon the appearance presented by microscopic preparations of our specimens, we should unhesitatingly remove it from *Heliolites*, since these do not exhibit a trace of tabulæ, and have other peculiarities as well. Unfortunately, however, they are so highly mineralised that we have found it extremely difficult to make satisfactory sections of them, and we cannot assert positively that both some of the positive and the negative phenomena which we have observed are not really due to the mode of preservation of the specimens. Still, it should be borne in mind that Milne-Edwards and Haime give no details as to the minute internal structure of *Heliolites Grayi*, and that the form and mode of growth of the corallum are very peculiar in this species, so that its reference to *Heliolites* will require confirmation.

Transverse sections of our specimens (Pl. V., fig. 1) remind us far more of such perforate corals as *Protaræa* and *Stylaræa* than of *Heliolites*. The stellate sections of the larger corallites, with their twelve broad septa, are evident enough, but the intervening tubules are only to be made out with difficulty, if at all, while they are often irregular and elongated in shape,

thus closely resembling what we see in cross sections of the reticulate sclerenchyma of *Protaræa*. On the other hand, in sections taken parallel with the larger tubes (Pl. IV., fig. 3 *a*), the appearances presented are very puzzling, though it is quite probable that they are only due in reality to the undoubted changes which the specimens have undergone subsequent to fossilisation. They show, in fact, no distinction between the larger and smaller tubes, and absolutely no traces of *tabulæ;* but they simply exhibit irregular, overlapping, and wavy lines, which run parallel with one another, and look as if they represented the division-walls between contiguous tubes. Sections taken across the branches of the corallum often clearly show that increase to its growth was effected by means of the addition of successive layers of short corallites. These sections also often show the characters of the surface to some extent (Pl. IV., fig. 3 *a*), and we learn from them that the actual cup of the larger corallites extended about half a line below the surface, its floor having often two or three tooth-like projections, while the smaller calices extended only to about one-sixth of a line or less below the surface.

Form. and Loc.—Not uncommon, but very badly preserved, in the limestone at Craighead, near Girvan. (*Coll.*, Mrs R. Gray, and *Coll.*, H. A. Nicholson).

Genus Stylaræa, Von Seebach, 1866.

(Zeitschr. d. deutsch. Geol. Ges., Bd. XVIII. p. 304.)

Gen. char.—Corallum composite, the sclerenchyma traversed by numerous fine inosculating canals. Corallites short, opening on the surface by rounded or polygonal calices, of moderate depth. Septa in the form of a variable number of short blunt ridges extending into the interior of the visceral chamber, the axis of which is occupied by a well-developed circular or oval columella, which the septa do not nearly reach. Strong and complete tabulæ present or absent. Corallum encrusting, or (?) attached only at a single point.

Obs.—The genus *Stylaræa*[1] was founded by Von Seebach (*loc. cit.*) for certain corals from the Lower Silurian of Esthland, which entirely agree with the well-known *Protaræa* of Milne-Edwards and Haime in most points, but are essentially distinguished by the possession of a well-developed columella. *Protaræa*, as is well known, always occurs in the form of thin crusts attached parasitically to foreign bodies, and some of its peculiarities may be merely adaptations to its special habit of growth. *Stylaræa*, however, must be so far different to *Protaræa* in habit, that it is stated to possess a distinct epitheca, which is hardly consistent with the use of the term "encrusting" employed by Von Seebach in his generic description. In their reticulate sclerenchyma, tuberculated walls, and short crenulated septa, the two genera are completely identical.

Amongst the specimens collected by Mrs R. Gray from Craighead, we find one which we cannot possibly place elsewhere than in the immediate neighbourhood of *Protaræa*, and which we think ought to be considered as a species of *Stylaræa*, though in order to place it in this genus, some extension of the characters of the latter, as given by Von Seebach, is necessary. Our form agrees with both *Protaræa* and *Stylaræa* in the minute structure of the sclerenchyma, in the form and disposition of the calices, and in the characters of the septa; while it further agrees with the latter genus in the possession of a strong and well-developed columella. This columella, however, cannot be said to be "spongy," as stated in Von Seebach's definition, for it is quite compact; and though we are unfortunately unable to say positively what was the mode of growth of our species, it certainly possessed much longer corallites than was the case with either *Protaræa* or *Stylaræa*, and can hardly be stated to have been "encrusting." Moreover, there is the very important point that the corallites in our form are provided with strong and well-developed *tabulæ*, structures

[1] So far as we can judge from his figures and description, the genus *Coccoseris* of Eichwald (Leth. Ross., vol. i. p. 442, Pl. XXV., fig. 4) is founded upon corals very similar in structure to *Stylaræa*, Von Seebach, if not absolutely identical with the latter.

which are wholly wanting in the two genera just mentioned. The absence of tabulæ, however, in *Stylaræa Rœmeri*, and in *Protaræa*, may well be due to the extreme shortness of the corallites in these forms, and for this reason we are not disposed to attach a generic value to their presence in our species. Without ignoring the differences which we have just alluded to, the general structure of the Ayrshire coral is so entirely similar to that of *Protaræa vetusta*, Hall,—as we have fully satisfied ourselves by a careful microscopic examination of both —that we should not feel justified in removing it far from the latter, and its possession of a columella would naturally place it in *Stylaræa*. If this reference be admitted, we must not only allow the occasional presence of tabulæ as one of the characters of the genus *Stylaræa*, but we have to note a further confirmation of the now acknowledged fact that well-developed tabulæ may exist in unquestionable perforate corals.

Stylaræa occidentalis, Nich. and Eth., jun., *sp. nov.*

(Pl. IV., fig. 2-2 *b*.)

Spec. char.—Corallum composite, forming a flattened expansion (?), of small size. Corallites irregularly cylindrical, about half a line in diameter, separated by thick sclerenchyma, which is equal in thickness to half the diameter of the tubes or more, and is traversed by numerous inosculating canals (Pl. IV., figs. 2 and 2 *a*), whereby each corallite is brought into communication with those immediately surrounding it. Calices slightly depressed, about half a line in diameter. Septa in the form of short blunt ridges, with broad bases (Pl. IV., fig. 2), which extend inwards for a variable distance into the visceral chamber, but always fall far short of the columella. Usually eight principal septa, sometimes with indications of as many short secondary septa alternating with them. Tabulæ strong, straight or curved (Pl. IV., fig. 2 *b*), placed at distances of from one-fifth to one-quarter of a line apart. Columella strong and compact, generally circular, and extending through the

tabulæ as a continuous rod in the axis of the visceral chamber, the course of the latter not being thereby deflected.

Obs.—The only described species of *Stylaræa*—viz., *S. Rœmeri*—is stated by Von Seebach to form thin laminar expansions, and to resemble *Protaræa vetusta*, Hall, in all essential points except in its possession of a columella. (We may here note, however, that *Protaræa vetusta* is seen in vertical sections not uncommonly to possess a predominant tubercle in the floor of the calice, as shown in Pl. IV., fig. 3 *a*; and this may perhaps be regarded as a rudimentary columella.) *S. occidentalis* appears to have grown in the form of a thin expansion, but as our material consisted of only a single specimen, we cannot assert anything positive as to its mode of growth. The corallites, however, in this specimen, are no less than three lines in height, and therefore greatly exceed those of *Protaræa vetusta* in this particular; and Von Seebach does not state that the tubes of his *Stylaræa Rœmeri* are any higher than those of the latter form. Apart from this difference, however, our species is fundamentally distinguished from that of Von Seebach by its possession of strong and complete tabulæ, by its compact, not spongy, columella, and by the absence of crenulation of the septa, these structures being apparently primarily eight in number.

Form. and Loc.—Rare in the shales associated with the limestone at Craighead, near Girvan. (*Coll.*, H. A. Nicholson).

Genus Calostylis, Lindström, 1868.

(Öfversigt K. Vetenskaps-Akad. Förhandl., 1868, p. 421.)

Gen. char. — Corallum compound or simple, increasing by lateral gemmation; wall rudimentary; epitheca poorly developed or wanting; septa porous, united with one another by lateral processes or imperfect dissepiments, continued centrally into a loosely reticulate or trabecular columella. Rudimentary tabulæ present or absent.

Obs.—The genus *Calostylis* was founded by Lindström for some very remarkable corals from the Upper Silurian of Gotland, which had previously been described by Kjerulf under the name of *Clisiophyllum denticulatum*. Lindström, however, showed (*loc. cit.*) that the form in question had no relation to the genus above named, but that it was truly the type of a new group of Palæozoic Perforate Corals, which, as far as known, are the only representatives of the *Eupsammidæ*,[1] which have been discovered in the entire series of the Palæozoic deposits. The peculiarities of *Calostylis denticulata* were subsequently described in greater detail by Lindström in a paper entitled "Description of the Anthozoa Perforata of Gotland" (Kongl. Svenska Vetenskaps-Akad. Handl., Bd. ix., 1870); and we are entirely able to confirm the general accuracy of the account there given, as we have made a careful microscopic examination of specimens which he himself kindly presented to us. We agree, therefore, with him in the conclusion that *Calostylis* is a true Perforate Coral, belonging to the family of the *Eupsammidæ*, and related to the genera *Endopsammia* and *Balanophyllia*. Lindström points out, however, that *C. denticulata* possesses some characters which remind one of the *Rugosa*, such as the existence of epithecal outgrowths, which occasionally act as processes of attachment. In a longitudinal thin section which we have prepared of this species, we further find that the visceral chamber is crossed by distinct though sometimes discontinuous horizontal plates, which appear to be clearly of the nature of tabulæ. Whether these structures are always present or not is a point which we are unable to determine, but their occurrence is not alluded to by Lindström.

The "Gray collection" contains a number of specimens of a small coral which are at once shown by microscopic examination to agree in every particular with *Calostylis*, and which differ from *C. denticulata*, Kjerulf sp., only in points of specific

[1] *Palæacis*, Haime, has been regarded as a Carboniferous representative of the *Eupsammidæ*, but we have elsewhere given reasons (Ann. Nat. Hist., 1878) for thinking that it is not referable to the *Actinozoa*.

importance. This coral we shall describe under the name of *Calostylis Lindströmi*; and its occurrence is of special interest, as it affords the first known instance of the discovery of this remarkable and ancient type of Perforate Corals outside of the Silurian rocks of Sweden.

Calostylis Lindströmi, Nich. and Eth., jun., *sp. nov.*

(Pl. V., figs. 2-2 *c*.)

Spec. char.—Corallum simple, or sometimes throwing out a few lateral buds, cylindrical, contorted, and generally more or less constricted at intervals, the usual diameter of seemingly full-grown specimens being from two to three lines. No wall. An epitheca, of small thickness, may be partially developed; but in other cases the outer edges of the septa appear on the surface as so many longitudinal ridges. Septa porous and cribriform, irregular, the larger ones thirty or more in number, sometimes with smaller septa which become coalescent with the larger ones. Centre of the corallum occupied by a very loosely reticulated and trabecular mass, which represents a spongiose columella occupying about one-third of the total diameter of the corallum. In the interval between the columella and the wall on each side, delicate and remote plates representing tabulæ can be detected. Contiguous septa send out imperfect tooth-like dissepiments by which they are loosely united to one another.

Obs.—This remarkable species can generally be without difficulty picked out by its slender, cylindrical corallum, apparently always more or less twisted, and usually constricted at intervals (Pl. V., fig. 2)—superficial characters exhibited by none other of the Girvan corals known to us. Its size varies from half an inch to nearly an inch in length, with an average diameter of about two lines; but none of our specimens can be certainly said to be perfect, so we do not know if this length was exceeded or not. Towards the base the corallum tapers, and most of the specimens appear to have been

simple. Some, however, show distinct lateral buds, though we have not noticed more than one such bud in any given individual. In the points just mentioned, the present form agrees with *C. denticulata*, which sometimes has a simple conical corallum, and at other times produces lateral buds. Its surface-characters—as almost universally with the Girvan corals—are extremely badly preserved; but we sometimes recognise a thin epitheca, which, at places where the corallum is constricted or contorted, may be developed into thickened encircling ridges. At other times, the surface shows longitudinal ridges formed by the outer edges of the septa. The characters of the calice, and the mode of attachment of the coral, are unknown to us.

Microscopic sections at once reveal the structure and true affinities of *Calostylis Lindströmi*. These show that the entire corallum is made up of reticulate and trabecular sclerenchyma. The septa are well developed, comparatively speaking; but as the shorter ones often become confluent with the larger as the latter in turn pass into the central spongy mass, and as all are more or less united together by lateral processes, it is very difficult to determine their number precisely. There appear to be about thirty principal septa in a specimen of three lines in diameter. Long sections show that imperfect horizontal partitions or tabulæ (Pl. V., fig. 2 *c*) are present, and that the septa are more or less largely cribriform; while both longitudinal and transverse sections show that the axis of the visceral chamber is occupied by a broad cylindrical mass of columellar tissue in the form of reticulating and inosculating trabeculæ (Pl. V., figs. 2 *b* and 2 *c*).

Calostylis Lindströmi, though agreeing with *C. denticulata*, Kjerulf, in its general plan of structure, is readily separated from it by its very much smaller dimensions, and the contortion and periodic constriction of all specimens known to us. It also has much fewer septa, and does not appear to produce epithecal processes of attachment. On the other hand, *C. denticulata*—the only other known representative of the type—attains a maximum length of from four to six inches, with a

diameter of an inch and a quarter, while its septa reach the great number of one hundred and forty, and in the early stages of its growth it fixes itself by root-like epithecal processes developed from the border of the calice.

We have named the species in honour of our friend Dr Gustav Lindström, one of the most distinguished of authorities on the subject of fossil corals.

Form. and Loc.—Apparently not uncommon in the greenish mudstones of Penkill, near Girvan, of Upper Silurian age. (Gray collection).

Genus Streptelasma, Hall, 1847.

Streptelasma, Hall, Pal. N.Y., vol. i. p. 17, 1847. (By clerical error, subsequently corrected, the name of the genus is spelt *Streptoplasma*).
„ Milne-Edwards and Haime, Pol. Foss. des Terr. Pal., p. 398, 1851.
Petraia (*pars*), M'Coy, Brit. Pal. Foss., p. 39, 1851.
Palæophyllum, Billings, Geol. Survey of Canada, Rep. of Progress, p. 168, 1857.
Streptelasma, Ferd. Roemer, Die foss. Fauna von Sadewitz, p. 17, 1861.
„ Kunth, Zeitschr. d. deutsch, Geol. Ges., 1871, p. 647.
„ Dybowski, Mon. Zoanth. sder. Rug., p. 125, 1873.
„ Nicholson, Pal. of Ohio, vol. ii. p. 217, 1875.
„ Nicholson, Ann. and Mag. Nat. Hist., Ser. 4, vol. xviii. p. 94.

Gen. char.—Corallum simple, cylindrical or turbinate; or compound and more or less fasciculate. Epitheca well developed. Proper wall doubtfully present; but a thick false wall, formed by the fusion of the broad outer ends of the septa with intermediate calcareous deposit. Septa well developed, lamellar, of two orders, the primary septa usually more or less flexuous, and always more or less extensively united at their inner ends with one another and with a pseudo-columella, which is composed of the twisted and inosculating edges of the septa; secondary septa of approximately equal size, much shorter than the primary septa, with which they are often united by their inner ends. Dissepiments in variable number

intersect the interseptal spaces, but never exist in amount sufficient to constitute an outer vesicular zone. Tabulæ are well developed in the outer zone of the corallum, but often do not completely cross from side to side. They are usually more or less convex upwards externally, and flat or convex centrally. A septal fossula present or absent.

Obs.—As regards the history of the genus *Streptelasma* we have but little to remark. It was originally founded by Hall (*loc. cit.*) upon the still undetermined and imperfectly understood *S. expansa* of the Chazy Limestone; and almost the only character of importance given in the generic diagnosis is that the septa are more or less spirally twisted in the centre. As the true structure of *S. expansa* is, however, still unknown, we must take the common and sufficiently investigated *S. corniculum* of the Cincinnati group as the type of the genus—a course the more justifiable as this species was described by Hall in the same volume and in the same year as *S. expansa* (Pal. N.Y., vol. i. p. 69). As the twisting of the primary septa in the centre of the visceral chamber is not particularly marked in *Streptelasma*, and as this feature is found in corals of very different affinities, it is not surprising that Milne-Edwards and Haime (*loc. cit.*) regarded the genus with some doubt, and only retained it upon the ground that the well-preserved specimens which they had seen rendered it certain that the coral is "destitute of an epitheca and covered by sub-lamellar costæ." This statement can only be explained upon the supposition that the eminent observers just named founded their remarks upon specimens which were really weathered and decorticated, since all the well-preserved examples of the genus which we have seen possess a distinct, though sometimes thin, epitheca. It is also probable that some of the so-called "*Petraiæ*" will prove to be really referable to *Streptelasma*, and this is certainly the case with at least one species of M'Coy's *Strephodes*. The only other point connected with the history of the genus which needs notice is the establishment, in 1857, by Billings (*loc. cit.*), of the genus *Palæophyllum* to include forms which only differ

"from *Petraia* or *Streptelasma* in forming long fasciculate or aggregate masses, instead of being simple." The generic diagnosis given by Billings is very brief and imperfect, and the only structural point of importance noted in it is, that the tabulæ are "either none or rudimentary." This, if certainly established, would separate the genus from *Streptelasma*, as we now understand it; but in the absence of information as to the microscopic structure of the type-specimens, it would be hazardous to attach much weight to this; and there remains, therefore, only the composite character of the corallum to consider. This, no doubt, is often considered as of itself sufficient to establish generic distinction, and we do not desire to express any opinion on this practice; but in this particular instance we think that it would be, at any rate, very inconvenient to adopt a similar course. Our reason for this opinion is, that though certain specimens, and certain species, can be said with certainty to be simple, while others with equal decision can be said to be compound, there are many broken examples which cannot be asserted positively to be one or the other, so that in the case of some species it becomes impossible to say if the corallum was always compound. This is the case, for example, with *S. Craigense*, M'Coy, sp., which, though certainly usually simple, cannot be structurally separated from examples exhibiting multiplication by division. For this reason we prefer at present to consider the genus *Palæophyllum*, Bill., as, at most, a sub-genus of *Streptelasma*.

From its minute structure, as elucidated by microscopic sections, the affinities of *Streptelasma* become abundantly clear. It is a Zaphrentine, and not a Cyathophylloid type. This is shown quite conclusively by the condition of development of the dissepiments alone, which, in all the true Cyathophylloids, are present in such quantity as to give rise to a regular exterior zone of vesicular tissue, the central twisting together of the septa being a wholly secondary feature. In all the *Streptelasmæ*, however, dissepiments are present in small number; and they agree further with *Zaphrentis* in possessing, without excep-

tion, well-developed tabulæ. Their special points of differentiation from *Zaphrentis* are to be found in the presence of a central reticulate pseudo-columella, and in the condition of the fossula. In all forms of *Streptelasma*, the axis of the visceral chamber is occupied by a very loosely constructed pseudo-columella, which often projects in the floor of the calice as a rounded boss, while in cross-sections it is seen to be formed by the irregular anastomosis centrally of a certain number of the primary septa. In long sections of the corallum, taken across the median line, it is equally conspicuous as a series of irregular and disconnected vertical rods. This pseudo-columella must be considered as the special feature distinguishing *Streptelasma* from *Zaphrentis*. On the other hand, the condition of the septal fossula varies. In *S. corniculum*, Hall, which, as before said, we may take as the type of the genus, a septal fossula is present, though this is not formed by the coalescence of a number of the primary septa. In other species (*S. aggregatum*, *S. Craigense*, &c.) we have failed to find any indications of a fossula at all. Upon the whole, therefore, we must rely upon the axial structure of the corallum, as separating *Streptelasma* and *Zaphrentis;* and we obtain thus an additional proof of the necessity of breaking up the latter genus. Some of the forms which would usually be referred here, will doubtless turn out to be referable to *Streptelasma*. Others, such as *Zaphrentis cylindrica*, E. and H., must form the type of a new genus; and others, again, of the type of *Z. Guerangeri*, E. and H., will remain as a compact and well-characterised group to form *Zaphrentis* proper.

There are two other points in the structure of *Streptelasma* which may be just alluded to. In all well-preserved specimens which have come under our notice, we find, as before remarked, a true epitheca to be present; but we have not been able to satisfy ourselves as to the existence of any proper *wall*. All the forms of the genus known to us have the visceral chamber bounded by a thick and dense investment, which looks at first sight like a true wall, but which seems really to be a kind of

false wall, formed by the widening out of the outer ends of the septa, which are united with one another by a small amount of intermediate sclerenchyma of secondary deposition (see Pl. V., fig. 3 *b*). The other point in question concerns the disposition of the septa. Dr Ferd. Roemer, in describing *Streptelasma Europæum* (Foss. Fauna von Sadewitz, p. 17 *et seq.*) lays considerable stress upon the pinnate arrangement of the septa (and consequently of the costæ), which diverge from a dorsal, and sometimes from two lateral lines. We cannot, however, agree with this distinguished palæontologist in regarding this as a character of generic importance; since it merely indicates a peculiarity in the method of development of the new septa, and is not only absent in some species of *Streptelasma*, but is present in other types of different affinities.

The genus *Streptelasma* (including *Palæophyllum*) is an essentially Lower Silurian type, though forms believed to be referable to it are found in the Upper Silurian. Originally known as abundant in the Silurian of North America, species of the genus have been described by Roemer, Fr. Schmidt, and Dybowski from European deposits of the same age. In the Craighead limestone at Girvan, we find at least three well-marked and common forms of *Streptelasma*, which we shall next proceed to describe.

Streptelasma (Palæophyllum) aggregatum, Nich. and Eth., jun., *sp. nov.*

(Pl. V., figs. 3-3 *c*.)

Spec. char.—Corallum composite, fasciculate, forming large colonies of slender cylindrical corallites, which have an average diameter of from two to three lines. Epitheca well developed; a thick false wall made up mostly of the thickened bases of the septa, and forming a dense outer investment to the visceral chamber. Calices, so far as known, deep, and having the septa continued over their sides as short ridges. Septa regularly developed, of two orders, the longer and shorter ones alternating, and each series varying from twenty to twenty-five in

number. No traces of a septal fossula. The septa are slightly flexuous, never conspicuously twisted centrally; but some of the principal ones unite with one another at their inner ends, and become connected with an irregular and loose pseudo-columella, which in long sections appears to be formed of discontinuous or partially anastomosing vertical rods. Tabulæ well developed, convex, with their convexity directed upwards, rarely or never extending completely across the visceral chamber, three or four in the space of one line. Dissepiments variable; sometimes absent in individual corallites; sometimes sparsely developed in the outer zone of the tubes. Increase by fission.

Obs.—This well-marked species is invariably compound, and belongs, therefore, to the section *Palæophyllum*, Billings. Fragments of individual corallites are found, of course; but these are in general easily distinguished from young examples of *S. Craigense*, M'Coy, either by the much smaller number of the septa, or by their showing marks of division. As a rule, the corallum occurs in the form of large colonies of cylindrical or slightly oval corallites, pretty uniformly between two and three lines in diameter, placed from two to four or five lines apart (Pl. V., fig. 3), and completely embedded in the rock, so that their characters can only be determined by microscopic examination. Sometimes two or three corallites occur in close contact, or even partially united; but this is due to their having been produced by fission from a single tube—this being clearly the regular mode of increase of the corallum, though, possibly, lateral budding occurs as well. In Pl. V., fig. 3 *a*, we have figured the summit of an old corallite dividing into no less than seven new ones, and thus appearing to increase by calicular gemmation; but more ordinarily a corallite simply divides into two. Owing to the mode of preservation of the specimens, little can be said as to the superficial characters. The epitheca is well developed, longitudinally striated, and with delicate annulations of growth, and the calice seems to have been deep, with a nearly flat floor. The internal characters, however, are

thoroughly determinable. In *transverse* sections (Pl. V., fig. 3 *b*) we are at once struck with the great thickness and density of the outer investment of the visceral chamber; but this is principally due to the thickening and fusion of the bases of the septa. There are from 20 to 25 long septa, not interrupted by a fossula, and regularly alternating with an equal number of short septa; and the interseptal loculi, though sometimes nearly or quite vacant, are usually crossed by a few, remote, curved dissepiments. Some of the primary septa always unite with one another by their inner ends, in groups, without being notably twisted; and they are generally more or less freely connected with a central pseudo-columella, the cross-section of which appears as a loosely reticulate framework in the axis of the visceral chamber. In long sections (Pl. V., fig. 3 *c*), the thickness of the false wall is as conspicuous as in transverse slices; the visceral chamber is seen to be crossed by irregular but well-developed curved tabulæ, rarely or never quite complete; and the centre is occupied by the pseudo-columella, in the form of a broad median band of reticulate calcareous tissue, mainly made up of short longitudinal rods.

The only other species of the genus with which it is necessary to compare the present form are *Palæophyllum rugosum*, Bill., and *P. divaricans*, Nich., these being the only compound members of the genus *Streptelasma* as yet described. In the case of neither of these species is the internal structure adequately known; but *S. aggregatum* is sufficiently distinguished from either by its general form, since *P. rugosum*, Bill., forms large masses of hardly separable corallites, which attain an individual diameter of six lines, while the colonies of *P. divaricans*, Nich., are composed of only from two to seven short conical corallites produced by budding.

Form. and Loc.—Not uncommon in the limestone of Craighead, near Girvan; forming large colonies half a foot or more in diameter (*Coll.*, C. Lapworth, H. A. Nicholson, and Mrs R. Gray).

Streptelasma Craigense, M'Coy, *sp.*

(Pl. V., figs. 4-4 *c*.)

Strephodes Craigensis, M'Coy, Ann. and Mag. Nat. Hist., ser. 2, vol. vi. p. 275, 1850.
„ „ M'Coy, Brit. Pal. Foss., p. 30, 1851.
Cyathophyllum articulatum, Milne-Edwards and Haime, Brit. Foss. Corals, p. 283, 1854.
Ptychophyllum Craigense, Lindström, Öfversigt af K. Vetenskaps Akad. Förhandl., 1873.

Spec. char.—Corallum simple, or rarely throwing out a few offsets, never forming large colonies. General form of the corallum straight, cylindrical, very slowly tapering to the base, full-grown examples attaining a diameter of seven, nine, or eleven lines. Epitheca well developed, marked with strong rounded vertical striæ, six in the space of two lines, and thrown into numerous conspicuous sharp-edged annulations of growth, of which about five occupy the space of one inch. A thick false wall formed by the fusion of the broad and widened outer ends of the septa. Septa numerous, slightly flexuous, never conspicuously twisted towards the centre of the corallum, of two sizes regularly alternating with one another. Fully adult examples have from seventy-two to eighty septa in all, half of these being long and the other half short, the larger number of the primary septa either being connected together in groups towards the centre, or becoming directly connected with a large reticulate pseudo-columella, composed of twisted and anastomosing vertical rods occupying the axis of the visceral chamber. The calice is apparently deep, but the form assumed by the columella in its floor has not been observed. A few remote and curved dissepiments are always developed in the interseptal loculi, but never form an exterior zone of vesicular tissue. No septal fossula. Tabulæ well developed, often complete, sometimes inosculating, curved upwards in the outer portions of the visceral chamber, but flat or depressed centrally, about five in the space of two lines.

Obs.—We feel no hesitation whatever in identifying the specimens upon which the above description is founded with the *Strephodes Craigensis*, M'Coy (*loc. cit.*); nor can we feel any more doubt as to their being in all respects properly referable to the genus *Streptelasma*. In their great work on the British fossil corals (*loc. cit.*), Milne-Edwards and Haime place *Strephodes Craigensis* as a synonym of *Cyathophyllum articulatum*, Wahl.; but they do not mention having seen examples of the former, and the slightest examination of its internal structure at once shows its radical dissimilarity to any form of *Cyathophyllum*. On the other hand, *S. Craigensis* is proved unquestionably to be a true *Streptelasma* by its thick false wall, composed largely of the amalgamated outer ends of the septa; its sparse dissepiments, and total absence of an exterior vesicular zone; its Zaphrentine tabulæ; and its large reticulated pseudo-columella. Lindström (*loc. cit.*) describes a coral from the Silurians of Sweden under the name of *Ptychophyllum Craigense;* but we are unable to say whether this is really the same coral as *Strephodes Craigensis*, M'Coy, or not.

From all the more ordinary forms of *Streptelasma*, such as *S. corniculum*, Hall, *S. Europæum*, F. Roemer, and the like, the present species is at once separated by its general shape. No other described species of the genus possesses a corallum so long, cylindrical, and slowly-tapering. None of our larger specimens are perfect; but as our larger fragments only taper at a rate of about one line in nine, and as they have a diameter of ten or eleven lines at the larger extremity, we should suppose the corallum to have attained a length of at least half a foot. The strong rounded longitudinal striæ, and the close-set and strongly-marked annulations of growth, are also good superficial features by which fragments may be recognised. Large examples of the species are invariably simple, and so cannot be confounded with any of the compound forms of the genus (*Palæophyllum*). We have, however, various small specimens, which agree in internal structure with *S. Craigense*, and which we suppose to be its immature form, but which present the

peculiarity that they give rise to one or two corallites, apparently by a process of fission. One of these is figured in Pl. V., fig. 4 *c*. Such specimens might easily be confounded with broken fragments of a colony of *S. aggregatum*, nobis, but they agree with the isolated coralla of the typical *S. Craigense* in the large number of their septa; and their corallites are of larger diameter than even full-grown stems of *S. aggregatum*.

Form. and Loc.—Common in the limestone and associated shales of Craighead, near Girvan. (*Coll.*, Mrs R. Gray and H. A. Nicholson.)

Streptelasma Europæum, F. Roemer.

(Pl. VI., figs. 1-1 *b*.)

Streptelasma corniculum, Fr. Schmidt, Untersuchungen über die Silur. Form. von Esthland, &c., p. 233, 1861 (not Streptelasma corniculum, Hall).

„ *Europæum*, Ferd. Roemer, Die Sil. Fauna von Sadewitz, p. 16, Pl. IV., figs. 1 *a-f*, 1861.

Spec. char.—Corallum simple, conical, more or less curved, varying in length (in our specimens) from one to more than three inches, the diameter of the calicular extremity being respectively from eight lines to an inch. Epitheca well developed, marked with strong rounded longitudinal ridges corresponding with the interseptal loculi, which, in well-preserved specimens, are crossed in turn by fine encircling striæ. Annulations of growth low and rounded, often inconspicuous. In specimens clearly exhibiting the surface, the ridges are seen to have a pinnate arrangement, being directed obliquely on both sides towards a line running down the convex or dorsal side of the corallum. Calice (in our examples) imperfectly preserved, but always more or less oblique, and apparently of considerable comparative depth. Septa of two sizes, regularly alternating with one another, the total number varying in coralla of different sizes from seventy-four to one hundred, but being usually about eighty. No septal fossula. The secondary septa generally very short, and often inclined towards and fused with the

primary septa at their inner extremities. Curved dissepiments sparingly developed in the interseptal loculi. Towards their inner ends the longer septa become more or less freely united with one another and with a reticulate pseudo-columella, which occupies the axis of the visceral chamber, and projects into the bottom of the calice. Tabulæ sometimes close-set and nearly horizontal, sometimes directed obliquely upwards and anastomosing.

Obs.—The Craighead limestone has yielded to the researches of Mrs Gray a number of specimens of a *Streptelasma*, of which the above description gives the most salient characters, and which we hardly think can be specifically separated from *S. Europæum*, F. Roemer. It is true our examples show some points of difference, but the investigation of these ancient cup-corals is attended with great difficulties, and some discrepancy is to be expected in specimens from widely distant localities. Our specimens agree with *S. Europæum*, F. Roemer, in their general form, and are thus readily distinguished from the cylindrical *S. Cragiense*, M'Coy, sp., of the same beds. We have no specimens nearly so large as the largest figured by Roemer, but this is a matter of little importance. In its conical, turbinate form, *S. Europæum* very closely resembles *S. corniculum*, Hall; but if our specimens are rightly identified, it is separated from the latter (with which Schmidt placed it) by its uniformly smaller number of septa, and by the entire absence of a septal fossula. According to Roemer, *S. Europæum* possesses epithecal ridges which are directed in a pinnate manner along three lines, one dorsal and two lateral. Most of our examples have the surface much obscured by adherent matrix, or worn away, and we have only been able to detect a feather-like arrangement of the septal furrows on the dorsum of the coral. Again, the tabulæ are figured by Roemer as being nearly horizontal, close-set, or more or less freely anastomosing in *S. Europæum*, and our larger specimens sometimes show the same feature. On the other hand, in the smaller examples, the tabulæ are highly inclined, with their convexity upwards,

and they are rather remote. Upon the whole, however, we think we are safest in identifying the Craighead specimens with *S. Europæum.*

Though badly preserved as regards external characters, the internal structure of our specimens can be readily investigated by the usual means adopted by us. Cross-sections (Pl. VI., fig. 1 *b*) show the same general structure as in *S. Craigense*, M'Coy, sp. The false wall formed by the amalgamation of the bases of the septa is, however, much less developed than in the latter. The septa are alternately of two sizes, generally about forty of each dimension being present, the shorter ones being often united internally with the longer, and the interseptal spaces being crossed by remote curved dissepiments. At their internal extremities the primary septa are mostly united in groups of from three to five, and these, in turn, become connected with a highly-developed reticulate pseudo-columella, which occupies a considerable space in the centre of the corallum. Long sections exhibit the same general features as in *S. Craigense*, and we have not thought it worth while to figure one. We may observe, however, that the lattice-work of the columella is seen conspicuously to be composed of vertical calcareous rods, irregularly uniting with one another; that the columella forms a conspicuous fasciculate projection in the floor of the calice; and that in sections taken slightly out of the true line of the centre it appears simply as a series of short spines springing from the upper surfaces of the tabulæ. It is a section of this last kind that is figured by Roemer (*loc. cit.*, Pl. IV., fig. 1 *f*). As before remarked, however, long sections show a variable condition of the tabulæ. In old specimens, towards their calicine extremities, the tabulæ are nearly horizontal, and are placed close together. On the other hand, they are usually greatly curved, with their convexities upwards, and are then comparatively remote.

Form. and Loc.—Common in the Craighead limestone, near Girvan. (Gray collection.)

Streptelasma (?) æquisulcatum, M'Coy, *sp.*

(Pl. VI., fig. 3.)

Petraia æquisulcata, M'Coy, Ann. and Mag. Nat. Hist., ser. 2, vol. vi. p. 279, 1850.
„ „ M'Coy, Pal. Foss., p. 39, Pl. I. B, figs. 23 and 24, 1851.

Spec. char.—Corallum simple, conical, slightly curved, with an oblique calice, attaining an adult diameter of from one inch and a quarter to one inch and a half, with a length of two inches or more. Epitheca well developed, marked by strong, obtuse or flattened, longitudinal ridges, which correspond with the interseptal loculi, and of which about three occupy the space of one line. Septa apparently from sixty-five to eighty-five in number, alternately large and small, centrally more or less twisted, and sometimes inosculating with one another. Tabulæ unknown. Dissepiments very few and remote, curved, not forming an exterior vesicular zone. Calice deep, the septa in its upper portion merely marginal.

Obs.—We have a few specimens from Mulloch Hill which we can identify with entire certainty with M'Coy's *Petraia æquisulcata*. Some of our examples are in the condition of casts; others retain the calcareous skeleton; but our material is unfortunately insufficient to enable us to pronounce an opinion upon the true affinities of this well-marked coral. M'Coy refers it to *Petraia*, as defined by him, chiefly upon the ground of its twisted septa, and its supposed absence of tabulæ and dissepiments. We have been unable to obtain any longitudinal sections, and our transverse sections are from specimens in which the centre of the visceral chamber is more or less filled up with matrix, to the partial destruction of the calcareous framework of the coral. As to the presence or absence of tabulæ we can therefore say nothing. Cross-sections (Pl. VI., fig. 3) show the septa to be greatly twisted as they approach the centre; but this character, of itself, goes for little. Dissepiments, however, are seen to be undoubtedly present, though they are but very few in number, and irregular in their occurrence. Some of

the septa, however, inosculate with one another, and there are indications that the centre of the visceral chamber was really occupied by a trabecular columella. It is not uncommon in specimens of undoubted *Streptelasmæ* to find the loosely-compacted columella more or less broken down and replaced by the matrix; and we are at present inclined to believe that *Petraia æquisulcata*, M'Coy, is really a *Streptelasma*, though only longitudinal sections can set this point finally at rest. If our conjecture be correct, *Streptelasma* (?) *æquisulcatum* will stand very near to *S. Europæum*, Roemer, from which it will be distinguished principally by its more curved form, more broadly expanded shape, and very limited number of dissepiments. Milne-Edwards and Haime (Brit. Foss. Cor., p. 280) identify *Petraia æquisulcata* with *Aulacophyllum mitratum*, His.; but a careful microscopical examination of the latter has satisfied us that there is no sufficient ground for this identification.

Form. and Loc. — Mulloch Hill, near Girvan, in beds of Upper Silurian (? Upper Llandovery age). Gray collection.

Genus Lindströmia, Nich. and Thoms., 1876.

(Proc. Roy. Soc. Edin., vol. ix. No. 95, p. 149.)

Gen. char. — Corallum simple, conical or turbinate, the epitheca complete, with well-marked longitudinal ridges, fine encircling striæ, and low annulations of growth. Septa well developed, lamellar, equally developed or of two sizes, united inferiorly in the axis of the visceral chamber, and augmented by a secondary deposit of sclerenchyma, so as to form a comparatively enormous pseudo-columella, which projects into the floor of the calice. The lower portion of the visceral chamber often more or less completely filled up by the deposition within it of solid sclerenchyma. Interseptal loculi, usually crossed by a few strong and remote dissepiments; and the upper portion of the visceral chamber not uncommonly traversed by thick transverse plates of the nature of tabulæ, though at other times

these are not recognisable, or at any rate have not been clearly made out.

Obs.—The genus *Lindströmia* was founded by one of the present writers and Mr James Thomson (*loc. cit.*), for the reception of certain small corals from the Devonian formation of North America, the specific description of which is still unpublished. From its general characters, which we shall discuss immediately in a more detailed manner, it is clear that the genus belongs to the *Cyathaxonidæ*, and the type to which it is most nearly allied is *Cyathaxonia*, Michelin, itself. In this genus, however, if we take into consideration the type-species —viz., *C. cornu*, Mich.—we find that the columella is a solid rod extending from the bottom of the visceral chamber to the calice, that there are neither dissepiments nor tabulæ, and that there is a well-marked septal fossette (*see* De Koninck, Nouv. Recherches sur les An. Foss., Prem. partie, p. 108, 1872). In *Lindströmia*, however, as we shall see, there is no septal fossula; dissepiments are always present, and tabulæ sometimes; and the columella, or pseudo-columella, has an entirely peculiar structure; while there are other special structural features as well.

There is, however, one species of *Cyathaxonia*, so called—namely, *C. Dalmani*, Edw. and H.—which agrees in its internal structure with the forms here united under the name of *Lindströmia*. That this well-known Silurian form is not a true *Cyathaxonia* seems to have been recognised by De Koninck, who remarks that the species of this genus "probablement sont toutes carbonifères;" and it has certainly been determined by Lindström, to whose kindness we owe specimens of this species, accompanied by the remark that it is not a genuine *Cyathaxonia*, and that he proposes for it the generic name of *Centrotus*. We are not aware of this name having been published formally; but we are not able to accept it, partly because it is already preoccupied by a genus of insects, and partly because we find it to be covered by the published *Lindströmia*, and thus very appropriately designated already. The *Cyath-*

axonia Siluriensis of M'Coy (Brit. Pal. Foss., p. 36, Pl. I. C, fig. 11) is also clearly a *Lindströmia;* and we have determined the same to be the case with at least one of the forms included by M'Coy under the head of *Petraia.* All these forms, except *Cyathaxonia Siluriensis*, M'Coy, we have now carefully examined by means of thin sections, and we find them to agree with one another in the following general characters :—

They are all small corals, of a conical or turbinate shape, with a well-developed epitheca, which exhibits longitudinal ridges and encircling striæ. All have a deep calice, with the septa nearly obsolete at the margin, but gradually becoming more prominent as we approach the floor of the cup. Those in which the interior of the calice is fully known exhibit at the bottom a comparatively very large and projecting columellar mass, and those in which the interior of the calice has not been observed can be shown by sections to possess a similar structure. In all, the structure of this columella, or pseudo-columella, is quite peculiar, and can only be demonstrated by means of transparent horizontal and vertical sections. Even by this method of investigation, the subject is not without its difficulties, for the lower part of the visceral chamber seems to be usually, if not always, filled up in process of growth by a dense secondary deposit of sclerenchyma, so that transverse sections—which ought to be most instructive—vary in the appearances which they present, according as they are taken near the base of the corallum or near the floor of the calice. Combining together the numerous sections which we have made of different species of this singular genus, we find that the so-called columella is really to be regarded as formed by the fusion of the inner ends of the whole or a number of the septa, together with a larger or smaller amount of dense calcareous tissue, which is clearly of secondary and non-essential origin, since it often invades the interseptal loculi, and may entirely fill up the lower part of the visceral chamber. The upper surface of this pseudo-columella may be quite smooth and sharply defined (as in *Lindströmia Dalmani*, E. and H.), or it

may exhibit its real structure by presenting itself in the floor of the calice as a bundle of partially fused lamellæ. In any case, longitudinal sections of the corallum show that it is really formed in the manner above described,—namely, by the amalgamation of the inner ends of a larger or smaller number of the septa, this amalgamation taking place without any twisting of the septa, and being accompanied by a more or less copious secondary deposition of sclerenchyma. The only other noteworthy points in the structure of the corallum concern the presence of dissepiments and tabulæ. The former structures undoubtedly exist, though they are always few in number and remote in distance; and they can by no means be invariably demonstrated, especially in cross-sections taken near the base of the corallum. That they always are present, however, we feel tolerably certain. With regard to the existence of tabulæ, on the other hand, we cannot speak with the same confidence. Longitudinal sections of *Lindströmia* (*Cyathaxonia*) *Dalmani*, Edw. and H. (fig. 4), certainly show strong plates crossing the upper part of the visceral chamber transversely, and it is impossible to regard these as being anything else than tabulæ. Vertical sections of *Lindströmia* (*Petraia*), *subduplicata*, M'Coy, and of *L. lævis*, nobis, sometimes show the same thing in a less marked manner; but in these small forms it is not surprising that it is difficult to pronounce a positive opinion as to the presence or absence of tabulæ, seeing that the whole of the visceral chamber, up to the floor of the calice, is more or less completely occupied by a dense secondary deposit of sclerenchyma. Moreover, when dissepiments are only present in small number, and are at all exceptionally strong, it becomes impossible to know whether one is dealing with structures of this kind, or with that more developed stage of the same which we know as "tabulæ." Upon the whole, however, we think that the presence of ill-developed tabulæ may be regarded as the rule in the genus *Lindströmia*. In the annexed engraving (fig. 4) we have represented vertical and transverse sections of three forms of *Lindströmia* upon an enlarged scale.

Before leaving this subject, a few words may be said as to the genus *Petraia* of Münster, merely in so far as the forms at present under consideration are concerned. Palæontologists have at various times included under the name of *Petraia*

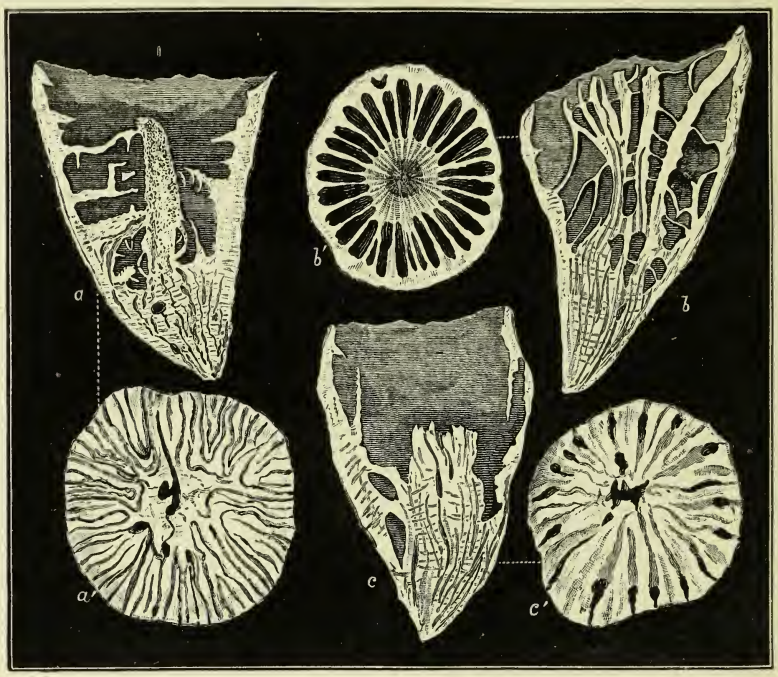

Fig. 4.—*a*, Vertical section of *Lindströmia* (*Cyathaxonia*) *Dalmani*, Edw. and H., enlarged two diameters, showing the dense infilling of the lower portion of the coral, the great columella, and the transverse plates or tabulæ; *a'*, Transverse section of the same, enlarged three times, showing the dense central mass, and the almost complete amalgamation of the septa by sclerenchyma. *b*, Vertical section of *Lindströmia columnaris*, Nich. and Thoms., enlarged three times, showing the filled-up base, the composition of the columellar mass of partially amalgamated vertical rods, and the imperfect tabulæ; *b'*, Transverse section of the same, similarly enlarged, showing the fusion of the septa by means of secondary sclerenchymatous deposit into a central columellar mass. *c*, Vertical section of *Lindströmia subduplicata*, M'Coy, sp., twice the natural size, showing the central fasciculate columellar mass, the deep calice, and the imperfect tabulæ; *c'*, Cross-section of the same, taken close to the base, enlarged five times, and showing the almost complete fusion of the septa by secondary deposit.

a number of small, simple, turbinate corals, of very varying structure, and, so far as known, of very different affinities; and perhaps the best course to adopt would be to entirely drop this title from our nomenclature. If this course be not followed, it will be necessary to restrict the name to some

one or other of the various types of structure which have been included under this name, since it does not appear to be known what was the true nature of the fossils originally placed here by Münster. From the definitions, however, of all later observers, it is evident that the essential features in the structure of *Petraia* are supposed to be the total want of *dissepiments*, *tabulæ*, and *columella*, conjoined with the presence of well-developed lamellar septa and a deep funnel-shaped calice. Our own personal investigations have not brought under our notice any Palæozoic corals in which we could assert positively that these features are present. Two or three small specimens from the curious fossiliferous ashes of Balcletchie, near Girvan, certainly *seem* to want both tabulæ and dissepiments, and to otherwise conform to the above definition; but our material is so scanty that we have held these forms over, in the hope of obtaining more light upon this subject at a later date. On the other hand, we are now able to speak positively as to the structure of at least one of the most typical of M'Coy's *Petraiæ*—viz., *Petraia subduplicata;* and we have been able to prove, as will subsequently appear, that this is a true *Lindströmia*, which in no way conforms to *Petraia* as ordinarily understood. The determination of the real structure of this well-known Silurian species may be regarded as probably settling the position of at any rate most of the small corals included by Phillips under the head of *Turbinolopsis* (Pal. Foss. of Cornwall, &c., p. 1). This name has been rightly regarded as a synonym of *Petraia*, in the usual acceptation of the latter; and it was founded, as is the case with many species of *Petraia*, upon *casts* of the interior of the corallum. These casts, as is well known, are abundant in the Devonian and Silurian rocks, and they are remarkable, as has been frequently noticed, for their being usually truncated below. This truncation of the cast, as noticed by M'Coy, is truly due to the fact that the lower portion of the visceral chamber was filled up with a dense secondary deposit of sclerenchyma, this being one of the characteristic features of *Lindströmia.*

In some cases, also, the lower end of the cast may be seen to present a depression in the centre, corresponding with the columella.[1] We need only add that it has seemed to us much the most preferable course not to attempt to retain the generic name of *Petraia* for *P. subduplicata*, M'Coy, and for those other forms which undoubtedly prove to be congeneric with this. It is true that these forms constitute the most typical section of the group which British palæontologists have usually understood by *Petraia;* but it seems clear that the name *Petraia* cannot be advantageously retained, unless it be strictly limited to forms which want dissepiments, tabulæ, and columella. Such forms have been described (*e.g.*, *P. Benediana*, De Koninck); but microscopic examination renders it certain that *P. subduplicata*, M'Coy, and its allies, must be placed in a totally different category.

Lindströmia subduplicata, M'Coy, *sp.*

(Fig. 4, and Pl. VI., figs. 2-2 *f*.)

Petraia subduplicata, M'Coy, Ann., and Mag. Nat. Hist., ser. 2, vol. vi. p. 279, 1850.
„ „ M'Coy, Pal. Foss., p. 40, 1851.
„ „ Salter, Quart. Journ. Geol. Soc., vol. vii. p. 171, Pl. IX., figs. 7 and 8, 1851.

Spec. char.—Corallum simple, small, conical, straight or slightly curved, averaging nine or ten lines in length, with a diameter at the larger extremity of six or seven lines. Epitheca well developed, marked with longitudinal ridges, corresponding with the interseptal loculi, of which about four occupy the space of one line. In well-preserved specimens fine encircling striæ are present as well, and there are shallow annulations of growth. The calice is deep, funnel-shaped, and oblique. The septa are well developed and lamellar, of two sizes, regularly alternating with one another, and varying from fifty to sixty in number in all. The secondary septa

[1] This feature is sometimes very marked. Compare the figure of the cast of *Petraia elongata*, Phill., given by Milne-Edwards and Haime in their Monograph (Brit. Foss. Cor., Pl. LXVI., figs. 6 and 6 *a*).

are short, and, near the base of the coral, may be unrecognisable. In the centre of the visceral chamber the primary septa unite with one another, and become more or less completely fused together by the deposition of a mass of secondary sclerenchyma, which more or less entirely fills up the lower portion of the corallum. Superiorly the central mass formed by the fusion of the inner ends of the septa, as afore-mentioned, is continued upwards as a large pseudo-columella, which projects to a greater or less extent into the floor of the calice. The interseptal loculi are crossed by a few remote and irregularly-developed dissepiments, and a few imperfect tabulæ can be occasionally detected. No septal fossula.

Obs. — The Gray collection contains a large number of specimens of this interesting little coral from the Craighead limestone, in which the original skeleton of the coral is preserved, and from thin sections of which we have been able to determine its structure in a satisfactory manner. Its general form is conical and nearly straight, the attenuated tip of the corallum being often slightly oblique, and its average dimensions are as above stated. Many individuals, however, are much smaller, and a few are larger. The epitheca is complete, with well-marked longitudinal rugæ, and, when perfectly preserved, with close-set, fine, encircling striæ. Annulations of growth, though present, are never a marked feature. In all our specimens the calice is filled up with the matrix, but it is seen in sections to be always deep, and more or less oblique, occupying one-half to two-thirds of the entire length of the corallum, the septa in its upper portion being merely marginal, and gradually becoming more developed as we descend towards the base. Longitudinal sections (fig. 4 *c*, and Pl. VI., figs. 2 *b* and 2 *c*) show the remarkable feature that the lower third or thereabouts of the visceral chamber is filled up by dense calcareous matter, which is really composed partly of the primary septa, and partly of a secondary deposit of sclerenchyma. In sections, taken accurately through the median line, this calcareous infilling is seen to be prolonged upwards

in the form of a large, apparently cylindrical pseudo-columella, which projects to a greater or less extent above the floor of the calice. In sections taken a little out of the median line, this columellar mass shows its true composition by its exhibiting more or less distinctly the projection into the calice of the cut edges of a number of the septa. The same fact can also be determined by microscopic examination, which shows that the essential elements of this mass are the inner ends of the septa. As regards the other points shown by long sections, we may notice the occasional occurrence of a few strong transverse or ascending plates, which we must regard as tabulæ, and which are most conspicuous in excentric sections. Transverse sections, again, enable us to considerably supplement the knowledge gained by means of vertical slices, but they differ greatly according to the height above the base at which they are taken. Sections taken close above the base (fig. 4 *c*) show that the apparently structureless and dense infilling of the lower part of the visceral chamber is really formed largely out of the primary septa, the interseptal loculi being occupied by a deposit of sclerenchyma, which is usually so far imperfect as to leave small interspaces between the outer ends of the septa. Sections taken at a higher level (Pl. VII., fig. 2 *d*) show the outer wall, the interseptal loculi, which may or may not be crossed by a few dissepiments, and a large central mass, which is formed by the union in the median line of the primary septa, together with structureless calcareous matter of secondary origin. Sections taken above the plane of the floor of the calice show the septa gradually to diminish in size, till they become almost obsolete. The number of primary septa which take part in the formation of the central pseudo-columella varies from twenty-five to twenty-eight; but between these there really exists a corresponding number of much shorter secondary septa. These latter, however, can often not be recognised — especially in sections taken close above the base; and even when present, they may appear to be absent in a variable number of the

interseptal loculi. Sometimes the development of the central pseudo-columellar mass is decidedly excentric, but in no case have we observed a regular septal fossula. As for *tabulæ*, they certainly are not present in a well-marked form. Longitudinal sections, however, often show—especially if excentric—ascending transverse plates, which we consider to be unquestionably imperfect structures of this nature.

Casts of *Lindströmia subduplicata* are not uncommon in the sandstones of Mulloch Hill, near Girvan, and their characters have been well described by M'Coy. As we can readily see from the structure of the corallum, as we now know it, these casts represent the filled-up vacuities of the *upper* portion of the corallum only. The cast is conical, truncated behind, of nearly equal width and length, marked externally with from twenty-four to thirty-two deep slits, which extend to near the centre, where they are slightly twisted. These slits represent the primary septa, and they are separated by an equal number of finer slits, which only extend a very short distance inwards, and which represent the short secondary septa. The radiating lamellæ of the cast, which separate and bound these slits, represent, of course, the filled-up interseptal loculi. The introduction of new septa was effected along the line of a principal interseptal space occupying the dorsal side of the corallum, giving rise to a pinnate arrangement of the sulci in the cast. We have also evidence that the septa within the calice were more or less markedly crenulated, ridged, or toothed on their sides. This is shown by the occurrence of grooves or pits upon the sides of the lamellæ which represent the filled-up interseptal loculi. In ordinary casts, this crenulation of the upper portions of the lamellæ just alluded to is not a marked feature, though usually to be detected with care. There are, however, other casts (Pl. VI., fig. 2 *f*) in which the crenulation of the upper parts of the lamellæ is extraordinarily conspicuous, the outer edge of each being cut into prominent teeth by deep and regular lateral grooves. These casts have been described and figured by M'Coy (Pal. Foss., p. 41, Pl. I. B, fig. 26 *b*),

and they are regarded by him, probably quite rightly, as merely a variety of *L. subduplicata*, to which he gives the title of *crenulata*.

Form. and Loc.—Common in the shales associated with the limestone at Craighead, near Girvan (Lower Silurian). Also not uncommon, though principally in the condition of casts, in the mudstones of Mulloch Hill, near Girvan, of Upper Silurian (? Upper Llandovery) age. A few individuals from the greenish mudstones of Penkill, near Girvan (? Upper Llandovery), also appear to belong to this species, though we have not examined them microscopically. (Gray collection.)

Lindströmia lævis, Nich. and Eth., jun., *sp. nov.*

(Pl. VI., figs. 4-4 *c*.)

Spec. char.—Corallum small, simple, expanding, and widely turbinate, slightly curved towards its smaller extremity. The width of the calice equal to or slightly larger than the total length of the corallum. Surface to the naked eye nearly or quite smooth, under the lens exhibiting fine and close-set encircling striæ, and obscure longitudinal ridges. Epitheca complete; wall thick. Generally one or two shallow annulations of growth near the calicine margin. Calice oblique, patulous, its interior unknown, but always deep, and having the septa obsolete, or nearly so, near its lip. From fifteen to twenty-three primary septa, at various diameters, becoming more or less united with one another below the floor of the calice, and fused by means of a secondary deposit of sclerenchyma, so as to form a central pseudo-columellar mass of large size, which projects to a greater or less extent into the bottom of the calice. Short secondary septa are probably present between the primary ones, but they have not been determined with certainty. Dissepiments unknown. Tabulæ apparently represented by a few remote and strong arched and ascending plates, which intersect the visceral chamber near the base, and take part in the formation of the pseudo-columella.

The smallest individuals observed are a line and a half long, with a width at the calice of a line and three quarters. Average examples are three lines long, and three and a half lines in their greatest diameter. Large individuals attain a length of six lines, with a calicine diameter of between six and seven lines.

Obs.—This pretty little species is abundant and well preserved in the mudstones of Penkill, near Girvan. It is by no means impossible that it may turn out to be really identical with *Petraia uniserialis*, M'Coy (Pal. Foss., p. 41, Pl. I. B, fig. 25); but as the latter is known only by *casts*, as our form is known only by the external and internal characters of the corallum itself, and as we have no means of connecting the two, we have thought it best to establish a new species for our examples. The external characters of *Lindströmia lævis* are very readily recognisable, and distinguish it at once from *L. subduplicata*, M'Coy. It is at once known by its short, curved, and very widely expanding corallum, and the apparent smoothness of the epitheca, the use of a lens at once showing that the surface is really covered with very fine and closely-arranged concentric striæ. Longitudinal ridges and annulations of growth are faintly marked or nearly obsolete. The calice is oblique, though not so markedly so as in *L. subduplicata;* but owing to the fact that it is filled up with the matrix in all our specimens, we can say nothing as to the condition of its interior. Long sections, however, show that it is deep and funnel-shaped, and the septa are also merely marginal ridges near its immediate lip.

As the corallum itself is preserved, thin sections enable us to study its internal structure quite satisfactorily, and it can be shown in this way to be a true *Lindströmia*, with closer affinities to *L.* (*Cyathaxonia*) *Dalmani*, E. and H., than is the case with *L. subduplicata*, M'Coy. Cross-sections, taken below the level of the calice, show that most or all of the primary septa become coalescent and embedded in secondary sclerenchymatous deposit, thus forming a comparatively immense pseudo-

columellar mass, which, in long sections, can be shown to project to a considerable height into the calice. We can also detect in vertical slices a few strong and arched transverse or ascending plates, which must be regarded as tabulæ, and which join the columella centrally. There are two points which we have been unable to determine with certainty—namely, the existence of dissepiments and of short secondary septa. There are indications of both, and, from the analogy of the other species of the genus, we may conclude that these structures were really present. That we should not have been able to detect them is probably due to the fact that the cavities of the wide and patulous corallum are generally filled with the matrix, fine structures being thus broken down, and microscopic examination considerably interfered with. The extreme base of the corallum is more or less completely solidified by a dense deposit of the sclerenchyma, though this is not so largely developed as in *L. subduplicata*, M'Coy.

Form. and Loc.—Common in the greenish mudstones (? Upper Llandovery) of Penkill, near Girvan. (Gray collection.)

GENERAL REMARKS UPON THE CORALS OF THE GIRVAN AREA.

Though we have now examined a very large number of corals from the Silurian rocks of the Girvan district, it remains clear that the materials at present to hand will be very considerably augmented by future researches. Up to this time, in fact, corals have been collected almost exclusively from some three or four horizons in the great and complicated series of the Ayrshire Silurians. Much, therefore, has yet to be done, as will be seen by a glance at the list of localities previously given, before we can give any complete *conspectus* of the coral-fauna of this region; and the time has not come at which it will be possible to enunciate positive conclusions as to the age of the deposits from fossils of this class. Nevertheless it may

be of advantage that we should make a few remarks as to the distribution and time-relations of the known corals of the region in question; and we may conveniently do so by reviewing briefly the chief horizons which, so far, have proved to be coralliferous.

I. The Craighead Limestone.—Up to the present time, the principal Silurian deposit in Ayrshire from which corals have been collected is the great limestone, which is best known as exposed in the quarries at Craighead, about three miles from the town of Girvan. As here seen, the limestone itself is generally more or less grey in colour, and compact or sub-crystalline in texture, but it varies much in different parts of its mass. Often it is greenish in colour, or mottled with lighter or darker green blotches, apparently from the presence of felspathic or serpentinous matter intimately mingled with it; and occasionally a well-marked oolitic structure is developed in it. This last feature, however, is much more conspicuous in the Tramitchell quarries, where the limestone is to a large extent a regular oolite, the component grains being of considerable size. Associated with the limestone at Craighead are also greenish shales, which have yielded a considerable number of fossils. Leaving out of sight some forms which our material has not allowed us to work out, the corals of the Craighead limestone and its associated shales, as at present known to us, are as follows :—

Lyopora favosa, M'Coy, *sp.*
Tetradium Peachii, Nich. and Eth., jun.
Favosites Girvanensis, Nich. and Eth., jun.
Fistulipora? pilula, Nich. and Eth., jun.
Prasopora Grayæ, Nich. and Eth., jun.
Thecostegites? Scoticus, Nich. and Eth., jun.
Heliolites Grayi, Edw. and Haime.
Stylaræa occidentalis, Nich. and Eth., jun.
Streptelasma Craigense, M'Coy, *sp.*
„ *Europæum*, Ferd. Roemer.
„ *aggregatum*, Nich. and Eth., jun.
Lindströmia subduplicata, M'Coy, *sp.*

So far as giving us a clue to the precise position in the Silurian series occupied by the Craighead limestone, the above twelve corals are clearly of limited value. The entire assemblage — which we feel certain will hereafter be considerably increased—is a most remarkable one, and admits of little comparison with the coral-fauna of any sub-group of the Silurian rocks known to us. *Lyopora favosa*, *Tetradium Peachii*, *Prasopora Grayæ*, *Streptelasma Craigense*, *S. Europæum*, *S. aggregatum*, and *Lindströmia subduplicata*, are the *common* forms of the Craighead limestone; and, with the exception of the last, they are not known to occur elsewhere in Britain. Moreover, *Lyopora* and *Prasopora* are special generic types, and *Streptelasma* and *Tetradium* have not been previously recognised in this country, though the former, at any rate, will doubtless be found to have a wide range. Of the remaining forms, *Stylaræa occidentalis* and *Thecostegites* (?) *Scoticus* both belong to generic types foreign to Britain, though the identification of the latter cannot be regarded as certain. Lastly, the only *specific* forms which are known to occur elsewhere in the British area are *Lindströmia subduplicata*, M'Coy, and *Heliolites Grayi*, Edw. and H., both of which occur in undoubted Upper Silurian deposits elsewhere.

That the Craighead limestone, however, is not of Upper Silurian age, may be considered as certain. The absence of the commoner massive species of *Favosites*,[1] *Alveolites*, and *Heliolites*, of *Cyathophyllum*, *Acervularia*, *Cystiphyllum*, *Halysites*, and *Omphyma*, together with the apparent total want of Stromatoporoids, would render this conclusion almost inevitable, even if we had nothing else to go by. The genera *Tetradium*, *Stylaræa*, and *Streptelasma* are, however, characteristically, or exclusively, found in deposits belonging to the Lower Silurian period. We also cannot avoid being greatly struck

[1] The *Favosites Girvanensis* of the Craighead limestone is a very diminutive form, and is a poor representative of the large and common *F. Gothlandica*, *F. Forbesi*, &c., of the Upper Silurian.

with the strongly *American facies* of the Craighead corals, and in particular their resemblance to those of the Trenton and Cincinnati groups. Thus *Tetradium*[1] is a common generic type in the Trenton limestone and Cincinnati formation in both the United States and Canada. *Streptelasma Europæum* is a close ally of the common *Streptelasma corniculum* of the same deposits. Our *Streptelasma aggregatum* belongs to the sub-generic group *Palæophyllum*, the only other members of which are found in the Trenton and Cincinnati formations. *Stylaræa occidentalis* may be taken as representative of the common *Protaræa vetusta* of the Cincinnati beds. Lastly, the nearest allies to the curious *Lyopora favosa* of Craighead are to be found in the so-called *Columnariæ* (not *Favistella*, Hall) of the Trenton limestone, and especially in such forms as *C. Goldfussi*, Bill. Upon the whole, therefore, we must conclude that the Craighead limestone is certainly of Lower Silurian age; and, if we judge only from the corals, we are led to conjecture that it occupies a tolerably low position in the Lower Silurian series, corresponding perhaps with the upper part of the Trenton limestone, or the base of the Cincinnati and Hudson River formations of North America.

II. Mulloch Hill Beds.—Mulloch Hill, near Dalquharran, has long been known as one of the most prolific localities for fossils in the Girvan district. M'Coy generally speaks of the rock here as a "quartzite" or "sandstone," but it contains no silica. It is a hard greenish mudstone, the colour of which, as seen in thin sections, appears to be due to the presence of numerous particles of serpentinous or felspathic matter. Owing to the absence of lime in these deposits, corals are, naturally, not abundant, and they occur commonly, though by no means exclusively, in the condition of casts. Disregarding two or three forms, which could not be determined with the material

[1] Since the above was written, our friend George J. Hinde, Esq., F.G.S., has shown us specimens which he has collected in the Trenton Limestone of Canada, which, so far as we can judge without microscopic sections, are specifically identical with our *Tetradium Peachii*.

at our command, we have recognised the following four corals in the Mulloch Hill beds :—

Heliolites interstincta, Wahl.
Pinacopora Grayi, Nich. and Eth., jun.
Favosites Mullochensis, Nich. and Eth., jun.
Lindströmia subduplicata, M'Coy, *sp.*

The last-named of the above is no test of age, as it occurs in rocks belonging to different periods; and *Pinacopora Grayi*, being both generically and specifically new, is also unavailable as a guide. The presence of *Heliolites interstincta*, however, together with a large-celled *Favosites* of the type of *F. Gothlandica* and *F. Forbesi*, would lead to the conclusion that the Mulloch Hill beds are certainly referable to the Upper Silurian. This conclusion is borne out by the nature of the associated fossils; and we may in the meanwhile consider this deposit as probably corresponding with the Upper Llandovery or May Hill sandstone of "Siluria."

III. Penkill Beds. — The rocks at Penkill, near Girvan, from which we possess corals, consist of a fine-grained grey or greenish-grey mudstone, and the number of corals is limited. From this horizon we have determined the following :—

Heliolites interstincta, Wahl.
Halysites catenularia, Linn.
Favosites Girvanensis, Nich. and Eth., jun.
Lindströmia subduplicata, M'Coy, *sp.*
„ *lævis*, Nich. and Eth., jun.
Calostylis Lindströmi, Nich. and Eth., jun.

The only species in this list which can be used as tests of age are *Heliolites interstincta* and *Halysites catenularia*, and these would go to prove that the beds here are of Upper Silurian age. The singular Perforate genus *Calostylis*, Lindstr., is likewise an Upper Silurian type, the only other known species of the genus being confined to the Wenlock limestone of Gotland. Such other evidence as we have points in the same direction, and we are probably right in concluding that the Pen-

kill beds must find their place towards the lower portion of the Upper Silurian series.

IV. Shalloch Mill Beds.—We are indebted to Mr Lapworth for specimens from a thin band of coralline limestone which crops out on the sea-shore, near a smithy not far from Shalloch Mill, about a mile and a quarter to the south of Girvan. The fossils appear to be tolerably plentiful, but they consist wholly of *Favosites Gothlandica*, Lam., and *Alveolites Labechei*, Edw. and H. The presence of these two well-known types would render it certain that the series of beds in which this limestone is intercalated must be of Upper Silurian age. Further along the shore, in beds considerably higher in position, Mr Lapworth has also detected the presence in calcareous nodules or "cement-stones" of *Halysites catenularia*.

V. Balcletchie Beds. — The last coralliferous horizon which we need notice is that of the Balcletchie beds, near Girvan. The beds in question, which are not the same as those from which we possess remains of Trilobites, consist of dark-green, coarse-grained volcanic ashes, and appear to be largely fossiliferous. The corals are few in number, and badly preserved; and the only form that we have been able to determine positively is *Fistulipora favosa*, nobis. We have also several small cup-corals, very fairly preserved, but our material is insufficient to allow of a thorough examination of these. There are two or three types, and one of them seems to conform to the definition of *Petraia*, which we have given in speaking of *Lindströmia*—that is to say, its interseptal loculi are open, and it shows no traces of dissepiments, tabulæ, or columella. It is much to be desired, however, that further collections should be made from this locality. The corals give us no clue to the age of the Balcletchie beds, but there is some reason to believe that they are low down in the Lower Silurian series—possibly near the horizon of the Craighead Limestone.

SUB-KINGDOM ANNULOSA.

CLASS CRUSTACEA.

Sub-class ENTOMOSTRACA.

Order TRILOBITA.

Genus PHACOPS, Emmrich, 1839.

(De Trilobitis, &c., p. 18.)

Section Phacops proper.

Phacops Stokesii, Milne-Edwards.

P. Stokesii (M.-Edwards), Salter, Mon. Brit. Trilobites, 1864, pt. 1, p. 21, t. 2, f. 1-6 (*for synonomy*).
„ „ Salter, Murchison's Siluria, 1867, 4th ed., t. 10, f. 6, t. 18, f. 6.
„ „ Bigsby, Thesaurus Sil., 1868, p. 64.
„ „ Woodward, Cat. Brit. Foss. Crustacea, 1877, p. 54.

Obs.—*P. Stokesii* was long ago recorded[1] as a Girvan species by the late Mr J. W. Salter, and a head and tail figured in the Appendix to Sir R. I. Murchison's paper "On the Silurian Rocks of the South of Scotland." We have not met with specimens.

Loc. and Horizon.—Mulloch Quarry, in shelly sandstone (*Salter*). Saugh Hill, in sandstone (*Salter*). Thrave.[2]

Phacops Downingiæ is stated to occur at Mulloch Quarry,[3] but we believe the next species has been mistaken for it.

[1] Quart. Jour. Geol. Soc., 1851, vii. pp. 171, 172.
[2] Cat. Foss. Mus. Pract. Geology, 1865, p. 12.
[3] Cat. W. Scot. Foss., 1876. p. 16.

Section Acaste, *Goldfuss.*

Phacops Brongniarti, Portlock.

(Pl. VII. figs. 1 and 2.)

P. (*Acaste*) *Brongniarti* (Portlock), Salter, Mon. Brit. Trilobites, 1864, pt. 1, p. 34, t. 1, f. 20-25 (*for synonomy*).
P. Brongniarti, Bigsby, Thesaurus Sil., 1868, p. 62.
,, ,, Woodward, Cat. Brit. Foss. Crustacea, 1877, p. 50.

Obs.—After Mr Salter's clear and detailed description it is quite unnecessary for us to redescribe *P. Brongniarti*, which with its var. *Dalmani* was first met with in the Girvan district by the late Mr R. Gibbs, and determined by Mr R. Etheridge, F.R.S.[1] We give a figure taken from a cast of an exceedingly well-preserved mould in the Museum of Practical Geology; we are indebted to the authorities of that institution for the loan of it.

Loc. and Horizon.—Ardmillan-brae, in flagstones (*Etheridge*); Mulloch Hill quarry. (Gray Collection.)

Section Chasmops, *M'Coy.*

Phacops truncato-caudatus, Portlock (?).

(Pl. VII. figs. 3 and 4.)

P. (*Chasmops*) *truncato-caudatus* (Portlock), Salter, Mon. Brit. Trilobites, 1864, pt. 1, p. 42, t. 4, f. 13-15 (*for synonomy*).
P. truncato-caudatus, Bigsby, Thesaurus Sil., 1868, p. 64.
,, ,, Woodward, Cat. Brit. Foss. Crustacea, 1877, p. 54.

Obs.—Our specimens are both unfortunately imperfect about the head, which necessitates a note of interrogation after the name of the species; otherwise, however, the characters of the specimens appear to accord perfectly with those given by Mr Salter as distinctive of the species. The sides of the axis of the thorax are conspicuously nodose, the axal furrows strong, and there is a strong node on the inner end of each pleura against the axis, a character upon which stress is laid by Mr Salter. Now these are all present in the specimens we refer

[1] Mem. Geol. Survey. Scot. Expl., No. 7, 1869, p. 10.

to *P. truncato-caudatus*; and in the absence of more negative evidence, we believe we are justified in referring them to that species. Moreover, one of the specimens shows that the head was granulated; and if we refer to Portlock's original figures,[1] we see a peculiar cross-puckering of the surface represented by vertical shading, a point exceedingly well marked in the Girvan individuals. In the determination of the latter we are happy to possess the support of Mr Etheridge, F.R.S. We think our specimens hardly possess as many segments in the pygidium as those figured by Mr Salter.

Loc. and Horizon. — Drummuck Quarry, in a compact greenish mudstone. (Gray collection.)

Genus CHEIRURUS, Beyrich, 1845.

(Ueber einige böhmische Trilobiten, p. 5.)

Cheirurus bimucronatus, Murchison.

C. bimucronatus (Murch.), Salter, Mon. Brit. Trilobites, 1864, pt. 1, p. 63, t. 5, f. 1-5, t. 6, f. 9-18 (*for synonomy*).
„ „ Bigsby, Thesaurus Sil., 1868, p. 44.
„ „ Woodward, Cat. Brit. Foss. Crustacea, 1877, p. 30.

Obs.—This species has been twice recorded by the late Mr Salter[2] as occurring at Girvan; but we have not seen specimens in any of the collections to which we have had access. We can only refer to its occurrence there, and hope that future observers will be more fortunate.

Loc. and Horizon.—Drummuck Quarry, in shaly beds; Mulloch Hill (*Salter*).

Cheirurus gelasinosus, Portlock.

(Pl. VII. figs. 5 and 6.)

C. gelasinosus (Portlock), Salter, Mon. Brit. Trilobites, 1864, pt. 1, p. 71, t. 5, f. 6-8 (*for synonomy*).
„ „ Bigsby, Thesaurus Sil., 1868, p. 44.
„ „ Woodward, Cat. Brit. Foss. Crustacea, 1877, p. 30.

Obs.—The specimens before us do not throw any further

[1] Geol. Report on Londonderry, &c., 1843, t. 2, f. 1-4.
[2] Quart. Jour. Geol. Soc., 1851, vii. p. 172; Monograph, p. 67.

light on the structure of this species, and as they are only badly preserved portions of the head, we refer the reader to Salter's description. Our chief reason for placing these fragments in this species rather than with *C. bimucronatus*, is the form of the forehead lobe of the glabella, which is about equal in breadth to the others, no wider, and does not overhang the other lobes on the sides, and in front is not produced, and, lastly, does not occupy all the margin, as in *C. bimucronatus*. The specimens are small, and in an unsatisfactory state of preservation, and further material is required for proper elucidation. We find *C. gelasinosus* was first mentioned as occurring at Girvan by Mr Salter,[1] who figured a portion of a fine head from that district.

Loc. and Horizon.—Craighead Quarry, in limestone (Salter, *Mus. Pract. Geol.*); Balcletchie, in a dark-green, slightly calcareous mudstone. (Gray collection.)

Cheirurus clavifrons, Dalman?

(Pl. VII. figs. 7 and 8.)

Calymene (?) *clavifrons*, Dalman, Vet. Akad. Handlingar, 1826, p. 260.
,, ,, Dalman, Om. Palæaderna eller de sa Kallade Trilobiterna, 1827, p. 75 (*separate copies*).
,, ,, Lovén, Öfv. K. Vet. Akad. Förhandlingar, 1844, No. 4, p. 63.
Cyrtometopus affinis, Angelin, Pal. Scandinavica, 1854, pt. 1, p. 77, t. 39, f. 10.
(Compare *Cheirurus octolobatus* (M'Coy), Salter, Mon. Brit. Trilobites, 1864, pt. 1, p. 69, t. 5, f. 13 and 14.)

Spec. char.—Glabella oval-oblong, blunt in front, regularly convex, most so in a line drawn across uniting the two foremost furrows—it is also broader at this point, slopes gradually off to the neck segment, and does not overhang the front margin. Frontal and ocular furrows moderately long and curved slightly backwards; basal furrows circumscribing the oval basal lobes, but faintly marked where they join the neck segment, otherwise they, and the frontal and ocular furrows, are deep; the distance

[1] Quart. Jour. Geol. Soc., 1851, vii. p. 170, t. 8, f. 1; Mems. Geol. Survey, Dec. vii., No. ii., p. 11; Monograph, p. 72.

between the ocular and basal furrows, on the one hand, and the ocular and frontals on the other, is about equal; the surface is microscopically granular. The fixed cheeks are rudely triangular, scrobiculate, and, like the glabella, microscopically granular or roughened; although not vertical, they are steeply inclined. Facial suture strongly marked, and in the first part of its course, starting from the external margin, is almost on a line with the ocular furrow. Frontal margin broad and distinct; axal furrows broad, deep, and well marked.

Obs.—The specimen we figure under this name, a glabella and one fixed cheek, has given us much trouble; neither do we yet feel satisfied that it is *C. clavifrons*, Dalman. This difficulty has arisen in a great measure from the want of a clear definition of what is *C. clavifrons*, Dal., accompanied by a good figure. It appears, from Angelin [1] and Salter's [2] account, that two distinct species were included by Dalman under this name, and placed in the Stockholm Museum: one of these has a narrow-fronted glabella, with parallel sides,[3] and for this Angelin retained the name *C. clavifrons;* the other, with a sub-clavate glabella, is more deserving of the name bestowed by Dalman. This, Professor Angelin has called *Cyrtometopus affinis.*[4] Had the name *clavifrons* been retained for the latter instead of the former, much confusion would have been prevented; and we quite agree with Salter's opinion—"We shall never have done with the confusion of these forms unless we restrict Dalman's name to the species called *Cyr. affinis* by Angelin."[5] Taking, therefore, *C. clavifrons*, Dal., as typified by *Cyrtometopus affinis*, Angelin, we may institute as close a comparison with our figured specimen as the side view of the head given by Angelin will permit. The form of the glabella in the two individuals is very much the same; in both, the basal lobe is completely circumscribed by the furrow; but in Angelin's figure the two anterior furrows are shorter than in the Girvan specimen. So far as the fixed cheek is preserved in the latter, there is a close

[1] Pal. Scand., p. 78. [2] Monograph, pt. 1, p. 68. [3] Pal. Scand., t. 39, f. 9.
[4] Pal. Scand., t. 39, f. 10. [5] Monograph, pt. 1, p. 68.

correspondence between the two; they are both scrobiculate; the position of the eye is much the same; and lastly, the facial suture, after leaving the external margin, proceeds in a direct line with the ocular furrow before turning off round the eye—a most important point of resemblance.

Amongst recognised British forms, we have to compare our specimen with *C. octolobatus* (M'Coy), Salter, and *C. juvenis*, Salter. Its resemblance to the former is, in some points, very striking: for instance, the circumscription of the basal lobes, length and direction of the ocular and frontal furrows, and form of the fixed cheeks, are similar; whilst, on the other hand, the elevation of the glabella above the front margin and the neck segment are not marked in our specimen as in *C. octolobatus*—neither does the glabella overhang the front margin. The form and ornamentation of the fixed cheeks is similar; and the facial suture, as in Angelin's figure, is directed towards the ocular furrow. On the whole, there appears to be such a dovetailing of characters between our Girvan form, *Cyrtometopus affinis*, Angelin, and *C. octolobatus*, M'Coy, as to strongly bear out Salter's view that the latter "will have to forego its baptismal privileges;" [1] and again, "our British name must give way to the prior one, for it seems to be really the long-contested *C. clavifrons* of Dalman." [2]

With regard to *C. affinis*, Salter,[3] the task of comparison is much easier: we have only to look at the position of the facial suture of this species in regard to its position with the ocular furrow, to see at once that it is quite distinct from the Girvan form. In *C. affinis* it is directed in a line with the basal instead of the ocular furrow, as in the others; although, so far as the form of the glabella only is concerned, that of *C. affinis* is perhaps more in accord with the Girvan specimen than are either *C. clavifrons*, Dal., or *C. octolobatus* (M'Coy), Salter.

The species now under consideration resembles *C. neglectus*, Barr,[4] but the form of the cheeks in the latter will enable the

[1] Monograph, pt. 1, p. 68. [2] Ibid., p. 70. [3] Ibid., t. 5, f. 9-12 (especially f. 11).
[4] Syst. Sil. Boh. Atlas, I., t. 40, f. 20 and 21.

two species to be distinguished. The form of the glabella and the very restricted circumscribed lobes in *C. gryphus*, Barr,[1] at once distinguish the latter from our *C. clavifrons* (?). A close comparison should also be instituted with *C. pectinifer*, Barr;[2] but it appears to us that the glabella of the latter is relatively too depressed.

In well-marked internal casts the basal lobes are found to be quite circumscribed; but in examples with the whole of the integument preserved, the basal furrows on nearing the neck furrow become much shallower, and in a specimen here and there would lead to the belief that they did not quite circumscribe the lobe.

We were at first inclined to regard the subject of fig. 9, Pl. VII., as distinct from *C. clavifrons*, Dal. (?). The specimen in question is certainly more depressed, and a little more acute in front; but the chief point of difference appeared to us to lie in the ornamentation—a microscopically granular surface with scattered pimples, prickles, or small tubercules. However, a further series of specimens has revealed to us the fact that the convexity of the glabella varies considerably; and one particularly good example, which we hope to figure in our second Fasciculus, shows an outer surface as described in our specific diagnosis, underlaid by a layer with the characters represented by fig. 9, Pl. VII., and just described. We hope to return to this subject at a later period.

Loc. and Horizon.—Drummuck, in a fine-grained mudstone (Gray collection). Thrave Glen, in a buff-coloured rock (Gray collection). Penwhapple, in greenish sandstone (*Salter*,[3] Coll. Brit. Mus., as *C. octolobatus*). *C. clavifrons* appears to have been first recorded as a Girvan fossil by Messrs Armstrong, Young, and Robertson;[4] if, however, *C. octolobatus* is identical, Dr H. Woodward first determined its existence in those rocks.

[1] *Loc cit.*, Supp. I., t. 3, f. 10-17.
[2] *Loc cit.*, t. 4, f. 16.
[3] Salter, Monograph, p. 70.
[4] Cat. W. Scot. Foss., 1876, p. 15.

Cheirurus trispinosus, Young.

(Pl. VII., figs. 10-17.)

C. trispinosus, Young, Proc. Nat. Hist. Soc. Glasgow, 1868, i., pt. 1, pp. 169-171, t. 1, f. 4, 6 *b*.
„ „ Etheridge, jun., Proc. R. Phys. Soc. Edinb., 1878, iv., pt. 3, p. 173.

Sp. char.—General form of the head probably semicircular; free cheek semilunate-triangular, with a rounded, broad, and entire free margin. Eye——? Facial suture cutting the outer margin in a line with the basal furrows of the glabella. Neck furrow deep and well marked. Glabella globular convex, dipping little towards the neck furrow, vertical and blunt in front, or slightly overhanging; frontal furrows short, shallow, sometimes quite inconspicuous and far forward; middle or ocular furrows longer than the frontal, more strongly marked, and inclined backwards; basal furrows the most conspicuous of all, deep, and curving inwards and backwards, uniting with the neck furrow, but faint at the point of union, enclosing prominent, well-marked basal lobes, bearing between them in the middle line a narrow neck. The fixed cheeks are equal in antero-posterior dimensions to the basal and cervical lobes; the anterior margins in a line with the posterior of the three furrows, and the gently arched surface well marked off from the prominent glabella by a slight longitudinal depression; the outer margins are not straight, but bend slightly inwards posteriorly, the greatest width is therefore where they join with the free cheeks; the posterior margins of the fixed cheeks slope obliquely outwards and backwards to the angles. The posterior angles are produced into long, tapering, genal spines, with a dorsal curvature, the apices not descending below the general level of the body. The neck lobe is prominent, thickened, and produced into a strong median spine curved in a similar manner to the others. The glabella, fixed and free cheeks, and the bases of the spines, are covered with large, coarse, and elongated tubercules, intermingled with finer ones,

and scattered without arrangement. The apices of the spines are delicately striate.

Obs.—After a lapse of nearly ten years since its original description by Prof. J. Young, M.D., we are able to add very little to the account of this interesting Trilobite. So far only the head of *C. trispinosus* has come to light, and, even in the case of specimens of this, always in a mutilated condition. The individuals present in the Gray Collection appear to exhibit the genal and cervical spines in a more satisfactory manner than those from which Prof. Young's description was made, now in the Hunterian Museum, Glasgow. In drawing up the above specific diagnosis we have availed ourselves of Prof. Young's description, and we have reproduced his outline drawing of the restored carapace (fig. 17).

C. trispinosus has the thickened neck segment seen in many species of the genus, and appears to be peculiar, so far as we have been able to ascertain from a comparison with a large number of specimens and figures, in the presence of the cervical spine, as Prof. Young originally pointed out. Many *Cheiruri*, as for instance *C. insignis*, Beyrich, *C. gibbus*, Beyrich, and *C. ornatus*, Dalman, have a small tubercule in the centre of the neck lobe, more or less developed according to species: may the cervical spine of *C. trispinosus* be a further development of this? Again, in some American species there is a median cephalic spine developed, as *C. Satyrus*, Billings, and *C. glaucus*, Billings,[1] but it arises from the posterior median portion of the glabella, and not from the neck lobe. Although placed in *Cheirurus*, Prof. Young remarks that it may "hereafter be found to form the type of a separate genus,"[2] but until the entire Trilobite can be described it is better where it is.

Loc. and Horizon.—Penkill, in greenish mudstone. (Gray collection.)

[1] Pal. Foss. Canada, i. pp. 323, 324, f. 308 and 309. [2] *Op. jam cit.*, p. 171.

Cheirurus, *sp. ind.*

(Pl. VII., fig. 18.)

Obs.—We illustrate a specimen consisting of six thoracic segments, which appears to be peculiar in the possession of a very broad axis in proportion to the width of the pleuræ. It has very much the character of the form called *C. octolobatus*, by M'Coy and Salter, only it tapers from before backwards much too rapidly for that species. So many *disjecta membra* require piecing together, especially in the present genus, that it becomes very difficult to determine a large number of fragments such as that now under discussion. The width of the axis cannot in itself be accepted as a distinctive character, so many species of *Cheirurus* possess it.

Loc. and Horizon.—Drummuck Quarry. (Gray collection.)

Cheirurus (?) *sp. ind.*

(Pl. VII., fig. 19.)

Obs.—Although minute and fragmentary, this specimen is worthy of a figure on account of the well-marked glabella furrows, also from the fact that the latter appear to be only two in number, and almost pass completely across the glabella. So far as preserved it is not unlike a species of *Amphion* (*A. pauper*, Salter).

Loc. and Horizon.—Balcletchie, in dark-green mudstone. (Gray collection.)

Genus SPHÆREXOCHUS, Beyrich, 1845.

(Ueber einige böhmische Trilobiten, p. 19.)

Sphærexochus mirus, Beyrich.

(Pl. VII., fig. 20.)

S. mirus (Beyrich), Salter, Mon. Brit. Trilobites, 1864, pt. 1, p. 76, t. 7, f. 1-6 (*for synonomy*).
„ „ Bigsby, Thesaurus Sil., 1868, p. 68.
„ „ F. Roemer, Lethæa Geog., 1877, Atlas, t. 17, f. 9.
„ „ Woodward, Cat. Brit. Crust., 1877, p. 58.

Obs.—We only possess one specimen of this peculiar Trilo-

bite, and so far as we recollect it has not hitherto been noticed as a Girvan species. It is an imperfect glabella, showing the strong basal glabella furrows and traces of the surface granulation.

Loc. and Horizon.—Dark-green coarse-grained ashes or ashy-conglomerate of Balcletchie. (Gray collection.)

Genus Encrinurus, Emmrich, 1845.

(N. Jahrbuch für Min., 1845, p. 42.)

Encrinurus punctatus, Brünnich.

E. punctatus (Brünnich), Salter, Mem. Geol. Survey, Dec. vii., 1853, No. 4, p. 6 (*for general synonomy*).

a. var. **calcareus**, Salter.

Encrinurus punctatus, Corda, Prodrom einer Monog. böhmischen Trilob., 1847, p. 91, t. 5, f. 55.
Cybele punctatus, Fletcher, Quart. Jour. Geol. Soc., 1850, vi., p. 403, t. 32, f. 15.
Encrinurus punctatus, M'Coy, Brit. Pal. Foss., 1851, fas. 1, p. 158.
E. punctatus, var. *calcareus*, Salter, Mem. Geol. Survey, Dec. vii., 1853, No. 4, p. 6, t. 4, f. 15.
Asaphus tuberculatus, Buckland, Bridg. Treatise, n. ed., 1858, ii., t. 64, f. 6.
E. punctatus, Salter and Woodward, Chart. Foss. Crustacea, 1865, p. 13, f. 52.
„ „ Baily, Char. Fossils, i., p. 67, t. 23, f. 2.
„ „ Salter, Murchison's Siluria, 1867, 4th ed., p. 235, foss. 65, f. 5.
„ „ Salter, Cat. Camb. Sil. Foss., Woodwardian Museum, Camb., 1873, p. 77.
„ „ Woodward, Cat. Foss. Crust., 1877, p. 37.

Obs.—Of Mr Salter's variety *calcareus* we have examined only two definite specimens from the Girvan district, both pygidia, and not in a good state of preservation. They do not call for further remark. We have given the synonomy of *E. punctatus* under the two varieties established by Mr Salter, and trust that this division will be found of service.

Hor. and Locality.—Penkill (Gray collection); burn passing Bargany Pond, near Dailly (*Coll. Geol. Survey, Scot.*, collected by Mr A. Macconochie).

b. var. **arenaceus**, Salter.

(Pl. VIII., figs. 1-4.)

Calymene variolaris, Brongniart, Hist. Nat. Crust. Foss., 1822, t. 1, f. 3 A.
„ *punctatus*, Dalman, Vet. Acad. Handlinger, 1826, p. 233, t. 2, f. 2, *a* and *b*.
„ „ Murchison, Sil. Syst., 1839, t. 23, f. 8.
Encrinurus punctatus, Salter, Quart. Jour. Geol. Soc., 1851, vii., pp. 170 and 172, t. 9, f. 4.
Cybele punctata, Hall, Pal. N. York, 1852, ii., p. 297, t. A. 61, f. 1, *g*, *h*, and *i*.
E. punctatus, var. *arenaceus*, Salter, Mem. Geol. Survey, Dec. vii., 1853, No. 4, p. 6.
„ „ Bronn, Lethæa Geognostica, 3d ed., 1851-56, i. p. 658, Atlas, t. 9^2, f. 24, a-c.
Asaphus tuberculatus, Buckland, Bdgw. Treatise, n. ed., 1858, ii., t. 64, f. 6.
E. Stokesii, M'Coy, Sil. Foss., Ireland, 1864, p. 46, t. 4, f. 15.
Cryptonemus punctatus, Angelin, Pal. Scandinavica, 1854, p. 3, t. 4, f. 4-8.
E. punctatus, Salter, Murchison's Siluria, 1867, 4th ed., p. 90, foss. 15, f. 10.
„ „ var. *arenaceus*, Bigsby, Thesaurus Sil., 1868, p. 51.
„ „ „ Salter, Cat. Camb. Sil. Foss. Woodwardian Mus., Cambg., 1873, p. 77.
E. punctatus, F. Roemer, Lethæa Geog., 1876, i., Th. Atlas, t. 17, f. 8, *a* and *b*.
„ „ var. *arenaceus*, Woodward, Cat. Brit. Foss. Crustacea, 1877, p. 36.

Obs.—The variety *arenaceus*, Salter, which has the termination of the pygidium deflexed and blunt, as distinguished from the produced mucro of *calcareus*, appears to be the predominating variety at Girvan. Nearly all the specimens are mere casts, usually of the pygidium only, sometimes the latter and a few of the thoracic segments united, and in one or two instances small casts of the entire Trilobite. As a rule, the pygidia, although casts, show traces of the characteristic tubercules on the axis and ribs to a greater or lesser extent; indeed the features of the tail in *E. punctatus* are so well marked and distinctive as to quite bear out Mr Salter's remark, when describing *E. variolaris*—viz., that "the characters of the tail are amply sufficient to separate the two common species."[1] However, to

[1] Mem. Geol. Survey, Dec. vii., No. 4, p. 7.

afford assistance to those not having ready access to books, we give the abbreviated characters of the tail in the three allied species, which may be used as distinctive ones, taken from the detailed descriptions of Messrs Fletcher[1] and Salter.[2]

Encrinurus punctatus.—Axis of about thirty segments, with the centre smooth, but having seven prominent and distinct tubercules, with an interval of four rings between every two tubercules. Lateral ribs eight in number, separated by deep furrows, and each with a tubercule at its proximal end.

E. variolaris.—Axis of ten rings, the first carrying a tubercule, the second a punctum between two tubercules. The succeeding five rings have a tubercule, and a punctum between two tubercules alternately; the three last have a tubercule only. There are seven lateral ribs, each with a tubercule at its proximal end.

E. sexcostatus.—Axis of twenty segments without tubercules. Lateral ribs six in number, strong, flattened, with obtuse tips, divided by narrow deep furrows. Surface of tail covered with a close scabrosity.

Loc. and Horizon. — Conglomerate of Cuddystone Glen (*Salter*); sandstones of Saugh hill (*Salter*); Craighead limestone (*Etheridge*,[3] Mus. Pract. Geol. Collection); Penwhapple (*Etheridge and Young*,[4] ibid.), all recorded simply as *E. punctatus.*

The variety *arenaceus* occurs at Craighead, in the limestone (Gray collection), and at Penkill in greenish mudstones (Gray collection.)

Genus Cybele, Lovén, 1845.

Cybele, Lovén, Vet. Akad. Forhandlingar, 1845, No. 4, p. 110.
Zethus (pars), M'Coy, Brit. Pal. Foss., 1851, fos. 1, p. 156 (non Pander).
Cybele, Salter, Brit. Pal. Foss., 1851, App. A, p. iii.
„ Salter, Mem. Geol. Survey, 1864, iii., p. 324, note.

Obs.—We adopt the name *Cybele* as restricted by Salter, in contradistinction to the interpretation of Volborth, M'Coy, and others, who considered it identical with *Zethus*, Pander. Mr Salter states that *Zethus* was founded upon a fragment of a *Cheirurus*, and is altogether a doubtful and dubious genus.

[1] Quart. Jour. Geol. Soc., vi. pp. 403 and 405.
[2] Dec. vii., No. 4, p. 3.
[3] Mem. Geol. Survey Scot., Expl. 14, 1869, p. 9.
[4] Ibid., Expl. 3, 1873, pp. 31 and 32.

Cybele was placed by Salter as a sub-genus of *Encrinurus*, from which it is chiefly distinguished by the possession of twelve thoracic segments, usually produced into spines, the position of the facial suture, and some minor points.

Cybele verrucosa, Dalman.

(Fig. 5 *c*.)

Calymene (?) *verrucosa*, Dalman, Vet. Akad. Handlingar, 1826, p. 285.
„ „ „ Om Palæaderna, &c., 1827, p. 100.
„ „ „ Arsberättelse om nyare Zoologiska arbeten, &c., 1828, p. 134, Note 1.
„ „ „ in Férrussac's Bull. des Sciences, Nat., 1829, xix., p. 128.
Chaperon d'un Trilobite, Brongniart, Hist. Crust. Foss. 1822, p. 145, t. 4, f. 11.
Trilobites (*Calymene*) *verrucosa*, Lovén, Vet. Akad. Forhandlingar, 1845, No. 3, p. 52, t. 1, f. 5, *a-c*.
Cybele verrucosa, Lovén, *loc. cit.*, No. 4, p. 111.
Atractopyge verrucosa, Corda, Prodrom einer Mon. böhmischen Trilob., 1847, t. 5, f. 52.
Cybele sexcostata, Salter, Mem. Geol. Survey, 1848, ii., pt. i., t. 8, f. 9 (non f. 10).
„ *verrucosa*, Salter, *loc. cit.*, p. 343.
Zethus atractopyge, M'Coy, Brit. Pal. Foss., 1851, fas. 1, p. 156, t. 1 G., f. 1-5.
Cybele verrucosa, Salter, Mem. Geol. Survey, 1853, dic. vii., No. 4, p. 4.
„ „ Salter and Woodward, Chart Foss. Crustacea, p. 12, f. 48.
„ „ Morris, Cat. Brit. Foss., 1854, 2d ed., p. 103.
„ „ Salter, Mem. Geol. Survey, 1866, iii., p. 324, t. 19, f. 7.
„ „ Salter in Murchison's Siluria, 1867, 4th ed., p. 206, Foss. 48, f. 2.
„ „ Bigsby, Thesaurus Sil., 1868, p. 47.
„ „ Woodward, Cat. Brit. Foss. Crustacea, 1877, p. 33.

Obs.—We have seen several imperfectly-preserved examples of this species from the Girvan district, sufficiently well marked to make identification satisfactory.

Loc. and Horizon.—South side of Green-hill, Penwhapple Glen (*Coll. Mus. Pract. Geology*); Drummuck, in greenish-grey mudstone ? (Gray collection) ; Balcletchie, in dark-green mudstone (Gray collection). *C. verrucosa* appears to have been first collected in the Girvan neighbourhood by the late Mr Richard Gibbs, and the specimen identified by Mr R. Etheridge, F.R.S., and Dr J. Young, F.G.S.

Cybele rugosa, *Portlock.*

(Pl. VIII., figs. 5-7.)

Ogygia (?)	*rugosa*,	Portlock, Geol. Report, Londonderry, 1843, p. 302, t. 5, f. 10.
Cybele	„	Salter in M'Coy's Brit. Pal. Foss., 1851, fas. 1. App. A., p. iii., t. i. G. f. 8.
„	„	Bigsby, Thesaurus Sil., 1868, p. 47.
„	„	Morris, Cat. Brit. Foss., 2d ed., 1854, p. 103.
„	„	Salter, Cat. Camb. Sil. Foss., Woodwardian Mus., Cambg., 1873, p. 51.
„	„	Woodward, Cat. Brit. Foss. Crust. 1877, p. 33.

Spec. char.—General form ovate-triangular, tapering rapidly towards the posterior. Head or carapace nearly semicircular; anterior margin strong, broad, vertical, and bent upwards in front of the glabella. Free cheeks very convex, unsymmetrically hatchet-shaped, and produced posteriorly into short, pointed, slightly curved, genal spines. Facial suture generally sigmoidal; posterior to the eye it curves outwards laterally until near the thickened margin, when a sudden downward curvature is taken, cutting the margin close to the genal spine; anterior to the eye the facial suture passes inwards towards the glabella, and in front of the latter some little distance above the front margin. Axal furrows broad and deep, well marked; marginal furrow distinct, but not deep; neck furrow rather broad and well defined, especially in the lateral portions. Neck segment or lobe strong. Glabella elongate, slightly clavate, attenuated posteriorly; frontal lobe expanded and overhanging the others, continuous with the main axis of the glabella; the three side lobes are club-shaped, connected with the axis by narrow necks, and so united with one another as to leave between them very shallow inconspicuous furrows and deep oval pits between the narrow necks; the upper or frontal furrows are directed obliquely forwards, the middle and basal are nearly at right angles to the glabella axis. The eyes are situated nearer to the glabella than to the lateral margins, a little behind the most convex part of the cheeks. Fixed cheeks

narrow and transversely elongated; general surface, except the anterior margin and genal spines, tuberculated.

Thoracic segments tapering rapidly towards the tail; axis about as broad as the pleuræ, with a single line of tubercules on each segment, and a few smaller ones scattered amongst them; pleuræ sharply divided longitudinally by a groove, near the anterior margin, into two very unequal parts, and produced distally into flat angulated curved spines. Pygidium long, triangular, gradually tapering to a point; axis less in width than the side lobes, of about twenty-eight coalesced rings, the divisions being visible only on the sides, leaving a clear, smooth, more or less longitudinal flattened space, unornamented and without tubercules; side lobes deflected, becoming strongly bent down towards the apex of the tail; the component pleuræ are five in number on each side, longitudinally curved when viewed laterally, and increasing in size outwards from the axis, each ornamented with a few tubercules; between the three upper ribs on each side an intermediate rugose small rib is interpolated; "the lateral ribs have terminal spines, but the four last ones are much longer; they are united for some distance, and then diverge to form the 4-5 serrate tip of the tail."

Obs.—With the exception of that of the tail, we are not acquainted with any further description of *Cybele rugosa;* it was therefore very gratifying to find two or three examples in Mrs Gray's collection, from which we have been able to draw up the above description, although some of the minor details, such as the ornamentation of the pleuræ and the full extent of the spines, still remain to be further elucidated.

From *Cybele bellatula*, Dalman, the present species is distinguished, as it also is from *C. verrucosa*, Dalman, by possessing much more decidedly hatchet-shaped free-cheeks, and by their greater posterior extension. From the first it is also distinguished by its highly ornate head, and from both by the production of the posterior angles into spines. So far we have no evidence of the two peculiar spines descending from

the sixth thoracic segment in *C. rugosa*, as in *C. bellatula*, neither is there any trace of the ornate anterior margin of *C. verrucosa*. The position of the eyes is also different in these species to what it is in *C. rugosa:* in *C. bellatula* the eyes are close to the glabella and far forward, judging from Angelin's figure;[1] whilst in *C. verrucosa* they are situated almost half-way between the glabella and the anterior lateral margin, and nearly opposite the frontal furrow. On the other hand, in *C. rugosa*, they are close to the lateral lobes of the glabella, and far back, approaching the posterior margin, and almost opposite the middle or ocular furrow. When we look at the tails of the respective species we see a still further and more decided difference. In the two Swedish species, which more or less resemble one another, we notice, in the first place, that the axis of the tail is more regularly segmented; in the second there is an absence of the deflection visible in *C. rugosa;* and, finally, the terminations of the lobes are free and not coalesced to form a spine.

Cybele dentata, Esmark,[2] and *C. brevicaudata*, Angelin,[3] are known only in the form of pygidia, and are easily distinguished from *C. rugosa* by similar characters to the preceding species.

Loc. and Horizon.—In the greenish-grey mudstone of Drummuck (*Gray Coll.*); Ladyburn, a little above Drummuck, in a similar matrix (*Geol. Survey Scot. Coll.*) We believe that *Cybele rugosa* was first indicated as a Girvan species by Mr John Young, F.G.S.[4]

Genus Dindymene, Corda, 1847.

Dindymene, Corda, Prodrom einer Mon. böhmischen Trilob., 1847, p. 119.
„ Barrande, Syst. Sil. Bohême, 1852, p. 816.

Obs.—The genus *Dindymene* was established by Dr Corda for a very peculiar trilobite devoid of eyes and facial suture,

[1] Pal. Scandinavica, t. 4, f. 1.
[2] Angelin's Pal. Scandinavica, t. 41, f. 12.
[3] Ibid., t. 41, f. 14.
[4] Proc. Nat. Hist. Soc. Glasgow, ii., pt. 2, p. 179.

and in which the glabella is unprovided with furrows.[1] The glabella is elevated somewhat above the cheeks, which are convex and sub-triangular. The thorax has ten segments, and its pleuræ have their extremities produced into oblique, free points or extremities, increasing in length posteriorly, and there inclined to become parallel to the axis. The axis of the pygidium is multi-segmentate. Upon each lateral lobe are two pleuræ, similar to those of the thorax, bent down nearly parallel to the axis, and terminating in similar points produced a short distance beyond its apex. We believe *Dindymene* has not hitherto been recognised as a British form, and we were for some time in much doubt to what genus to refer the fossils which follow. The descriptions of Corda and Barrande, however, are so clear, especially when used in conjunction with their admirable figures, that we think little doubt can be entertained as to the correctness of our determination.

Dindymene Cordai, Etheridge, jun., and Nicholson, *sp. nov.*

(Pl. VIII., fig. 8, and Fig. 5, A and B.)

Spec. char.—Outline of the head nearly semicircular; front margin somewhat bent up in the middle line, in front of the glabella. The latter is strongly pyriform, and very convex, widest at about, or a little less than, a third behind the anterior margin, then rapidly narrowing to the neck furrow. No lobes or furrows are present, and there is no point or occipital tubercule. Cheeks convex, prominent, and obtusely triangular. Axal furrows strong, deep, and wide; neck furrow well marked but not so strong as the axal furrows. Posterior angles produced into diverging spines. Entire thorax unknown; axis gradually tapering, moderately convex, the segments rounded, distinct, and prominent. The united portion of the pleuræ a little broader than the axis, the segments resembling those of the latter, slightly bent downwards, terminating in short free points,

[1] M. Barrande described a third species of this genus in the supplement to the first volume of his Bohemian work, which has glabella furrows,—so that this statement requires modification.

which become bent more and more parallel to the general axis of the trilobite as the posterior end is approached. Pygidium narrow; axis of many segments, about eight or ten (?), tapering to a fine point; the side lobes are very narrow and reduced, being composed of two pleuræ on each side, resembling those of the thorax, and given off from the two first segments of the axis; the inner of these are pressed quite close to the lateral margins of the axis, and both the inner and the outer terminate in similar points to the pleuræ of the thorax, the two inner by their extension beyond the apex of the tail forming a well-marked apical-notch. The surface of the glabella is ornamented with granules or small tubercules, and that of the segments of the body and tail is very minutely and inconspicuously granular.

Obs.—M. Barrande has described three species of this genus from the Silurian rocks of Bohemia, all of which differ from the present form. The markedly pyriform shape of the glabella separates *D. Cordai* from all the Bohemian species, and the

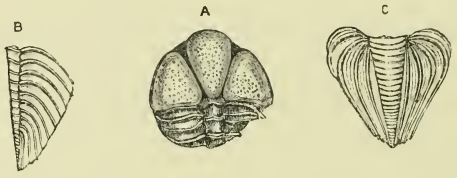

Fig. 5.—A, Head-shield of *Dindymene Cordai*, Eth. and Nich., without eyes or facial suture, but showing the granulated surface; Ladyburn, above Drummuck, enlarged twice. (*Coll. Geol. Survey Scot.*). B, Cast of pygidium accompanying the same, similarly enlarged. (Compare fig. 8, Pl. VIII.) C, Cast of pygidium of *Cybele verrucosa*, Dalm., similarly enlarged, from Balcletchie.

absence of any trace of lobation from *D. Bohemica*, Barr. in particular. In *D. Friderici-Augusti*, Corda, and *D. Haidingeri*, Barr., the glabella swells out anteriorly, tapering gradually towards the posterior, the axal grooves are somewhat curved, and there is a cephalic tubercule present. In *D. Cordai*, nobis, on the other hand, the axal grooves are straight, the glabella is quite pyriform, becoming very narrow at the neck furrow, and there is no trace of a cephalic tubercule. In the thorax of *D. Cordai* the axis narrows, and the segments are individually more rounded and projecting.

There is evidently a close resemblance between the tails in all the species of this genus, but in *D. Cordai*, nobis, the axal segments are more numerous than in *D. Friderici-Augusti*, Corda, and the free terminations of the lateral lobes are more widely separated. So far as we are aware, the biserial arrangement of the tubercules on the axes of the thorax and pygidium of the latter species does not exist in the Girvan form.

We were at first acquainted only with the tail of this species, and had provisionally placed it in *Cybele*, Lovén, but the accidental discovery of a head and tail (Fig. 5, A and B) on the same piece of matrix in the collection of the Geological Survey of Scotland gave us a further clue. The general features of this peculiar Tribolite are so marked, more especially those of the head and tail, that little doubt can exist of the relation of our fossil to those described by M. Barrande.

Loc. and Horizon.—Drummuck, in fine grey mudstone (*Gray Coll.*); Ladyburn, above Drummuck, in a hard mudstone; collected by Mr A. Macconochie (*Coll. Geol. Survey Scot.*)

Genus STAUROCEPHALUS, Barrande, 1846.

(Note Préliminaire, p. 52; Syst. Sil. Bohême, 1852, i., p. 810.)

Staurocephalus globiceps, Portlock.

St. globiceps (Portlock), Salter, Mon. Brit. Trilobites, 1865, pt. 2.
„ „ Bigsby, Thesaurus Sil., 1868, p. 68.
„ „ Woodward, Cat. Brit. Foss. Crustacea, 1877, p. 59.

Obs.—In his 'Monograph,' Mr Salter gave a woodcut[1] of a specimen of this species from Ayrshire, without defining any particular locality. We have been allowed to examine this example, now in the Museum of Practical Geology, and find that Salter's figure does more than justice to the specimen, and is greatly enlarged. The cheeks are much more convex than in *St.* (?) *unicus*, and this with the position of the eye appears to be a very good point of distinction between the two species.

Loc. and Horizon—Ardmillan Brae, in shale (*Etheridge*[2]).

[1] P. 86.
[2] Mem. Geol. Survey Scot., Expl. No. 7, 1869, p. 10; Expl. No. 3, 1873, p. 32.

Staurocephalus (?) unicus, Wyv. Thomson.

(Pl. VIII., figs. 9-16, and Fig. 6, A, B.)

Acidaspis unicus, Wyv. Thomson, Quart. Jour. Geol. Soc., 1857, xiii., p. 209, t. 6, f. 13 and 14.
St. (?) *unicus*, Salter, Mon. Brit. Tribolites, 1865, pt. 2, p. 86, t. 7, f. 22-24.
St. Maclareni (Wyv. Thomson, MS.), Salter, *loc. cit.*, p. 86.
St. unicus et *St. Maclareni*, Bigsby, Thesaurus Sil., 1868, p. 68.
,, ,, Woodward, Cat. Brit. Foss. Crustacea, 1877, p. 59.

Spec. char.—General form of the body oblong, and sparingly ornamented with granules. Head broad, and rather long. Free cheeks very minute, with entire margins. Eyes very slightly, if at all, pedunculate, distinctly faceted, situated far forward, immediately under the swollen hemispherical glabella on each side. Neck furrow broad and strongly marked. Glabella more or less clavate, with the frontal lobe produced into a globular or somewhat more or less pyriform prominence, occupying almost, if not quite, two-thirds of the whole length of the entire glabella, much elevated above the general surface of the head, and projecting above the frontal margin. The two basal lobes bear no comparison to the frontal lobe, and are separated from it by a broad, distinct, and well-marked furrow. Cheeks broad, gently convex, and distinctly punctate, with a thickened margin produced anteriorly into two almost straight or slightly recurved spines, of variable length, but generally short; posterior angles produced into short recurved genal spines. Thorax of twelve (?) segments; axis convex, about half as broad as the pleuræ, or perhaps a little more; pleuræ horizontal, with a double ridge running along each, the two ridges coalescing at the distal extremity, and ending in a strong, long, reflexed spine. Tail broad and short; axis of two minute segments; pleuræ of the first tail segment spatulate, divided almost medianly by a shallow groove, and posteriorly bent almost at right angles to the axis, and continued backwards into two long spines. Ornamentation: thorax with

a double row of minute granules on each segment; pygidium granular; cheeks punctate; frontal lobe of the glabella minutely granular.

Obs.—This species was originally described by Sir Wyv. Thomson as an *Acidaspis*, but it was transferred to *Staurocephalus* by Mr Salter in his earlier description of it. Prof. Wyv. Thomson drew attention to the abnormal number of thoracic segments present in *St. unicus*, and to its position as a link between the *Acidaspidæ* and *Cheiruridæ*. Salter remarked: "If Prof. Thomson be correct in figuring twelve segments to the body, the species is abnormal for either *Acidaspis* or *Staurocephalus*. The shape of the head shows clearly enough that it is to *Staurocephalus*, or else to one of the sections of *Cheirurus*, that this bizarre fossil must be referred. *Cheirurus* often has twelve segments, *Acidaspis* nine or ten, *Staurocephalus* only ten. The grooved pleuræ are unlike *Staurocephalus*, but like the section *Eccoptochile* among the genus *Cheirurus*. But no *Cheirurus* has so clavate a glabella, though a tendency towards it is exhibited in some species, and *Sphærocoryphe* of Angelin is very near to our fossil." If the almost entire cast we figure (Pl. VIII.) as *St. unicus* is in reality that species, as we believe it to be, we think we are in a position to corroborate Sir Wyv. Thomson's view of the number of thoracic segments, for we are strongly under the impression that this cast possesses twelve. We are inclined to regard this as *St. unicus* and not *St. globiceps* from the less convexity of the cheeks, forward position of the eye, and spatulate appendages to the tail. Salter, who was the first to figure the glabella of *St. unicus*, represents the frontal lobe as much elongated or pyriform, and projecting far beyond the frontal margin. Salter's figure must represent an extreme variety of *St. unicus*, for not one of the numerous heads of this species we have examined, and which otherwise accord perfectly with the characters of *St. unicus*, possesses this extremely pyriform and projecting outline: on the contrary, they all more nearly resemble the form of frontal lobe seen in the other species of the genus.

The frontal lobes before us are hemispherical, or in one or two cases very slightly pyriform, and without the anteriorly elongated form of Salter's figure,[1] and quite accord with Barrande's generic description.[2] The outline of the former more nearly corresponds with Angelin's *Sphærocoryphe*, as displayed in the type species *S. dentata*, than any of its fellows. We much wish we possessed specimens of *Sphærocoryphe* for comparison with *Staurocephalus*, for we are quite convinced of the close relationship of the two genera. The position of the eyes in *St. unicus* appears to be a little different from that in either *S. Murchison*, Barr., *S. globiceps*, Portlock, or *S. clavifrons*, Angelin. In *St. unicus* the eyes are situated far forward, and as if sheltering themselves under the sides of the frontal lobe of the glabella; but in the three species just mentioned the eyes have a more posterio-central position on the lateral elements of the head. The bidentate character of the limb is a well-marked and distinctive point in *St. unicus;* but, strange to say, the same peculiarity is present in *Sphærocoryphe dentata*, Angelin.

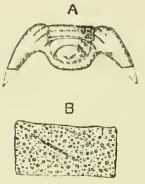

Fig. 6.—A, Pygidium of *Staurocephalus* (?) *unicus*, Wyville Thomson; possibly a variety of it, or a new species, of the natural size. B, Enlargement of the surface of the same. Shalloch Mill.

Sir Wyv. Thomson's manuscript species *S. Maclareni* was considered by Mr Salter identical with *St. unicus*. We have been favoured with the loan of specimens of the former from the Museum of Practical Geology, and can fully bear out Salter's statement. We give a figure of a somewhat peculiar pygidium (Fig. 6, A), from another locality, Shalloch Mill. It has the general character of that of *St. unicus*, but the surface, including that of the long spines, is scabrous (Fig. 6, B), instead of granular or tubercular. It may be specifically distinct, but the one specimen is all we have at present at our command. It is in a calcareous shale.

Loc. and Horizon.—Penwhapple Glen, in schists at the base of the Orthoceratite and Graptolite flags (*Wyv. Thomson*);

[1] Monograph, t. 7, f. 22[b].

[2] Syst. Sil. Bohm., i., p. 811.

Piedmont Glen[1] (as *S. Maclareni*, Wyv. T.); Balcletchie (*Gray Coll.*); Drummuck (*Coll. Geol. Survey Scotland*).

Staurocephalus nodulosus, Salter.

S. nodulosus, Salter (MS.), Mon. Brit. Foss., 1865, pt. 2, p. 87, t. 7, f. 25.
S. sp. ind., Woodward, Cat. Brit. Foss. Crustacea, 1877, p. 59.

Obs.—Under this name Salter figured two thoracic segments, "an imperfect fossil, but distinct from *St. unicus*. It has tuberculate pleuræ." The pleural spines appear to be bent down at a much more acute angle than in *St. unicus*. Nothing more appears to be known about this fossil.

Loc.—Ayrshire.

The peculiar and interesting Trilobite, *Deiphon Forbesii*, Barrande, is stated[2] to have been found at Balcletchie, but we have not met with any direct evidence of it. Hemispheric, disjointed glabellæ are common at that locality, but we see no reason to doubt their identity with the preceding species but one.

Genus Acidaspis, Murchison, 1839.

Acidaspis, Murchison, Sil. Syst., 1839, p. 638.
„ Salter, Mem. Geol. Survey, Dec. vii., 1853, No. 6., p. 1.
Odontopleura, Emmrich, de Trilobitis, 1839, p. 33.

Acidaspis Lalage, Wyv. Thomson.

(Pl. VIII., figs. 17-22.)

A. Lalage, Wyv. Thomson, Quart. Jour. Geol. Soc., 1857, XIII., p. 206, t. 6, f. 1-5.
„ „ Bigsby, Thesaurus Sil., 1868, p. 33.
„ „ Woodward, Cat. Brit. Foss. Crust., 1877, p. 19.

Spec. char.—General form oblong, inclined to square. Head or carapace roundly triangular, moderately convex, with the frontal margin rounded. Free cheeks small, fringed in front

[1] Cat. Foss. Mus. Pract. Geol., 1865, p. 6. [2] Cat. W. Scot. Fossils, 1876, p. 16.

with short, minute spines; posterior angles produced into short divergent genal spines. Eyes somewhat remote; ocular ridge distinct. Facial suture apparently cutting the posterior margin close to the base of the genal spines. Neck furrow strongly marked. Glabella triangular, moderately convex, with a distinct, broad, median lobe, and two pairs of oval convex lateral lobes entirely circumscribed, and of which the lower pair appear to be a little the larger; glabella furrows well marked and deep.

Fixed cheeks very gibbous, separated from the glabella by deep axal grooves. Neck segment convex and expanding posteriorly, produced into two divergent or slightly curved spines. Thorax square-oblong, horizontal, of nine or ten segments; axis narrow and prominent; pleuræ convex, divided by the pleural grooves into two ridges which coalesce at the distal extremities, and are produced as long diverging posteriorly directed spines. "Pygidium short, semicircular, of two short segments fringed with from twelve to fourteen long radiating equal spines; a ridge from the anterior axis-segment is continuous with the antepenultimate spine on either side." General surface tuberculate, the head more so than the body; tail reticulate.

Obs.—Our description is drawn up from several detached fragments of this species, as we have not seen a complete example; the characters of the tail are taken from Prof. Thomson's description. We are able to add one or two characters to the original general diagnosis of the Trilobite, which will serve to fix the species in a more satisfactory manner. The occurrence of the cheeks appears to be rare, for only in one example in the Gray collection is there any trace of them; indeed, information about the free cheeks and eyes is required before the above remarks relating to them can be considered as definite. The circumscribed lateral lobes of the glabella appear to be well-marked features of *A. Lalage*, so also do the gibbous fixed cheeks with their closely set tubercules. Another point to be noticed in the structure of this

species is the highly tuberculate head, as compared with the sparingly ornamented body and reticulate tail.

A. Lalage may be distinguished from its ally *A. hystrix*, Wyv. Thomson, by the more uniform character of the lateral lobes of the glabella, by its single, as compared with the double thoracic pleural spines of the latter, and by possessing a reticulate instead of a tuberculate surface to the pygidium. From *A. Grayæ*, R. Etheridge, which it resembles in the reticulate tail, *A. Lalage* may be distinguished by the simple nature of its spines, by the smaller and less developed condition of the spines of the last thoracic segment, and by a dissimilar number of spines fringing the pygidium.

Sir Wyv. Thomson says,[1] "The form of the tail of this species at once distinguishes it from all its British congeners, as indeed from all species hitherto described, with the exception of *A. radiata*, which it closely resembles. The tail-spines of the present species are longer than in *A. radiata*, and slightly curved." We may observe on this point that, according to Goldfuss's figure,[2] the posterior axis segment of the tail is represented by two nodes or elevations, which quite separates it from *A. Lalage*.

Loc. and Horizon.—Penwhapple Glen, in schists at base of the Graptolite and Orthoceratite flags (*Wyv. Thomson*). Balcletchie (*Gray Coll.*)

Acidaspis hystrix, Wyv. Thomson.

(Pl. VIII., figs. 23-25.)

A. hystrix, Wyv. Thomson, Quart. Jour. Geol. Soc., 1857, xiii., p. 207, t. 6, f. 6-10.
" " Bigsby, Thesaurus Sil., 1868, p. 33.
" " Woodward, Cat. Brit. Foss. Crustacea, 1877, p. 19.

Spec. char.—General form parallelogrammatic, slightly tapering posteriorly, densely fringed with spines. Head or carapace almost semicircular. Limb of the free cheek ornamented with a fringe of short simple spines, increasing in length backwards;

[1] Quart. Jour. Geol. Soc., xiii., p. 207. [2] N. Jahrbuch, 1843, t. 4, f. 1.

posterior angles produced into curved genal spines extending backwards to the third thoracic segment, and so curved that the convexity is outward laterally from the body of the trilobite, when in its natural position. "Glabella broadly triangular, not very highly arched; middle lobe rather narrow; lateral lobes two, oval, separated by distinct grooves from the central lobe and from the cheek; basal lateral lobe fused with the neck segment. Portion of the cheek within the facial suture very gibbous, likewise confluent with the neck segment. Neck segment very prominent, separated from the middle lobe of the glabella by a shallow groove." Thorax of nine segments; axis narrow and prominent, rounded; pleuræ horizontal and convex, divided into an anterior and posterior portion by a groove which is placed somewhat nearer the anterior than the posterior margin of each pleura, so that the latter are divided longitudinally into two unequal portions; the anterior half terminates in a short pointed reflexed spine, the posterior on the other hand terminating in a long, simple, more acutely reflexed straight spine, very gradually tapering; the spines are so placed, with regard to one another, that the short anterior spine of one pleura passes under the posterior spine of the pleura next in front, the length of the former being such that in nearly every case two are overlaid by the same posterior long spine. Pygidium minute, short, and a little less than the width of the thorax; axis of two segments, the anterior giving off ridges on each side continuous with the antepenultimate spine of the tail on each side; limb produced into twelve nearly parallel or slightly radiating spines, graduating in length right and left from the two central ones, which are nearly equal. The spines of the last thoracic segment are more acutely bent down than any of the others of the thorax, and are extended backwards beyond the extremity of the longest tail-spines. Surface of the head, thorax, and pygidium densely granular, the granules on the thorax being arranged in two lines on each of the divisions of the pleuræ.

Obs.—The regular contour, long radiating spines, and highly granular surface give to this species a peculiarly graceful appearance. According to Sir Wyv. Thomson, *A. hystrix* somewhat resembles *A. Prevosti*, Barr.,[1] but the structure of the head, and the number and arrangement of the tail-spines (sixteen), distinguish it. The elongated large basal lateral lobes of the glabella will serve to distinguish the head of the present species from that of *A. Lalage;* whilst as regards the thorax, the profuse granulation and spines of two orders in *A. hystrix* will be sufficient. In the one the tail is reticulate, in the other tuberculate. The doubly-spined pleuræ and granular ornamentation separate *A. hystrix* from *A. Grayæ*, R. Eth., to say nothing of the denticulated spines of the latter form, but unfortunately we are unable to compare the heads of the two species. *Acidaspis Dufrenoyi*, Barr.,[2] resembles *A. hystrix* to a certain extent, but the distal ends of the pleuræ are produced into three spines each, one of them almost vertical, and the others sub-parallel, not passing under one another. Again, the thorax is ornamented with only one row of tubercules on the pleuræ, arranged vertically, and two on the axis, and the pygidium is plain except on the axis. In the double spines to the pleuræ, *A. hystrix* resembles *A. ovatus*, Emmrich,[3] but the arrangement is different.

Acidaspis callipareos, Wyv. Thomson.

A. callipareos, Wyv. Thomson, Quart. Jour. Geol. Soc., 1857, xiii., p. 208, t. 6, f. 11, 12.
„ „ Bigsby, Thesaurus Sil., 1868, p. 33.
„ „ Woodward, Cat. Brit. Foss. Crustacea, 1877, p. 18.

Obs.—Although we have not had the advantage of studying the original specimens upon which Sir Wyv. Thomson based his determinations, we are inclined to think that the head described in his interesting paper under the above name would have been more appropriately ascribed to the thorax and pygi-

[1] Syst. Sil. Bohm., i., p. 739, t. 39, f. 33-41. [2] Ibid., i. t. 38, f. 25.
[3] *Odontopleura*, Emmrich, Untersuch. über boh. trilob., 1846, p. 18, t. 3, f. 1.

dium [1] named by him *A. hystrix*—a view which is borne out by the highly ornate character of the test in the whole of the remains referred to. In the only specimen of *A. hystrix* in the Gray collection in which the head is shown it is unfortunately imperfect, and, so far as preserved, the distinctive characters assigned to it by Sir Wyv. Thomson cannot be satisfactorily made out, as they appear to be common throughout the genus. Of *A. hystrix*, Prof. Thomson remarked, "We have only one specimen of this species showing the head," whilst of *A. calliparcos* only the head is known likewise. According to the descriptions of the two species, the heads chiefly differ in that of *A. hystrix* having the basal lateral lobes fused with the neck segment, and the fixed cheeks confluent with the neck segment. It is just possible that the imperfect state of the head of *A. hystrix* may have given rise to the appearance of characters which did not really exist; they are, however, said to be from different horizons.

Loc. and Horizon.—Sandstone of Mulloch Hill. (*Coll.*, Wyv. Thomson.)

Acidaspis Grayæ, R. Etheridge, jun.

(Pl. VIII., fig. 26: Pl. IX., figs. 1-6, and 7 (?); Fig. 7 B.)

A. Grayæ, Eth., jun., Proc. R. Physical Soc., Edinb., 1878, iv., pt. 3, p. 170, t. 2, f. 6-8.

Spec. char.—General form oblong-oval, depressed, bordered with a fringe of delicate, radiating spines. Head rounded, triangular convex; limb of the free cheek produced into a fringe of delicate, simple spines graduating and becoming longer from before backwards. Glabella apparently oval, convex, basal lobes oval, elongated, apparently quite circumscribed. Posterior angles produced into genal spines which extend backwards for about half the length of the thorax, and appear to be but little bent or curved; neck segment prominent and apparently non-spinous; surface of the glabella and lobes covered with scattered tubercules or granules. Thorax horizontal, square-

[1] *Loc. cit.*, t. 6, f. 7 and 8.

oblong, of ten segments; axis narrow and prominent, gradually decreasing in width towards the pygidium; pleuræ horizontal, traversed by a nearly central groove, and produced laterally into long, recurved, denticulated spines, those of the last segment (that next the pygidium) bent down almost in a parallel direction with the limb-spines of that division of the body—no trace of surface-ornamentation preserved. Pygidium short, semicircular, surface reticulate; axis of two segments; limb produced into fifteen sub-equal radiating denticulated spines; the anterior axis segment gives off a ridge on each side, continuous with the antepenultimate spines on each side the central one of the pygidium; the denticles are sub-alternate on each side of contiguous spines, and alternate on opposite sides of the same spine.

Obs.—All the specimens of this species contained in Mrs Gray's cabinet are more or less fragmentary, with the exception of that represented by Fig. 6, a cast; and even here the specimen is a good deal crushed, and the characters of the carapace obliterated. So far as present observation has enabled us to judge, the spines projecting from the anterior part of the carapace are simple, whilst those of the thorax and pygidium are unquestionably denticulated. The head is not in a good state of preservation, and little can be said about the characters of the glabella, its lobes and furrows, the facial suture, and the fixed and movable cheeks, except that the glabella and lobes appear to have been convex and prominent.

Amongst British species, *A. Grayæ* must be first compared with three species of *Acidaspis* from Girvan, described by Sir Wyville Thomson, F.R.S.[1] The form and general proportions of the thorax and pygidium closely resemble those of two of these—*A. Lalage* and *A. hystrix;* but the characters of the carapace, so far as they can be made out, do not correspond particularly, in the absence of any cervical spines in *A. Grayæ*. It undoubtedly differs from *A. Lalage* in its denticulated spines, those of the latter being quite simple and plain, both on the

[1] Quart. Jour. Geol. Soc., 1857, xiii., pp. 206-209.

pygidium and thorax. Similarly it is also distinguished from *A. hystrix*, Wyv. Thomson, and *A. Caractaci*, Salter; in the first of these each pleura terminates in two reflected spines, one passing under the other, and in the latter is bispinose, one spine being much longer than the other, but in neither case are the spines denticulated. Again, *A. Grayæ* does not appear to agree with any other described British species with which we are acquainted, either by specimens or figures, such as *A. Barrandei*, Fletcher; *A. bispinosa*, M'Coy; *A. Brightii*, Murchison; *A. coronatus*, Salter; *A. Jamesii*, Salter; or *A. Hughesii*, Salter. In fact, the increased number of spines round the pygidium separates *A. Grayæ* from all the foregoing forms, to say nothing of their denticulated character, except *A. Lalage* and *A. hystrix*, where the spines are twelve to fourteen in the one case, and twelve in the other, and apparently all simple. All the specimens of pygidia which we refer to *A. Grayæ* have constantly fifteen denticulated spines, except in one specimen where we counted sixteen.

Leaving British species and passing to Bohemian Silurian Trilobites, we find there are several with which a comparison may be made. M. Barrande has figured two species with the spines of the pleuræ denticulated—*Acidaspis Keyserlingi*, Barr.,[1] and *A. mira*, Barr.[2] In the first of these the spines in question are of a form totally different from those of *A. Grayæ*, and the thoracic axis is very much broader in proportion to the general size of the trilobite. In *A. mira* the spines of the pleuræ are of two kinds, one denticulated and the other not, both attached to the same pleura. In neither are the spines of the pygidium denticulated, but M. Barrande also figures at least five species in which these particular spines are so, viz.:—

1. A. Verneuilii, *Barr.*, loc. cit., t. 38, f. 1-9.
2. A. Portlockii, „ „ „ f. 10-12.
3. A. vesiculosa, „ „ „ f. 13-21.
4. A. tricornis, „ „ suppl., t. 8, f. 21.
5. A. rara, „ „ „ t. 12, f. 28.

[1] Système Sil. Boh., I., t. 36, f. 10-22. [2] Ibid., t. 39, f. 1-11.

In the first three of these the form of the pygidium, and the number, form, and arrangement of the spines into which the limb of each is produced, are so different as to necessitate little or no comparison. The ornamentation of these trilobites consists of small granules or tubercules, both on the thorax and pygidium; on the other hand, on the only part of *A. Grayæ* where the ornamentation is preserved, it is seen to be reticulate, as in *A. Lalage*. In *A. tricornis*, Barr., the pygidium spines are only eight in number; finally, there are eight also in *A. mira*, but the arrangement of them is again different from any of the preceding.

A specimen of this species lately obtained by Mrs Gray leads us to think that the arrangement of the spines was even more complicated than at first supposed. It will be seen that in Fig. 7, A and B, two pleuræ taken from a larger specimen, the central portion of each pleura terminates in the long denticulated spine as described, and there appears to be anterior and posterior to this the broken bases of other supplementary spines: whether these were also denticulated we cannot say.

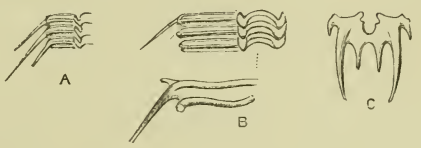

Fig. 7.—A, Part of one side of thorax of *Acidaspis*, sp., with long and slender spines, of the natural size, from Balcletchie. B, Part of one side of thorax of *Acidaspis Grayæ*, Eth., jun., enlarged twice, with one pleura enlarged still further. At the termination of the pleuræ is seen the central denticulated spine, along with the broken bases of the anterior and posterior spines of the same (from Balcletchie). C, Pygidium of *Acidaspis*, sp. ind., with six spines, enlarged twice (cast from Mulloch Hill).

Loc. and Horizon.—Balcletchie, in a fine, greenish mudstone (*Gray Coll.*)

Acidaspis, *sp. ind.*

(Fig. 7 C.)

(Compare *Acidaspis* (*Ceraurus*) *crenatus*, Emmrich, as figured by Lovén, Ofv. K. Vet. Akad. Förhandl., 1845, No. 3, p. 47, t. 1, f. 1, *a-f.*)

Obs.—The pygidium we represent in Fig. 7 C is quite different from any others which have come under our notice. The axal segments are not distinctly preserved, but they are apparently

two in number. As usual in this genus, from the anterior of the two proceed two ridges, which on reaching the margin are prolonged into straight, tapering, plain spines. Between these are two smaller and shorter ones, placed opposite the termination of the axis. External to the two principal spines are two small prolongations, almost proceeding from the angles of the pygidium, and the shortest of all those visible in the specimen. No traces of ornamentation are preserved.

This form of pygidium differs from all the other Girvan species here described, by the fact that the elongated spines, continuous with the ridges from the first axal segment, are separated by only two secondary spines proceeding from the limb of the pygidium, instead of three or more, as in *A. Lalage*, *A. hystrix*, or *A. Grayæ*, as the case may be; and that external to these primary spines, the secondary are reduced to one on each side. M. Barrande has figured several Bohemian forms in which a similar number and arrangement of spines is to be seen, as in the species under consideration, but in each case there is also present some other good distinctive character. Such are *A. Dormitzeri*, Barr.;[1] *A. Laportii*, Barr.;[2] *A. propinqua*, Barr.;[3] *A. Roemeri*, Barr.;[4] *A. Geinitziana*;[5] and *A. direlicta*, Barr.[6] Much nearer, however, than any of the foregoing is *A.* (*Ceraurus*) *crenatus*, Emmrich, as figured by Lovén. Here we find an exact representation of the spines seen in the Girvan fossil, except that in Lovén's figure the whole of the parts are on a much larger scale. We think it not at all improbable that it may be a small variety of *A. crenatus*, or else an undescribed form.

Loc. and Horizon.—Mulloch Hill (*Gray Coll.*)

Acidaspis (?) *sp. ind.*

(Fig. 7 A.)

Obs.—We figure this fragment of a thorax from the fact that it appears to differ in the length of its spines and other minor

[1] Syst. Sil. Boh. Atlas, I., t. 38, f. 22.
[2] *Loc. cit.*, t. 39, f. 23.
[3] *Loc. cit.*, t. 39, f. 25.
[4] *Loc. cit.*, t. 39, f. 29.
[5] *Loc. cit.*, t. 39, f. 49.
[6] *Loc. cit.*, Suppl. I., t. 7, f. 10, t. 9, f. 4.

characters from any of the other Girvan forms which have come under our notice. We provisionally refer it to *Acidaspis*, although we quite admit that it may be a *Staurocephalus*, but probably the former. The central ridge of each pleura is minutely granulated, and is produced into a long, tapering, posteriorly-recurved, simple spine. The horizontal portions of the pleuræ appear to be unornamented.

Loc. and Horizon.—Balcletchie, in a fine-grained greenish mudstone (*Gray Coll.*)

Genus Lichas, Dalman, 1826.

(Ofv. Vet. Akad. Handlingar för aar 1826, p. 93.)

Lichas laxatus, M'Coy.

Lichas laxatus (M'Coy), Salter, Mem. Geol. Survey, 1848, II., pt. 1, p. 340, t. 8, f. 4-6.
,, ,, Salter, Quart. Jour. Geol. Soc., 1851, VII., p. 172, t. 9, f. 5.
,, ,, Morris, Cat. Brit. Foss., 1854, 2d ed., p. 110.
,, ,, M'Coy, Sil. Foss. Ireland, 1862, p. 51, t. 4, f. 9.
,, ,, Salter, Mem. Geol. Survey., 1866, III., p. 324, t. 19, f. 1-3.
,, ,, Salter, in Murchison's Siluria, 1867, 4th ed., p. 204, foss. 46, f. 5.
,, ,, Bigsby, Thesaurus, Sil., 1868, p. 57.
,, ,, Woodward, Cat. Brit. Foss. Crustacea, 1877, p. 43.

Obs.—We know this as a Girvan species only from the figure given by Mr Salter, representing a small glabella, showing very distinctly the narrow neck of the latter, and the circumscribed side-lobes, although it appears to us that these are represented in this figure as much more oval in outline than those of the later figures of the same author.

Loc. and Horizon.—Lower Thrave, in yellowish sandstone (Salter), on a similar horizon to the beds of Mulloch Hill quarry.

Lichas Barrandei, Fletcher (?).

(Pl. IX., fig. 8.)

L. Barrandei, Fletcher, Quart. Jour. Geol. Soc. 1850, vi., p. 238, t. 27, f. 10, t. 27 *bis*, f. 5.
,, ,, Morris, Cat. Brit. Foss., 1854, 2d ed., p. 110.
,, ,, Salter in Murchison's Siluria, 1867, 4th ed., p. 234, foss. 64, f. 3.
,, ,, Bigsby, Thesaurus Sil., 1868, p. 57.
,, ,, Woodward, Cat. Brit. Foss. Crustacea, 1877, p. 43.

Obs.—We are indebted to Mr R. Etheridge, F.R.S., for the loan of a pygidium of this species from the M.P.G. Collection, but as we are unable to add to Mr Fletcher's description, we content ourselves with simply giving a figure of the specimen. We have to observe, however, that, unlike Fletcher's example, the axis of ours is not wider than the side-lobes, scarcely so wide indeed. It will be seen by the figure that the projecting teeth of the broad foliaceous pleuræ are not visible, consequent upon the non-preservation of the margin. In this state some hesitation might be manifested whether to refer the specimen to *L. Barrandei*, Fl., or *L. laciniatus*, Dalman, and indeed it appears really to occupy an intermediate position between the two. In some respects the specimen approaches *L. Barrandei*, and in others equally so *L. laciniatus*. Unfortunately the matter is not simplified by the indefinite character of the margin of the Girvan specimen. However, it appears to possess the three-segmented axis, broad foliaceous pleuræ with their central division, the axal tubercle, and the rapidly attenuated posterior portion of the axis of both species, but the axis and the attenuation are relatively much narrower than in either of the above, but of the two it is probably nearer *L. Barrandei* than *L. laciniatus*. On the other hand, the outline of the margin, so far as it is preserved, assumes more the form of *L. laciniatus*, especially of Lovén's figure,[1] although there are at the extreme apex, we think, indications

[1] Öfv. Vet. Akad. Förhandl., 1845, No. 3, t. 1, f. 7, *a* and *b*.

of a notch, which would be a strong indication of alliance with *L. Barrandei.* This is only one of the many unsatisfactory points which have appeared during the examination of the present collection, and which can only be settled by the acquisition of further material. It is the *L. laxatus* of the Catalogue of Fossils in the Museum of Practical Geology,[1] quoted from Girvan, but not of M'Coy.

Loc. and Horizon.—Mulloch Hill (*Coll. Mus. Pract. Geol.*)

Lichas Hibernicus, Portlock.

(Pl. IX., figs. 9, 10.)

Nuttania Hibernica,		Portlock, Geol. Report, Londonderry, 1843, p. 274, t. 1, f. 1, t. 5, f. 1-3.
,,	,,	Morris, Cat. Brit. Foss., 1843, p. 75.
Lichas	,,	Beyrich, Ueber einige Böhm. Trilob., 1845, pp. 25, 29.
,,	,,	Bronn, Index Pal. Nomenclator, 1848, p. 641.
,,	,,	M'Coy, Sil. Foss. Ireland, 1862, p. 51.
,,	,,	Bigsby, Thesaurus Sil., 1868, p. 57.
,,	*sp.*	R. Etheridge, jun., Proc. R. Phys. Soc., 1878, iv. pt. 3, p. 169.

Spec. char.—Head obtusely semicircular or semi-oval, and gibbous in front. Glabella convex, broader in front than behind; forehead lobe continuous from the front margin backwards to the neck-segment, and not expanding posteriorly; anterior portion of the forehead-lobe expanding, and slightly overhanging the side-lobes; neck of the glabella rather broad, flattened, formed by its posterior prolongation to the neck segment. Side-lobes elongate, concavo-convex laterally, extending rather further back than the base of the glabella. Neck segment broad but not very convex. Surface covered with pustules of various sizes and irregular form, arranged without regard to order. Glabella furrows well marked.

Obs.—We are only acquainted with the glabella of this species from Girvan, but its characters are so essentially simple as compared with most other members of the genus, that it is easily recognised. The almost straight neck-lobe, with the

[1] 1865, p. 21.

oval side-lobes descending quite to the latter, without the intervention of any intermediate lobes, is very characteristic. It is the *Lichas avus* of the 'Catalogue of Western Scottish Fossils,' but not of M. Barrande. It certainly resembles the Bohemian form in the character of its ornamentation; otherwise it is totally different.

We have four specimens, all glabellæ, and only in one specimen are the accessory lobes preserved; the others consist merely of the forehead and side lobes. *L. macrocephala*, Eichwald, is another similar form.

Lichas ornatus, Angelin, closely resembles the Girvan species, and like it has the large side-lobes descending to the neck-furrow, giving it a bold and marked appearance.

Loc. and Horizon.—Craighead quarry, in limestone; Balcletchie, in fine-grained mudstone. (Gray collection.)

Lichas Grayii, Fletcher (?).

(Pl. IX., figs. 11, 12.)

Lichas Grayii, Fletcher, Quart. Jour. Geol. Soc., 1850, vi., p. 237, t. 27, f. 8, t. 27 *bis*, f. 3, *a* and *b*.
,, ,, Morris, Cat. Brit. Foss. 2d. ed. 1854, p. 110.
,, ,, Bigsby, Thesaurus Sil., 1868, p. 57.
,, ,, Woodward, Cat. Brit. Foss. Crustacea, 1877, p. 43.

Spec. char. — Head nearly semicircular, gibbous in front. Glabella large, convex, as broad or broader anteriorly than posteriorly; forehead-lobe continuous from the front margin to the neck-segment, narrowing posteriorly till on a level with the base of the side-lobes, where it is marked by a slight constriction or transverse groove, then suddenly expanding at the base, with a slight prominence or node on each side. Upper lateral lobes oval, obtusely pointed, not extending to the neck-segment, but cut off by the posterior expansion of the forehead-lobe; lateral side-lobe more or less triangular. Neck-segment not prominent; glabella furrows well marked; surface covered with close-set granules.

Obs.—We refer this specimen to *L. Grayii* provisionally, as

we have not had the advantage of comparing it with any typical examples : it appears to agree better with this species, however, than with any other. The form of the side-lobes and the posterior expansion of the forehead-lobe separate our specimen from *Lichas Bucklandi*, M. Edw., and *L. Salteri*, Fletcher. From *L. laxatus*, M'Coy, and *L. verrucosus*, Eichwald, it is separated by the much greater width of the neck of the forehead-lobe, and the different form of the supplementary side-lobes. Its dissimilarity to *L. Hibernicus* is at once apparent.

Loc. and Horizon. — Drummuck, in fine-grained greenish mudstone. (Gray collection.)

Lichas, *sp. ind.*

(Pl. IX., figs. 13, 14.)

Obs.—This is in all probability a portion of the cephalic shield of a *Lichas*. We observe the fore part of the forehead-lobe, and a small portion of the right side-lobe, a portion of the eye-lobe, and the right eye with its facets, preserved. The lobes are all granulated. On the under side is visible the hypostome, of an oval or egg-shaped form, with one of its alar prolongations partially preserved. This fragment is interesting, from the forward position of the eye in relation to its position with the side-lobe, and its size.

Loc. and Horizon.—Drummuck. (Gray collection.)

END OF THE FIRST FASCICULUS.

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PLATE I.

Fig. 1. Small specimen of *Lyopora favosa*, M'Coy, sp., of the natural size. *Coll.* H. A. Nicholson.

Fig. 1 *a*. A few calices of the same, enlarged.

Fig. 1 *b*. Thin transverse section of the same, viewed on a dark background, of the natural size. *Coll.* H. A. Nicholson.

Fig. 1 *c*. Another transverse section, also viewed on a dark background, of the natural size. *Coll.* H. A. Nicholson.

Fig. 1 *d*. Vertical section of same, similarly viewed, of the natural size. *Coll.* H. A. Nicholson.

Fig. 1 *e*. A few calices of 1 *c*, enlarged about ten times.

Fig. 2. Side view of a large specimen of *Favosites Girvanensis*, Nich., and Eth. jun., of the natural size.

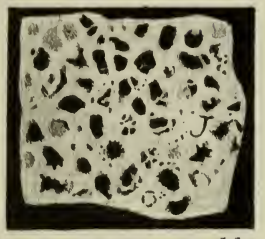
Fig. 2 *a*. Under surface of an average example of the same, of the natural size.

Fig. 2 *b*. Vertical section of the same, showing tabulæ, enlarged about twenty-five times.

Fig. 2 *c*. Vertical section of another example, without tabulæ, similarly enlarged.

Fig. 2 *d*. Transverse section of the same, similarly enlarged.

Fig. 3. Transverse section of *Tetradium Peachii*, magnified about one hundred times. *Coll.* H. A. Nicholson.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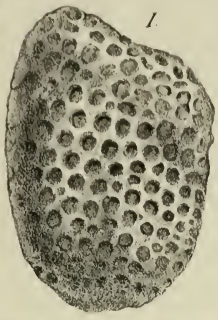
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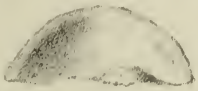
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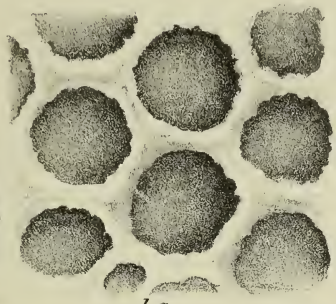
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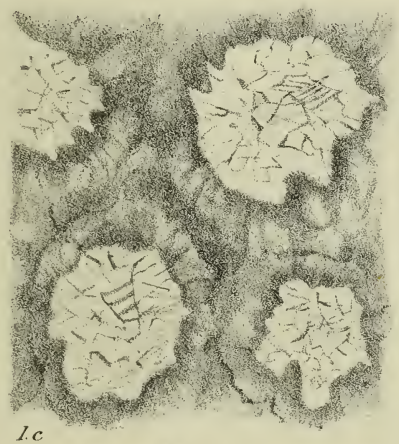
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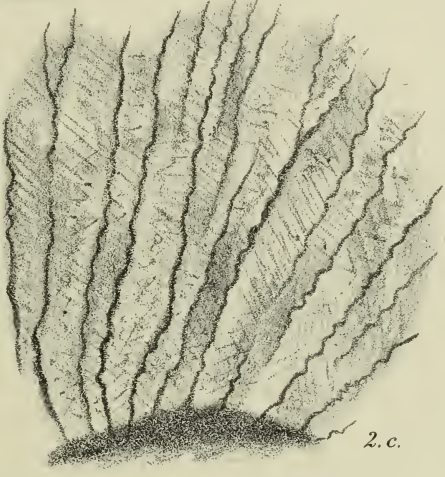
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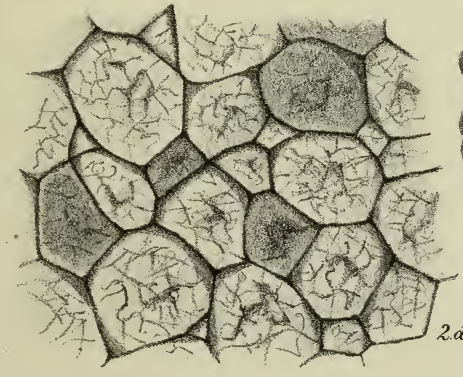
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PLATE II.

Fig. 1. Vertical section of *Tetradium Peachii*, in which tabulæ are abundantly developed, enlarged about fifty times. *Coll.* H. A. Nicholson.

Fig. 1 *a*. Another vertical section of the same, similarly enlarged, in which tabulæ are absent.

Fig. 1 *b*. Mass of *Tetradium Peachii*, showing the form of the surface, of the natural size.

Fig. 2. A small example of *Favosites Mullochensis*, the base of which has been cut away, of the natural size. No surface-characters are shown.

Fig. 2 *a*. Transverse section of the same, enlarged ten times.

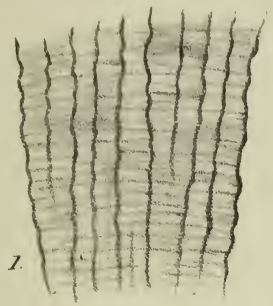
Fig. 2 *b*. Vertical section of part of the same, similarly enlarged.

Fig. 3. Fragment of the base of a mass of *Fistulipora favosa*, of the natural size. The outline shows the original size of the mass prior to sectioning.

Fig. 3 *a*. Portion of the weathered surface of the same, enlarged about six times. The larger tubes appear black, not from shadow, but from being filled with the dark matrix, while the intervening tubuli are filled with calcite.

Fig. 3 *b*. Portion of a transverse section of the same, enlarged twenty-five times.

Fig. 3 *c*. Longitudinal section of the same, similarly enlarged.



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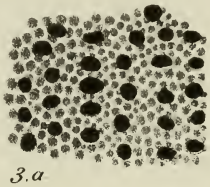

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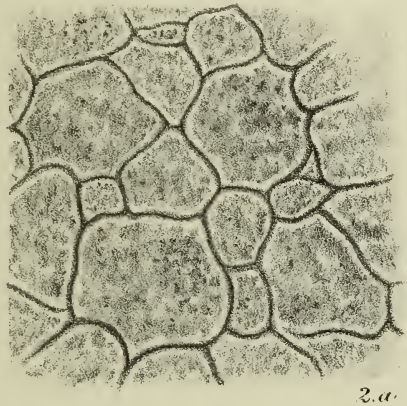

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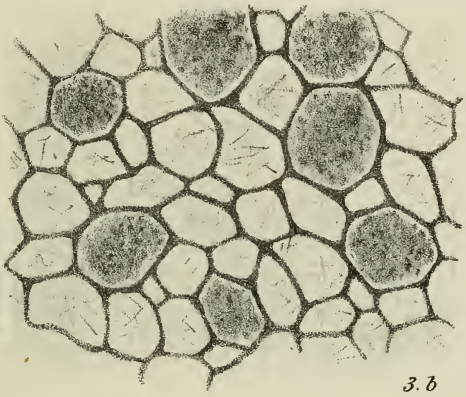

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PLATE III.

Fig. 1. A specimen of *Fistulipora* (?) *pilula*, of the natural size, viewed from one side.

Fig. 1 *a*. Small portion of the transverse section of the same, enlarged about twenty-five times.

Fig. 1. *b*. Portion of the vertical section of the same, enlarged about twelve times.

Fig. 2. Fragment of *Chætetes*, sp., of the natural size.

Fig. 2 *a*. Part of the transverse section of the same, enlarged ten times.

Fig. 2 *b*. Part of the vertical section of the same, similarly enlarged.

Fig. 3. *Under* surface of the epithecal plate of a small example of *Pinacopora Gray*, of the natural size.

Fig. 3 *a*. *Upper* surface of the epithecal plate of another specimen of the same, from which all the corallites have been denuded, except a few casts on the extreme margin,—of the natural size.

Fig. 3 *b*. *Upper* surface of another specimen of the same, in which the bases of a number of the corallites are still left adherent to the epithecal plate,—of the natural size.

Fig. 3 *c*. Vertical section across the corallum of another specimen of the same, imperfect at the sides,—of the natural size.

Fig. 3 *d*. Horizontal section across the corallites of another specimen of the same, enlarged about twenty times.

Fig. 3 *e*. Vertical section through part of the corallum of another specimen of the same, enlarged about ten times. In this and the preceding figure the large-sized corallites are lettered *p*, while the intervening tabulate tubes are lettered *t*.

Fig. 3 *f*. Cast of the upper surface of a large specimen of *Pinacopora Grayensis*.

Fig. 3 *g*. Portion of the cast, enlarged five times. The short fluted columns in this are casts of the larger corallites, while the intervening spaces were originally occupied by the smaller tubes.

Fig. 3 *h*. Portion of a corallum which has naturally split in two along a horizontal plane, showing the corallites embedded in the dark matrix, —enlarged five times.

Fig. 3 *i*. Portion of a vertical section of corallum, similarly embedded in matrix, and similarly enlarged.

Fig. 3 *j*. Portion of the surface of a gutta-percha mould of the natural cast of *Pinacopora Grayensis*, showing the calices,—enlarged five times.

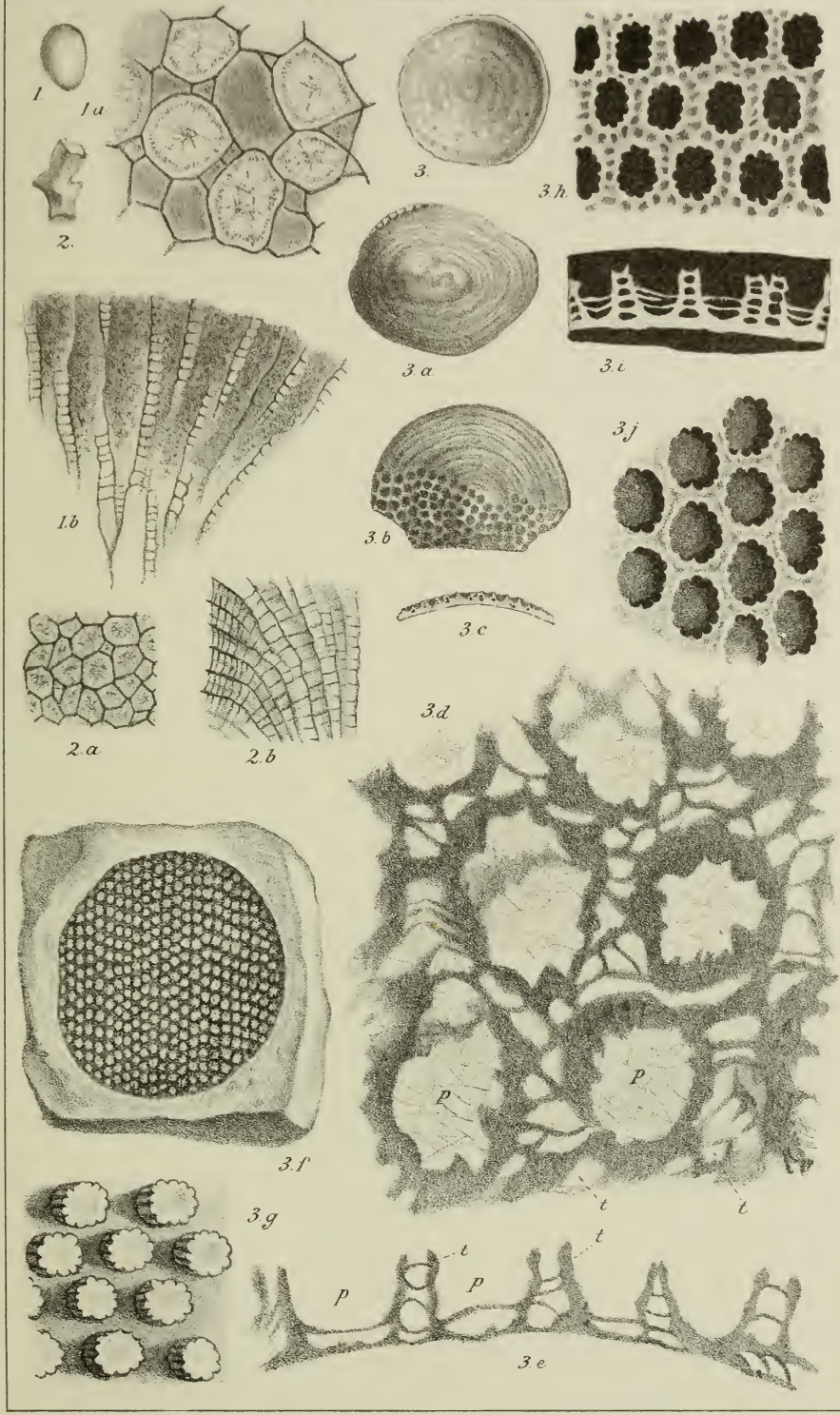
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PLATE IV.

Fig. 1. Portion of the surface of *Thecostegites* (?) *Scotucus*, enlarged five times.

Fig. 1 *a*. Portion of a slice of the same, taken parallel with the surface, enlarged ten times, showing the calices, with their rudimentary septa. The calices are filled with the dark-coloured matrix, and as the section intersects the corallites obliquely, the walls of the tubes are brought into view.

Fig. 1 *b*. Portion of a vertical section of the same, enlarged ten times. The section traverses on one side the exterior of the corallum, and the surrounding matrix is seen to have penetrated to some extent into some of the tubes.

Fig. 2. Portion of the transverse section of *Stylaræa occidentalis*, enlarged twenty times, showing two calices, and part of a third, with their columellæ, and the reticulate structure of the cœnenchyma. Viewed by transmitted light. *Coll.* H. A. Nicholson.

Fig. 2 *a*. Portion of the same section as the preceding, enlarged ten times, and viewed on a dark background.

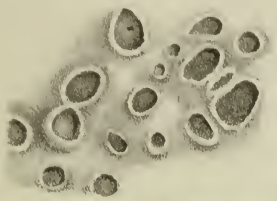
Fig. 2 *b*. Part of a vertical section of *Stylaræa occidentalis*, enlarged ten times, showing tabulæ. The columella is shown in parts of the tubes.

Fig. 3. Portion of a transverse section of *Protaræa vetusta*, from the Cincinnati group of Ohio, viewed on a dark background, and enlarged ten times. The circular light-spaces in the floors of the calices are sections of tubercles which rise from the bottom of the cup, and project into the visceral chamber. *Coll.* H. A. Nicholson.

Fig. 3 *a*. Vertical section of *Protaræa vetusta*, enlarged, and shown in outline. In the floor of two of the calices is seen a predominant tubercle, which may represent a rudimentary columella. *Coll.* H. A. Nicholson.

Fig. 4. Fragment of a branched specimen of *Heliolites Grayi*, Edw. and H., of the nat. size.

Fig. 4 *a*. Portion of the transverse section of the branch of another specimen of the same, enlarged about five times, showing parts of two successive layers of growth—the lower layer exhibiting sections of the calices and smaller tubes. Between the two layers there exists an in-filling of the dark matrix of the surrounding rock.



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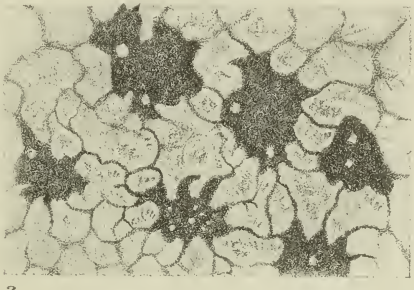

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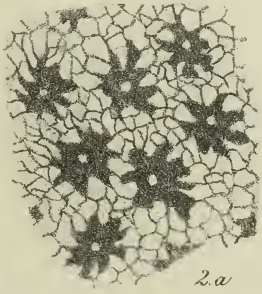

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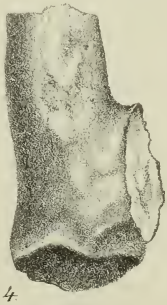

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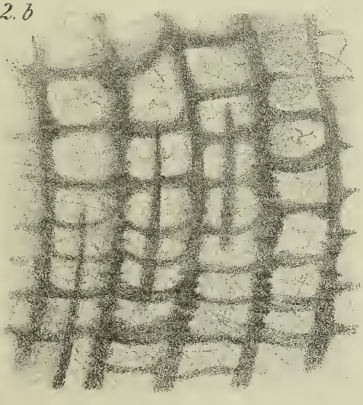
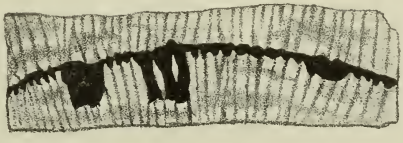




4.a

PLATE V.

Fig. 1. Part of a thin transverse section (the best of many made) of *Heliolites Grayi*, Edw. & H. (?), enlarged nearly twenty times.

Fig. 2. An average example of *Calostylis Lindströmi*, Nich. and Eth., of the natural size.

Fig. 2 *a*. Another example of the same, showing the base of a lateral bud, enlarged two diameters.

Fig. 2 *b*. Transverse section of the same, enlarged six times.

Fig. 2 *c*. Portion of a longitudinal section of the same, enlarged six times, showing the trabecular sclerenchyma, the central spongy columellar mass, with imperfect tabulæ crossing the lateral spaces.

Fig. 3. Thin section across part of a colony of *Streptelasma aggregatum*, Nich. and Eth., of the natural size. Several of the corallites are seen in process of division.

Fig. 3 *a*. A single corallite of the same, giving off young corallites from its oral extremity, of the natural size.

Fig. 3 *b*. Transverse section of a corallite of the same, enlarged about eight times, showing the thick false wall, the two orders of septa, and the union of some of the primary septā with a central trabecular columella. In this particular corallite no dissepiments can be detected.

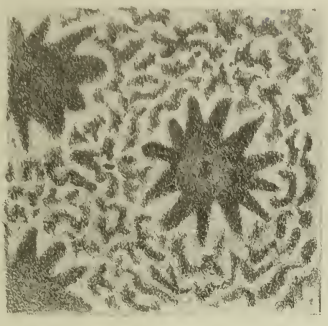
Fig. 3 *c*. Longitudinal section of a corallite of the same, enlarged eight times, showing the thick wall, the well-developed tabulæ, and the columella.

Fig. 4. Fragment of a full-grown specimen of *Streptelasma Craigensis*, M'Coy, sp., viewed sideways, of the natural size. The specimen shows, more markedly than many, the close-set and conspicuous annulations of growth of this species.

Fig. 4 *a*. Transverse section of a small example of the same, enlarged four times, showing the characters of the pseudo-columella, septa, and dissepiments. The sides of the section are broken away, so that the false wall is imperfect.

Fig. 4 *b*. Long section of a small example of the same, enlarged four times, showing the false wall, the tabulæ, and the pseudo-columella.

Fig. 4 *c*. A small specimen, supposed to belong to *S. Craigensis*, M'Coy, sp., with which it agrees in internal structure, but consisting of three corallites, apparently produced by fission.



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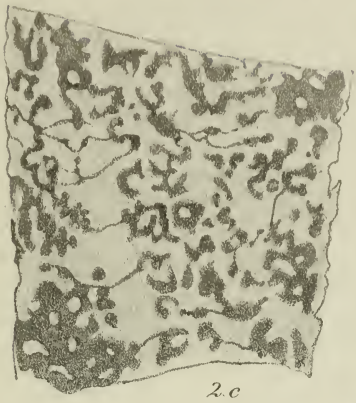

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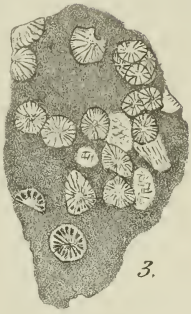

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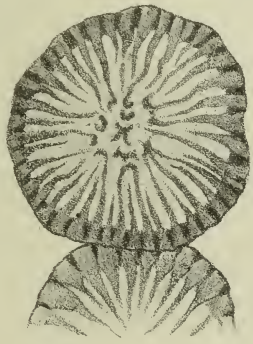

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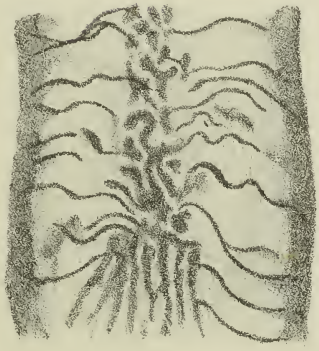

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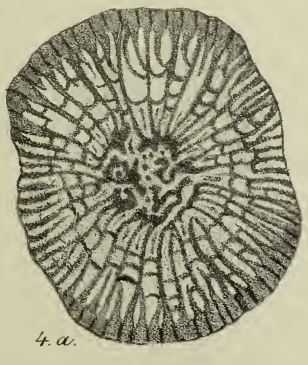

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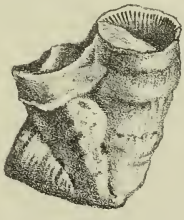

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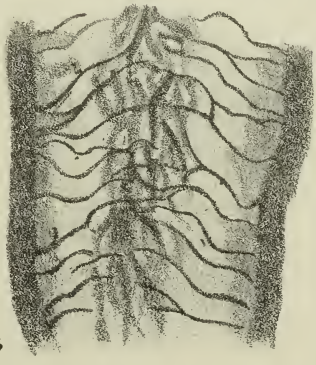

4.b

PLATE VI.

Fig. 1. Side view of one of the larger specimens of *Streptelasma Europæum*, Roemer, the upper part of which is crushed in,—of the natural size.

Fig. 1 *a*. A smaller example of the same, of the natural size.

Fig. 1 *b*. Cross-section of another specimen of the same, enlarged rather more than three times, showing the central reticulate pseudo-columella.

Fig. 2. An average specimen of *Lindströmia subduplicata*, M'Coy, sp., viewed from the front, of the natural size. The upper part of the specimen being crushed in, its apparent width is unnatural, and it looks more widely turbinate than it really is.

Fig. 2 *a*. A smaller specimen of the same, viewed sideways, of the natural size.

Fig. 2 *b*. Vertical section of the same, enlarged about four times, showing the deep calice, the fasciculate structure of the pseudo-columella, and two or three imperfect tabulæ.

Fig. 2 *c*. Vertical section of another specimen of the same, enlarged four times, showing a great upward prolongation of the columella into the bottom of the calice, and the nearly solid filling of the bottom of the visceral chamber.

Fig. 2 *d*. Transverse section of another example of the same, enlarged five times, showing the union of the larger septa with the great central mass of the columella.

Fig. 2 *e*. A small portion of the outer surface of the cast of the same species, showing the slight crenulation of the laminæ representing the interseptal loculi, which is present in ordinary examples. Enlarged.

Fig. 2 *f*. Small portion of the cast of the supposed variety of the same (var. *crenulata*, M'Coy) showing the deep crenulation of the laminæ representing the filled-up interseptal loculi. Enlarged.

Fig. 3. Cross-section of *Streptelasma* (?) *æquisulcatum*, M'Coy, sp., enlarged four times, showing the twisted and inosculating septa, the presence of secondary septa, and the few dissepiments. The centre of the visceral chamber is filled up in reality with the matrix, but there are indications of a reticulated pseudo-columella. The light spaces represent the original cavities of the corallum.

Fig. 4. A medium-sized example of *Lindströmia lævis*, Nich. and Eth., viewed dorsally and in profile, of the natural size.

Fig. 4 *a*. Side view of a very large specimen of the same, of the natural size.

Fig. 4 *b*. Vertical section of the same, enlarged five times, showing the central columellar mass, the deep calice, and the arched ascending tabulæ.

Fig. 4 *c*. Vertical section of another example of the same, enlarged similarly.

Fig. 4 *d*. Transverse section of the same, close above the base, enlarged five times, showing the union of the larger septa with the central columellar mass.

Fig. 4 *e*. Transverse section of another specimen of the same, taken just below the floor of the calice, enlarged five times, showing the decrease in proceeding upwards of the size of the columella.

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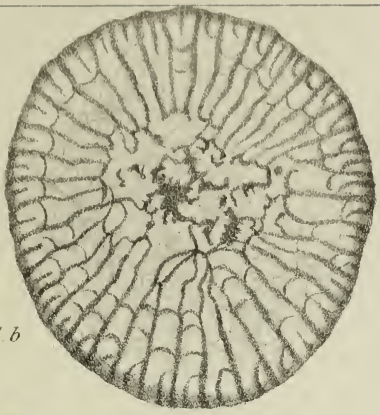

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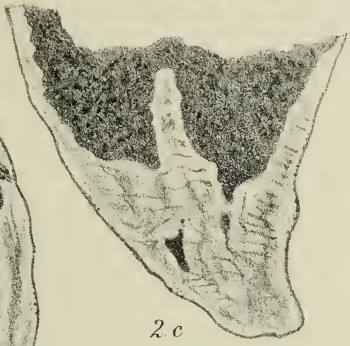

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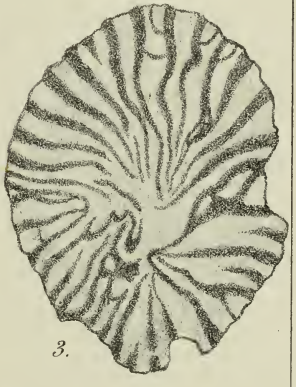

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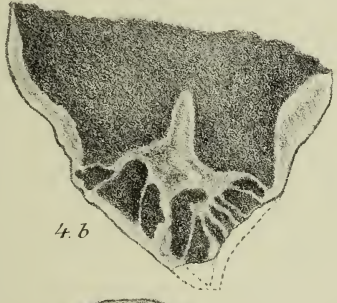

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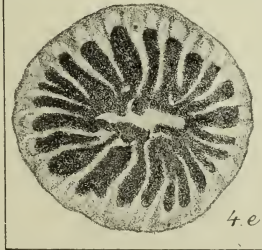

4 e

4.

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PLATE VI.

Fig. 1. Side view of one of the larger specimens of *Streptelasma Europæum*, Roemer, the upper part of which is crushed in,—of the natural size.

Fig. 1 *a*. A smaller example of the same, of the natural size.

Fig. 1 *b*. Cross-section of another specimen of the same, enlarged rather more than three times, showing the central reticulate pseudo-columella.

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Fig. 2 *c*. Vertical section of another specimen of the same, enlarged four times, showing a great upward prolongation of the columella into the bottom of the calice, and the nearly solid filling of the bottom of the visceral chamber.

Fig. 2 *d*. Transverse section of another example of the same, enlarged five times, showing the union of the larger septa with the great central mass of the columella.

Fig. 2 *e*. A small portion of the outer surface of the cast of the same species, showing the slight crenulation of the laminæ representing the interseptal loculi, which is present in ordinary examples. Enlarged.

Fig. 2 *f*. Small portion of the cast of the supposed variety of the same (var. *crenulata*, M'Coy) showing the deep crenulation of the laminæ representing the filled-up interseptal loculi. Enlarged.

Fig. 3. Cross-section of *Streptelasma* (?) *æquisulcatum*, M'Coy, sp., enlarged four times, showing the twisted and inosculating septa, the presence of secondary septa, and the few dissepiments. The centre of the visceral chamber is filled up in reality with the matrix, but there are indications of a reticulated pseudo-columella. The light spaces represent the original cavities of the corallum.

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Fig. 4 *a*. Side view of a very large specimen of the same, of the natural size.

Fig. 4 *b*. Vertical section of the same, enlarged five times, showing the central columellar mass, the deep calice, and the arched ascending tabulæ.

Fig. 4 *c*. Vertical section of another example of the same, enlarged similarly.

Fig. 4 *d*. Transverse section of the same, close above the base, enlarged five times, showing the union of the larger septa with the central columellar mass.

Fig. 4 *e*. Transverse section of another specimen of the same, taken just below the floor of the calice, enlarged five times, showing the decrease in proceeding upwards of the size of the columella.

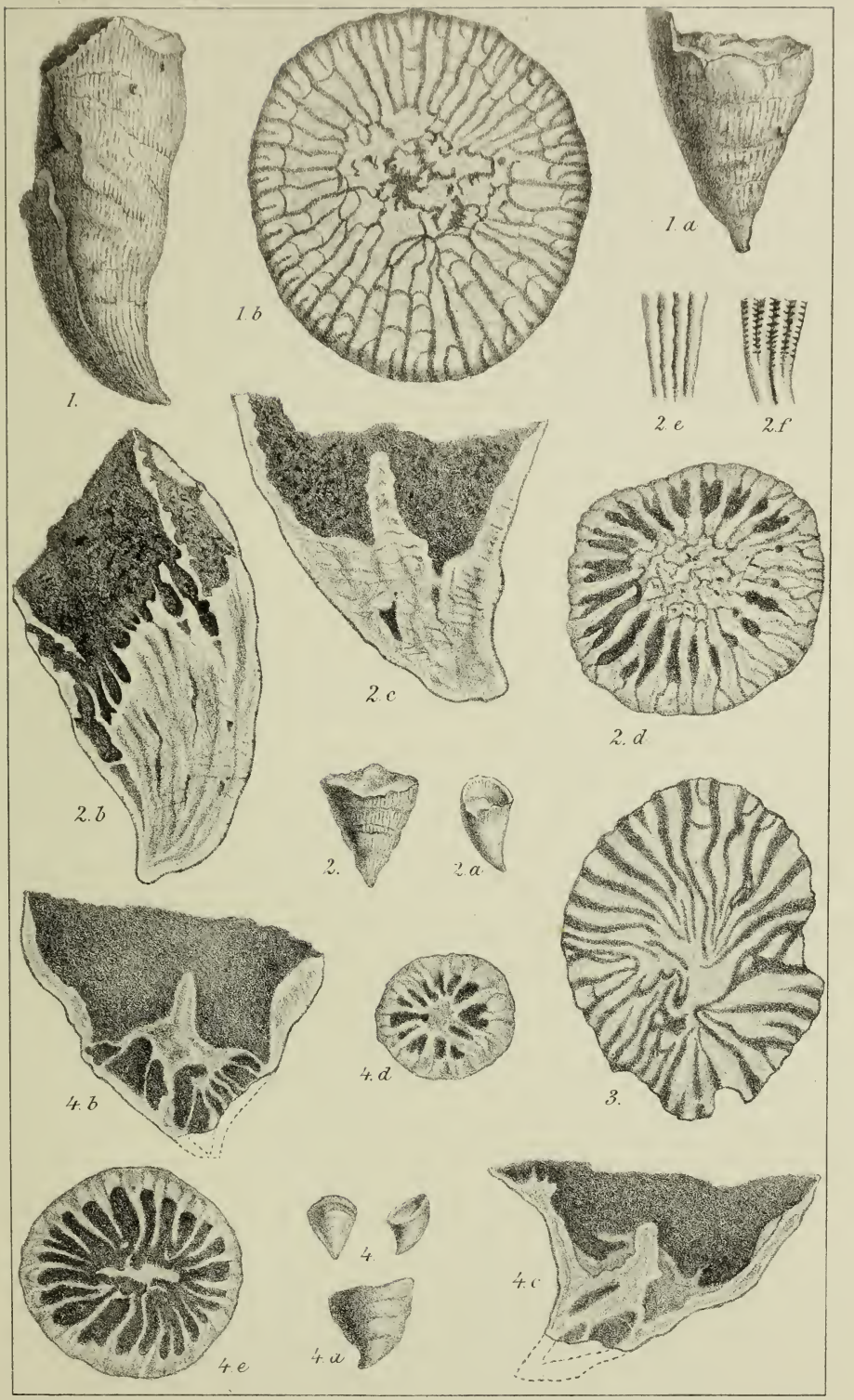
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PLATE VII.

PHACOPS BRONGNIARTI, *Portlock*, p. 99.

Fig. 1. Exceedingly fine cast of a specimen from Ardmillan Brae (*Coll. Mus. Pract. Geology*); x 2.

Fig. 2. Decorticated example from Mulloch Hill quarry, with half the head only preserved; x 2.

PHACOPS TRUNCATO-CAUDATUS, *Portlock*, p. 99.

Fig. 3. Decorticated specimen of the pygidium and a portion of the thorax; small transverse striæ are well shown. Drummuck Quarry; x 5.

Fig. 4. Similar example from same locality; x 2.

CHEIRURUS GELASINOSUS, *Portlock* (?), p. 100.

Fig. 5. An example showing the glabella and its furrows, a portion of the cheek and neck-segment. Balcletchie; x 2.

Fig. 6. Another example from the same locality, showing a larger portion of the cheek and neck-segment; x 2.

CHEIRURUS CLAVIFRONS, *Dalman* (?), p. 101.

Fig. 7. A fine glabella, placed somewhat on one side, showing the three furrows, the posterior quite circumscribing the posterior lobe; the scrobiculæ of the cheeks are also visible. Drummuck quarry—nat. size.

Fig. 8. The same specimen, front view—nat. size. Fig. 8 *a*, a portion of the roughened surface highly magnified.

CHEIRURUS, *sp. ind.*, p. 104.

Fig. 9. A portion of a glabella, allied to, but slightly different from, *C. clavifrons* (?). The glabella is broken-off across the posterior furrows. Drummuck—nat. size. Fig. 9 *a*, ornamentation magnified.

Plate VII.—*continued.*

Cheirurus trispinosus, *Young*, p. 105.

Fig. 10. A glabella, with the ornamentation preserved, the three spines in place, the middle one being broken off, and the position of the posterior lobe and furrow shown. Penkill—nat. size.

Fig. 11. A crushed head, showing the three spines projecting from the matrix. Penkill; x 2.

Fig. 12. A part of a free-cheek, showing the ornamentation and the thickened anterior margin. Penkill—nat. size.

Fig. 13. A somewhat crushed head from the same locality, exhibiting the genal spines in a fine state of preservation, and the broken base of the cervical spine—nat. size. Fig. 13 *a*, the right spine enlarged three times.

Fig. 14. A glabella, with some of the original integument remaining, the basal and ocular furrows visible and basal lobes. The bases of the genal spines are preserved, but not the cervical. Penkill—nat. size.

Fig. 15. Another glabella seen from behind, in which the neck-segment and base of its spine are exceedingly well shown, as also are the circumscribed basal lobes and the ornamentation. Penkill—nat. size.

Fig. 16. The same seen from the front, showing the blunt anterior of the glabella—nat. size.

Fig. 17. A restoration of the head, copied from Dr J. Young's figure (*Proc. Nat. Hist. Soc. Glasgow*, I., pt. 1, t. 1, f. 6 *a*).

Cheirurus, *sp. ind.*, p. 107.

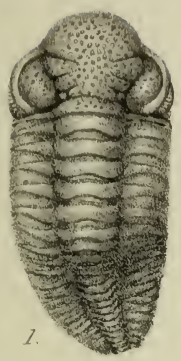
Fig. 18. Portion of thorax and pygidium of an undetermined species from Drummuck; x 3.

Cheirurus (?), *sp. ind.*, p. 107.

Fig. 19. A minute form from Balcletchie, showing only two glabella furrows; x 4.

Sphærexochus mirus, *Beyrich*, p. 107.

Fig. 20. Glabella, exhibiting the characteristic form and lobes of this species, from the coarse-grained ash, or fine conglomerate, of Balcletchie—nat. size.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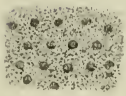
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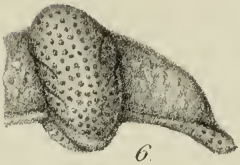
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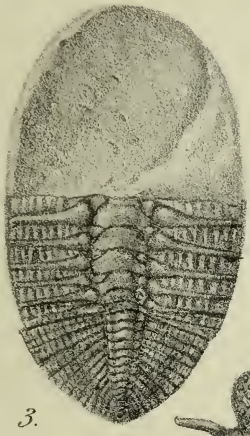
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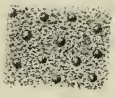


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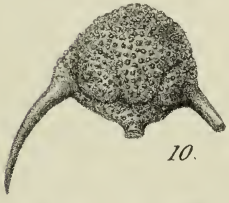
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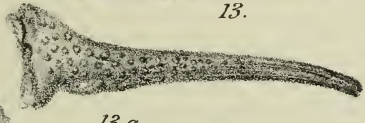
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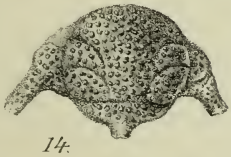
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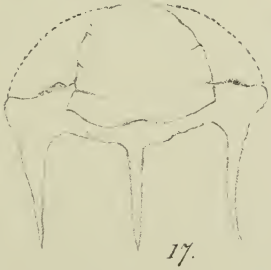
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C. Berjeau, lith.

Waterston, Sons & Stewart, Lith^rs Edin^r

PLATE VIII.

ENCRINURUS PUNCTATUS, *Brünnich*, var. ARENACEUS, *Salter*, p. 109.

Fig. 1. A nearly complete specimen from Penkill; the tubercules on the head and tail are well preserved, and also the eyes; x 3.
Fig. 2. A well-preserved decorticated specimen from Mulloch; x 3.
Fig. 3. A pygidium from Penkill; x 2.
Fig. 4. A pygidium from the Craighead limestone; x. 3.

CYBELE RUGOSA, *Portlock*, p. 112.

Fig. 5. An almost perfect example from Drummuck, showing the chief characters of the species; it is a little imperfect about the tail, but on comparison with fig. 6, the features will be found to be identical—nat. size.
Fig. 6. A well-preserved cast of a typical pygidium from Drummuck—*a*, nat. size; *b*, x 2.
Fig. 7. A coiled and decorticated specimen split in half longitudinally; the course of the facial suture and the peculiar glabella lobes are well shown. Drummuck; x 2.

DINDYMENE CORDAI, *Eth.* and *Nich.*, p. 115.

Fig. 8. A well-preserved example, minus the head, from Drummuck. The characteristic tail is plainly exhibited; x 2.

STAUROCEPHALUS (?) UNICUS, *Wyv. Thomson*, p. 118.

Fig. 9. The cephalic shield with the glabella removed—a cast from Balcletchie; x 2.
Fig. 10. An impression of an almost perfect specimen from the same locality; the glabella has been accidentally pressed down upon the other portions; x 2.
Fig. 11. The type of *St. Maclareni* (Wyv. Thomson); cast of the tail from Penwhapple Glen (*Coll. Mus. Pract. Geology*)—nat. size.
Fig. 12. A portion of the cephalic shield, with the integument remaining; the relative positions of the genal and anterior spines are exhibited. Balcletchie; x 2.

Plate VIII.—*continued.*

Fig. 13. Two heads in contact, in both of which the frontal lobe, eyes, and cephalic spines are well exhibited. Penkill; x 2. Fig. 13 *a*, a portion of the ornamentation of the frontal lobe highly magnified.

Fig. 14. A cephalic shield partly protruding from the matrix, in which the frontal lobe is visible, with a portion of its ornamentation; the eye *in situ*, and the broken bases of the three spines on the left side. Balcletchie; x 2. Fig. 14 *a*, the eye enlarged.

Figs. 15 and 16. Two isolated frontal lobes of the glabella from Balcletchie—nat. size.

Acidaspis Lalage, *Wyv. Thomson*, p. 121.

Fig. 17. An example, with the portions of the head and thorax preserved, including the thoracic spines. Balcletchie; x 3.

Figs. 18-22. The head or cephalic shield in various states of preservation, with and without the spines preserved. Balcletchie. Figs. 18, 21, 22; x 3. Fig. 19; x 5.

Acidaspis hystrix, *Wyv. Thomson*, p. 123.

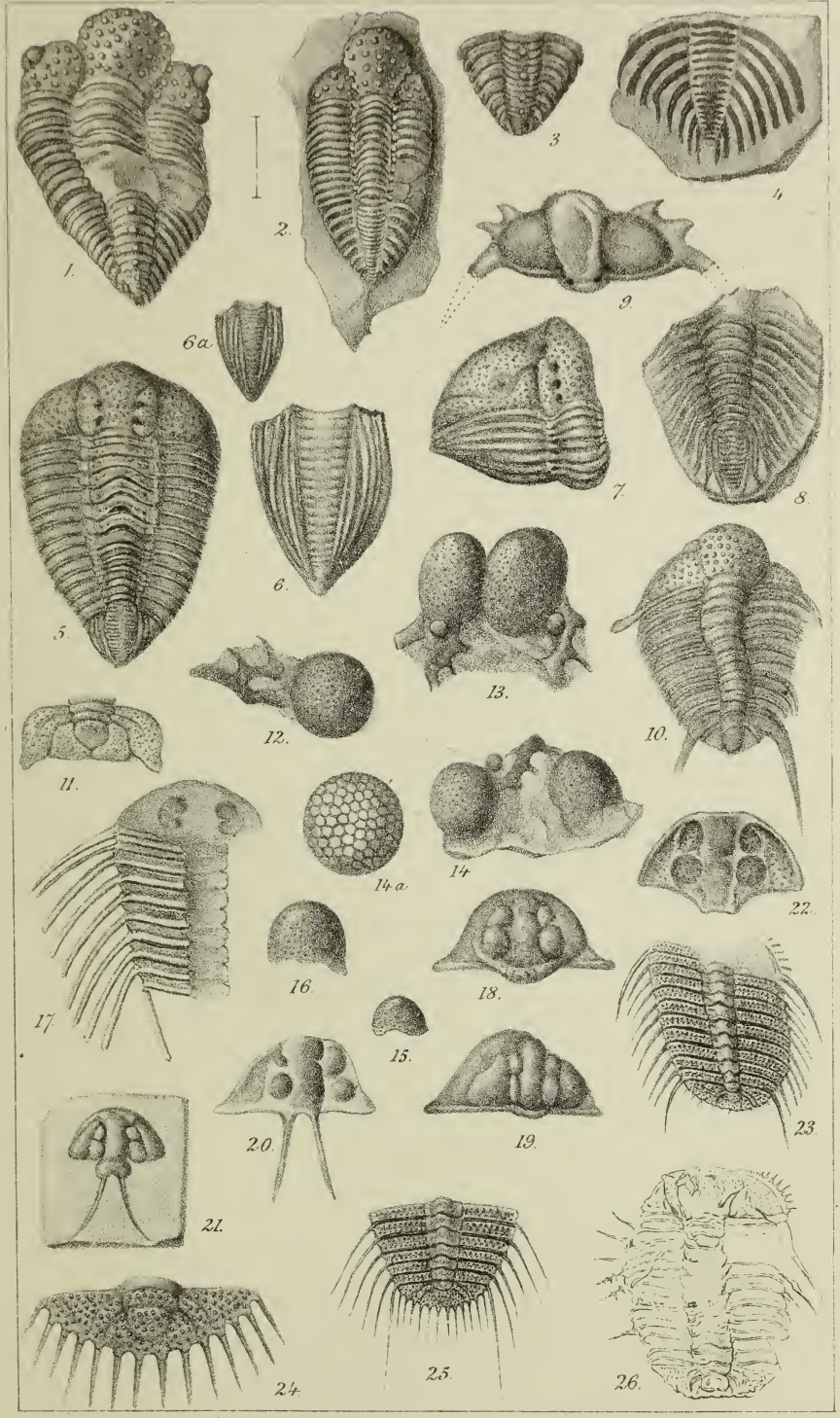
Fig. 23. A cast of the thorax and pygidium from Balcletchie, showing the granulated surface and spines; x 3.

Fig. 24. An isolated pygidium from Balcletchie; x 5.

Fig. 25. Another example, showing the pygidium, and a part of the thorax, spines, granular ornamentation, &c. Balcletchie; x 5.

Acidaspis Grayæ, *R. Etheridge, jun.*, p. 126.

Fig. 26. A decorticated and somewhat crushed specimen, showing the general characters of the species. Balcletchie; x 2.



C. Berjeau, lith.

Waterston, Sons & Stewart, Lith^rs Edin^r

PLATE IX.

ACIDASPIS GRAYÆ, *R. Etheridge, jun.*, p. 126.

Figs. 1 and 3. Casts of the pygidium and portion of the thorax, with the denticulated spines in place, and also the reticulate surface of the former. Balcletchie. Figs. 1 x, 2 ; fig. 3 ; x 1½ times.

Figs. 2, 4, and 6. Various specimens of the pygidium; in figs. 2 and 4 the spines are fifteen in number, but in fig. 6 there are sixteen. Fig. 4 *a*, one of the spines magnified, showing the denticles. Balcletchie. Figs, 2, 4, and 6 ; x 2. Fig. 4 *a ;* x 5.

Fig. 5. A cast of a few thoracic segments, with spines attached; the positions of the denticles are shown as small holes in the casts of the spines. Balcletchie. Fig. 5 *a ;* x 2. Fig. 5 *b ;* x 10 times.

Fig. 7. A portion of a cephalic shield, with the genal spine, probably of this species. Balcletchie ; x 3.

LICHAS BARRANDEI, *Fletcher* (?), p. 132.

Fig. 8. An impression in yellow schist of a well-preserved pygidium, showing the extended axis, lateral flaps, and ornamentation. Mulloch Hill (*Coll. Mus. Pract. Geology*)—nat. size.

LICHAS HIBERNICUS, *Portlock*, p. 133.

Fig. 9. Forehead and side lobes of a large glabella, highly ornamented, and with a portion of the neck-segment preserved. Craighead—nat size. Fig. 9 *a*, ornamentation highly magnified.

Fig. 10. A somewhat crushed cast, showing similar features to the last, and also a portion of one of the accessory lobes. Balcletchie—nat. size.

LICHAS GRAYII, *Fletcher* (?), p. 134.

Fig. 11. A decorticated example of the forehead-lobe, two side-lobes, one of the accessory lobes, and the neck-lobe. Mulloch Hill ; x 2.

Fig. 12. The same specimen seen from the front, showing the anterior portion of the front lobe, and the two side-lobes ; x 2.

Plate IX.—*continued.*

Lichas, *sp. ind.*, p. 135.

Fig. 13. Part of the forehead-lobe, one of the lateral lobes, the eye-lobe, and eye of a large species of *Lichas*. Drummuck—nat. size.

Fig. 14. Opposite side of the same specimen, showing a part of the hypostome and one of its wings—nat. size.

Nidulites favus, *Salter*, p. 18.

Fig. 15. Portion of a cavity left by a specimen resembling fig. 16, showing the convex casts of the cups, with here and there the papillæ formed by the casts of the styliform processes—nat. size. Mulloch Hill.

Fig. 16. Half of a globose or pyriform (?) specimen, being the internal mould of an individual from which the true integument has disappeared, leaving the characteristic hexagonal or pentagonal cups, with the styliform pits or depressions in the centre—nat. size. Mulloch Hill.

Fig. 17. Portion of another globose example, showing the cup-casts and styliform pits; x 4. Mulloch Hill.

Fig. 18. Portion of a specimen similar to fig. 15, showing the irregular form of the cups, the central papillæ, and the surface peeling-off concentrically; x 4. Mulloch Hill.

Fig. 19. Showing the cups of the globose body of *Nidulites* similar to fig. 16, in apposition with their convex casts, such as fig. 15, leaving between them a narrow space from which has been removed the true integument or shell of the organism; x 2. Mulloch Hill.

Fig. 20. A transparent microscopic section obtained from a slice taken from fig. 19, where preserved in the matrix as a series of small, hollow calcareous cups, the general convexity of the body being clearly discernible; x 2. Mulloch Hill.

Fig. 21. Portion of a specimen similar to fig. 15, exhibiting a depression (? central), with the remains of a small plug or peduncle, and spreading from it fibres resembling an investing membrane; x 4. Upper Llandovery, Haverford West (*Coll. Mus. Pract. Geology*, London).

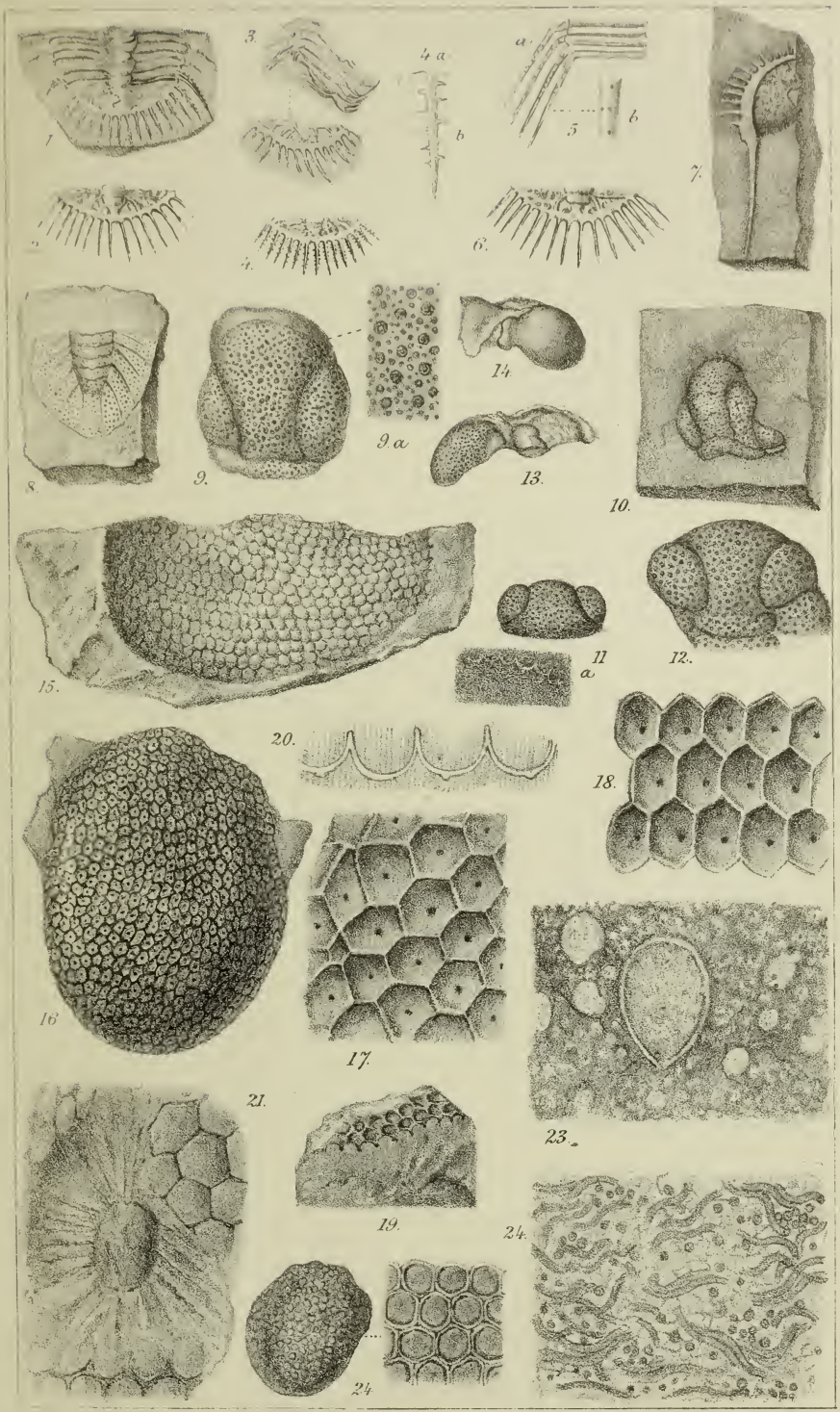
Fig. 22. An almost perfect globose specimen similar to fig. 15, but in which the cup-casts have been worn down, leaving spaces unoccupied representing the true walls. Mulloch Hill—nat. size. A few of the plates are enlarged 4 diameters.

Saccammina Carteri, *Brady*, p. 21.

Fig. 23. Portion of a slice of limestone showing sections of *S. Carteri*. Tramitchell; x 5 (*Coll.* H. A. Nicholson).

Girvanella problematica, *N.* and *E.*, p. 23.

Fig. 24. Portion of a slice of limestone showing the tubes of *G. problematica*. Tramitchell; x 50 (*Coll.* H. A. Nicholson).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