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VOL. LV.

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* The Volume for the year 1849 consists of two separate portions, each of which is stitched in a paper cover, on which are printed the dates 1848, 1849, and 1850. The one portion contains 'Cretaceous Entomostraca' and 'Permian Fossils;' the other, 'London Clay Reptilia,' Part II, and 'Fossil Corals,' Part I.

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A MONOGRAPH

OF THE

CRETACEOUS LAMELLIBRANCHIA

OF

ENGLAND.

BY

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UNIVERSITY LECTURER IN PALÆOZOOLOGY, CAMBRIDGE.

PART III.

MODIOLOPSIDÆ AND SPONDYLIDÆ.

Pages 113—144; Plates XX—XXVI.

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to *Septifer tegulatus*, are regarded by him as probably identical with Sowerby's species. I believe that view is probably correct, but without a larger series of specimens it is difficult to speak with confidence on the subject. The Aachen form is smaller and more variable in outline than the English species. I am indebted to Professor Holzapfel for the loan of several specimens.

M. subarcuatus, Meek and Hayden, from the Fox Hills group, is considered by Meek[1] to be near *M. lanceolatus*, but is only known from an internal cast.

Although it is possible for small fluviatile Lamellibranchs to be carried out to sea by currents and become entombed in marine deposits, such does not appear to have been the case with the species we are now considering, because (1) all the associated fossils are marine; (2) the lithological evidence is not in favour of the strata having been deposited near a shore-line; (3) the species occurs at several horizons and in more or less widely separated localities; and (4) some specimens have the two valves still united.

If, then, this species be truly marine, it might be urged that it is unlikely to belong to the genus *Dreissensia*, which at the present day is found in brackish and fresh waters only. That it does not belong to the genus *Septifer* is shown by the entire absence of radial sculpture, which characterises all the known species of that genus; in this feature, and also in the form of the shell, it agrees with living species of *Dreissensia*, differing only in the very young stages when (as shown by growth-lines on adult specimens) the shell was rather more elongate proportionately.

We have therefore apparently only two views to choose from concerning the generic position of the species here described as *Dreissensia lanceolata*:—(i) That it is an early marine form of *Dreissensia*; or (ii) that, although possessing the characters of *Dreissensia*, yet it has no direct genetic connection with that genus, but is an instance of heterogenetic homœomorphy. If the latter view be taken, then this species must be regarded as the type of a new genus. The former view seems more likely to be correct, unless it can be shown that the Tertiary *Dreissensiæ* have no connection with this species, but have descended from some other generic type.

That *Dreissensia* may have been marine at no very remote geological period seems possible from the fact that living forms occur in the brackish waters of the Aralo-Caspian area, etc.; that it probably was marine is supported by a study of its development,[2] which differs from that of other fresh-water Lamellibranchs, and agrees closely with that of certain marine forms. It is further noteworthy

[1] "Invert. Cret. and Tert. Foss. Missouri" ('U.S. Geol. Surv. Territ.,' vol. ix, 1876), p. 69, pl. xxxviii, fig. 2.

[2] A detailed account of the development of *Dreissensia polymorpha*, with a full bibliography, has been recently given by J. Meisenheimer, 'Zeitschr. für wissensch. Zool.,' vol. lxix (1901), pp. 1—137, pls. i—xiii.

that whilst a number of living genera of fresh-water mollusks occur in pre-Tertiary rocks, *Dreissensia* has not yet been found associated with them.[1]

Remarks.—Four examples from the Blackdown Greensand were described by Sowerby as distinct species under the names *edentulus, lanceolatus, tridens, prælongus.* Most later authors (d'Orbigny, Forbes, Bronn, Pictet and Renevier, Pictet and Campiche, Briart and Cornet, Stoliczka, Whiteaves, etc.) have considered these forms to be inseparable, and have united them under the name *lanceolatus*, but that view was not shared by Morris. An examination of all the available specimens leads me to agree with the opinion generally held.

In 1850 d'Orbigny regarded the Lower Cretaceous examples as distinct from those found in the Blackdown Greensand, and named them *Mytilus abruptus.* Pictet and Campiche did not uphold this separation. The only difference that I can detect is that, on the average, the examples found in the earlier beds reach a larger size than those in the later.

Types.—From the Blackdown Greensand: *M. edentulus* is in the British Museum; *M. tridens* and *M. prælongus* are in the Bristol Museum. I have not been able to trace the type of *M. lanceolatus.*

Distribution.—*Perna*-bed, Crackers, and Fitton's Beds 32 and 45, of Atherfield. *Perna*-bed of Sandown. Atherfield Beds of East Shalford and Peasmarsh. Ferruginous Sands of Shanklin. Sandgate Beds of Parham Park. Blackdown Greensand (zones x and xv). Greensand of Haldon. Upper Greensand of Shaftesbury.

Family—MODIOLOPSIDÆ, *Fischer.*

Genus—Myoconcha, *J. de C. Sowerby*, 1824.

(Min. Conch., vol. v, p. 103, pl. ccccLxvii.)

Myoconcha cretacea, *A. d'Orbigny*, 1844. Plate XX, figs. 3 *a, b.*

? 1832. Mytilus simplex, *A. Passy.* Géol. de la Seine-infér., p. 6 (expl. of plates), pl. xiii, figs. 4, 5. (Non *M. simplex*, Defrance, 1824.)

[1] W. J. Sollas, "On the Origin of Fresh-water Faunas," 'Scient. Trans. Roy. Dublin Soc.,' ser. 2, vol. iii (1884), p. 106; C. A. White, 'Third Ann. Rep. U.S. Geol. Survey' (1883), p. 423. It has been suggested that *Mytilus membranaceus,* Dunker, from the North German Wealden of Obernkirchen, Egestorf, Oesede, etc., and the Purbeck beds of Nienstedt and Linden, may belong to the Dreissensiidæ, but the characters of the interior of the shell are at present unknown; the same may be said of *Mytilus Lyelli,* Sowerby, from the English Purbeck and Wealden. See Dunker, 'Mon. Norddeutsch. Weald.' (1846), p. 25, pl. xi, f. 10, 11; C. Struckmann, 'Die Wealden-Bildungen von Hannover' (1880), p. 63, pl. i, f. 11, 12; P. Oppenheim, 'Zeitschr. der deutsch. geol. Gesellsch.,' vol. xliii (1891), p. 944.

1844.	MYOCONCHA CRETACEA,	*A. d'Orbigny.*	Pal. Franç. Terr. Crét., vol. iii, p. 260, pl. cccxxxv.
? 1847.	— —	*A. d'Archiac.*	Mém. Soc. géol. France, ser. 2, vol. ii, p. 307.
1850.	— —	*A. d'Orbigny.*	Prodr. de Pal., vol. ii, p. 165.
1854.	— —	*J. Morris.*	Cat. Brit. Foss., ed. 2, p. 214.
1862.	— —	*J. G. Chenu.*	Manuel de Conch., vol. ii, p. 155, fig. 766.
1866.	— —	*F. J. Pictet and G. Campiche.*	Moll. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 344.
? 1868.	— —	*E. Eichwald.*	Lethæa Rossica, vol. ii, p. 588, pl. xxii, fig. 10.

Description.—Shell subtriangular, or more or less oblong, gradually increasing in height posteriorly. Anterior end blunt, rounded; posterior border rounded, somewhat oblique; ventral border nearly straight. Valves flattened, gradually compressed posteriorly, more sharply compressed towards the ventral margin.

Ornamentation consists of slender, equidistant, slightly curving, radial ribs, which are absent near the dorsal margin; the most dorsal rib is stronger than the others. The radial ribs are crossed regularly by numerous slender concentric ribs which are parallel to the growth-lines.

Measurements:

Length	74 mm.
Height	38 ,,
Thickness	28 ,,

Affinities.—*M. Requieniana*, Mathéron,[1] is less expanded posteriorly, and more concave ventrally.

Myoconcha, n. sp., Müller,[2] may be an allied form, but is known only by internal moulds.

Types.—From the Cenomanian of Saintes, Angoulême, Rouen, etc.

Distribution.—Basement bed of Chalk Marl (zone of *Schloenbachia varians*) of Chard, Maiden Newton, and Evershot. Chloritic Marl of Maiden Bradley, Woolcombe, and Toller Fratrum.[3]

[1] 'Cat. Foss. Bouches-du-Rhône' (1842), p. 177, pl. xxviii, figs. 3, 4. D'Orbigny, 'Prodr. de Pal.,' vol. ii (1850), p. 196.

[2] "Die Mollusk. d. Untersen. v. Braunschweig u. Ilsede" ('Abhandl. d. k. preuss. geol. Land.,' n. F., pt. 25, 1898), p. 48, pl. vii, fig. 3.

[3] Casts of *Myoconcha*, from the Lower Greensand of Seend, are preserved in the Museum of Practical Geology, but the species cannot, at present, be determined.

Family—SPONDYLIDÆ, *Gray*.

Genus—Spondylus, *Linnæus*, 1758.

('Syst. Nat.,' ed. 10, p. 690.)

Spondylus Roemeri, *Deshayes*, 1842. Plate XX, figs. 4 *a—d*.

1841. Spondylus radiatus, *F. A. Römer* (non *Goldfuss*). Die Verstein. d. norddeutsch. Kreidegeb., p. 60.
1842. — latus, *G. P. Deshayes* (non *Sowerby*), in *A. Leymerie*. Mém. Soc. géol. de France, vol. v, pp. 10, 27, pl. vi, fig. 7.
— — Roemeri, *Deshayes*. Ibid., pp. 10, 27, pl. vi, figs. 8—10.
1847. — — *A. d'Orbigny*. Pal. Franç. Terr. Crét., vol. iii, p. 655, pl. cccli, figs. 1—6.
1850. — — *d'Orbigny*. Prodr. de Pal., vol. ii, p. 83.
1855. — — *G. Cotteau*. Moll. Foss. de l'Yonne, p. 118.
1861. — — *P. de Loriol*. Anim. Invert. Foss. du Mt. Salève, p. 107, pl. xiv, figs. 4, 5.
1870. — — *F. J. Pictet and G. Campiche*. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 5), pp. 256, 260.
? 1871. — — *W. A. Ooster*. Pteropodenschicht Schweizer-Alpen (Protozoe Helvetica, 2), pp. 126, 141, pl. xviii, figs. 8—10.
1883. — — *W. Keeping*. Foss., etc., Neoc. Upware and Brickhill, p. 113.
1896. — — *A. Wollemann*. Zeitschr. d. deutsch. geol. Gesellsch., vol. xlviii, p. 834.
1900. — — *Wollemann*. Die Biv. u. Gastrop. d. deutsch. u. holländ. Neoc. (Abhandl. d. k. preuss. geol. Land., n. F., pt. 31), p. 20.

Description.—Shell oval in outline, the proportion of length to height variable, more or less oblique. Right valve flattened, with numerous radial ribs, usually faintly marked, and strong concentric lamellæ. Left valve convex, with numerous slightly unequal ribs, separated by grooves of the same width; the larger ribs occur at regular intervals, and bear spines mostly directed ventrally: between the larger ribs are two or three smaller ribs, either smooth or with small spines. Ears of both valves apparently smooth.

Measurements :

Length	38 mm.
Height	40 „
Thickness	23 „

Affinities.—This species appears to be closely allied to *S. gibbosus*, d'Orbigny, but the ribs are more spiny and rather coarser, and the valves less convex in proportion to their size. It seems to differ from *S. striato-costatus*, d'Orbigny, in having more numerous and more slender ribs.

Remarks.—Deshayes' figures of this species appear to represent worn specimens, and consequently do not show the real characters of the ornamentation. In the absence of other specimens from the locality of the types one is obliged to rely on the figures and descriptions by d'Orbigny as giving the specific characters of *S. Roemeri*.

This species appears to be very rare in England. The examples from Brickhill are rather water-worn, but the stumps of the spines remain on some of the ribs.

Types.—From the Neocomian of Fouchères, in the École des Mines, Paris.

Distribution.—*Perna*-bed of Atherfield. Lower Greensand of Brickhill.[1]

Spondylus gibbosus, *d'Orbigny*, 1847. Plate XX, figs. 5, 6 *a—c*, 7 *a—c*, 8 *a*, *b*, 9 *a*, *b*, 10, 11.

1847. Spondylus gibbosus, *A. d'Orbigny*. Pal. Franç. Terr. Crét., vol. iii, p. 658, pl. cccclii, figs. 1—6.
1850. — — *d'Orbigny*. Prodr. de Pal., vol. ii, p. 139.
1853. — Brunneri, *F. J. Pictet and W. Roux*. Moll. Foss. Grès verts de Genève, p. 514, pl. xlvii, fig. 1 (? 2).
1858. — — *F. J. Pictet and E. Renevier*. Foss. Terr. Aptien (Matér. Pal. Suisse, ser. 1), p. 136.
1866. — gibbosus, *H. G. Seeley*. Ann. Mag. Nat. Hist., ser. 3, vol. xvii, p. 177.
1870. — — *F. J. Pictet and G. Campiche*. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 5), p. 257, pl. clxxxii, figs. 1—4.
1875. — — *A. J. Jukes-Browne*. Quart. Journ. Geol. Soc., vol. xxxi, p. 297.
— — Dutempleanus? *Jukes-Browne*. Ibid., p. 297.
— — — *J. Phillips*. Geol. Yorks., ed. 3, pt. 1, p. 245.

[1] *Dianchora ? guttata*, Sharpe, from the Lower Greensand of Faringdon, is probably a *Spondylus*, but I have not succeeded in finding the type or any other specimens. Sharpe, 'Quart. Journ. Geol. Soc.,' vol. x (1853), p. 197, pl. vi, fig. 3.

Description.—Shell oval, oblique, higher than long. Right valve variable, flattened when attached by its entire surface, more convex when attached by a part only, the umbonal part sometimes much produced and talon-like. The attached part with concentric lamellæ, the free part with many radial ribs without spines.

Left valve moderately convex; umbo more or less produced; ribs numerous, unequal: the stronger occur at regular intervals, and are separated by two or three (rarely one only, or more than three) smaller ribs; the stronger ribs bear numerous spiny processes, the smaller ribs are usually without spines.[1]

Measurements of left valve:

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	
Length .	31	31	30	29	26	25	25	21	19·5	23	21	19	16	mm.
Height .	36	35	34	36	31	28	27	25	23	25	23	22·5	19	,,

(1—9) Cambridge Greensand.
(10—13) Red Limestone, Hunstanton.

Affinities.—For the relation of *S. gibbosus* to *S. Roemeri* see p. 117.

In *S. Dutempleanus* the shell is less oblique than in *S. gibbosus;* the spines on the left valve are generally more irregular and more nearly vertical than in the latter (judging from the figure of Pictet and Campiche). The stronger ribs which occur at regular intervals in *S. gibbosus* are never so distinctly marked in *S. Dutempleanus*.

Remarks.—The specimens figured by d'Orbigny, as pointed out by Pictet and Campiche, are worn examples with the shell imperfect. The specimens found in the Cambridge Greensand vary considerably; a gradual passage can be traced from forms in which the right valve is flat (fig. 9 *b*) to others in which it is much produced and talon-like (fig. 11); in the right valve the appearance of the surface depends largely on the amount of wearing the shell has undergone,—one specimen, in which the ribs appear almost equal and without spines, agrees perfectly with d'Orbigny's fig. 2; in most cases, however, the stronger ribs occurring at regular intervals are distinctly seen (fig. 6 *a*). Only the bases of the spines remain; they are generally regularly developed on the stronger ribs, but occasionally occur more irregularly (fig. 8 *a*).

The specimens found in the Red Limestone of Hunstanton and Speeton are, on the average, smaller than those in the Cambridge Greensand, and the spines, probably owing to the hardness of the matrix and consequent difficulty of extraction, are usually wanting or indistinct, but one specimen in the British Museum shows them clearly.

[1] The specimen figured by Pictet and Campiche shows spines on the small ribs. The general absence of small spines on our specimens is probably due to the worn nature of the shell.

Types.—D'Orbigny's specimens came from the Albian of Novion and Machéroménil (Ardennes).

Distribution.—Cambridge Greensand (derived from the Gault), Cambridge. Red Limestone of Hunstanton and Speeton.

SPONDYLUS STRIATUS (*Sowerby*), 1815. Plate XXI, figs. 1 *a*, *b*, 2, 3 *a*, *b*, 4, 5.

1815. DIANCHORA STRIATA, *J. Sowerby*. Min. Conch., vol. i, p. 183, pl. lxxx, fig. 1.
1819. — — *Defrance*. Dict. Scien. nat., vol. xiii, p. 161, pl. lxxviii, fig. 1.
1833. SPONDYLUS STRIATUS, *A. Goldfuss*. Petref. Germ., vol. ii, p. 98, pl. cvi, fig. 5.
1829–40. DIANCHORA STRIATA, *F. E. Guérin-Méneville*. Icon. du Règne Anim. Moll., p. 42, pl. xxv, fig. 4.
1837. SPONDYLUS STRIATUS, *H. G. Bronn*. Lethæa Geog., p. 687 (ed. 3, pt. 5, p. 283), pl. xxxii, fig. 4.
1840. — — *H. B. Geinitz*. Char. d. Schicht. u. Petref. des sächsisch. Kreidegeb., pt. 2, p. 58.
1841. — — *F. A. Römer*. Die Verstein. d. nord-deutsch. Kreidegeb., p. 59.
? 1846. — — *A. E. Reuss*. Die Verstein. d. böhm. Kreideformat., pt. 2, p. 37, pl. xl, figs. 5, 10, 11.
1847. — CAPILLATUS, *A. d'Archiac*. Mém. Soc. géol. de France, ser. 2, vol. ii, p. 311, pl. xvii, fig. 1.
— — STRIATUS, *A. d'Orbigny*. Pal. Franç. Terr. Crét., vol. iii, p. 660, pl. ccccliii.
? 1850. — — ?, *R. Kner*. Kreidemerg. von Lemberg, etc. (Haidinger's Naturwiss. Abhandl., vol. iii, pt. 2), p. 30.
? — — — ?, *A. Alth*. Geogn.-pal. Beschreib. Umgeb. von Lemberg (Haidinger's Naturwiss. Abhandl., vol. iii, pt. 2), p. 251.
— — — *A. d'Orbigny*. Prodr. de Pal., vol. ii, p. 170.
— — — *H. B. Geinitz*. Das Quadersandst. oder Kreidegeb. in Deutschland, p. 194.
— — CAPILLATUS, *Geinitz*. Ibid., p. 194, pl. xi, figs. 2, 3.
? 1852. — STRIATUS ?, *R. Kner*. Denkschr. d. k. Akad. d. Wissensch. Wien. Math.-nat. Classe, vol. iii, pt. 1, p. 318, pl. xvii, fig. 8.
1854. — — *J. Morris*. Cat. Brit. Foss., ed. 2, p. 182.
1858. — — *J. A. Eudes-Deslongchamps*. Mém. Soc. Linn. de Normand., vol. xi, p. 134, pl. xx, figs. 24—26.
? 1866. — — *K. A. Zittel*. Die Biv. der Gosaugeb. (Denkschr. d. k. Akad. d. Wissensch. Math.-nat. Classe, vol. xxv), p. 118 (p. 42 of reprint), pl. xviii, fig. 7 *b*, *c* (? fig. 7 *a*).

? 1868. Spondylus striatus, *E. Eichwald.* Lethæa Rossica, vol. ii, p. 422.
1870. — — *F. J. Pictet and G. Campiche.* Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 5), p. 261.
1872. — — *H. B. Geinitz.* Das Elbthalgeb. in Sachsen (Palæontographica, vol. xx), pt. 1, p. 186, pl. xlii, figs. 1—3.
? 1877. — — *A. Fritsch.* Stud. im Gebiete der böhm. Kreidef.: II, Die Weissenberg. u. Malnitz. Schicht., p. 138.
1878. — — *G. Behrens.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xxx, p. 259.
1893. — — *R. Michael.* Ibid., vol. xlv, p. 237.
1895. — — *E. Tiessen.* Ibid., vol. xlvii, p. 475.
1897. — — *R. Leonhard.* Die Kreidef. in Oberschles. (Palæontographica, vol. xliv), p. 50.

Non 1822. Podopsis striata, *A. Brongniart.* Descript. géol. des Envir. de Paris. In *Cuvier*, Ossem. foss., ed. 2, vol. ii, pp. 319, 604, pl. v, fig. 3.
— 1870. Spondylus striatus, *F. Römer.* Geol. von. Oberschles., p. 315, pl. xxxvii, figs. 3, 4.

Description.—Shell large, obliquely ovate, high; anterior and ventral margins regularly rounded; posterior margin slightly concave or nearly straight.

Right valve usually more inflated than the left, and generally attached by the larger part of its surface; free part with radial ribs, separated by shallow grooves, and crossed by numerous very fine concentric lamellæ.

Left valve moderately convex, umbonal part prominent and produced; surface sometimes undulating; ribs numerous, equal, smooth, flattened, separated by deep grooves except on the later formed parts of the valve, where the grooves become shallow and the ribs less distinct. The grooves and ribs are crossed by concentric lamellæ, like those on the right valve. Ears smooth except for growth-lines.

Measurements of left valve:

	(1)	(2)	(3)	(4)
Length	56	52	50	40 mm.
Height	77	65	58	48 ,,

(1—4) from Warminster.

Affinities.—For the relation of this species to *S. latus*, Sowerby, see p. 123.

S. hystrix, d'Orbigny (? Goldfuss) is distinguished from this species by the left valve being less convex, the umbo less produced, the narrower and more widely separated ribs, and the spines on the earlier part of the valve.

S. capillatus, d'Archiac, from the Tourtia of Tournay, has been regarded by Geinitz, d'Orbigny, and other authors as a synonym of *S. striatus;* specimens which I have obtained from Tournay agree perfectly with the English examples, but the example figured by d'Archiac appears to differ in having the umbo of the left valve less produced.

S. subcostulatus, Stoliczka,[1] appears to be a closely allied form, and was indeed regarded by Geinitz as identical with *S. striatus.*

S. complanatus, d'Orbigny, is imperfectly known, but may be closely allied to, or identical with, *S. striatus*; it is recorded by Morris from the Lower Greensand of Folkestone.

Remarks.—This species is known chiefly from specimens found at Warminster. An example from that locality in Mr. J. F. Walker's collection shows the interior of the right valve. The size of the attached surface varies considerably in different specimens.

Specimens showing the interiors of fixed valves, resembling *S. gibbosus* and *S. latus*, occur in the Blackdown Greensand and the Gault of Folkestone, but I am unable to determine the species without more specimens.

Type.—From Chute Farm, Warminster, in the British Museum.

Distribution.—Lower Greensand of Faringdon. Rye Hill Sand of Warminster. Upper Greensand, Longleat. Cenomanian Sandstone of Wilmington. Base of Chalk Marl of Maiden Newton. Cenomanian (Bed 11) of Branscombe.

SPONDYLUS LATUS (*Sowerby*), 1815. Plate XXII, figs. 1 *a*, *b*, 2 *a*, *b*, 3, 4 *a*, *b*, 5—7, 8 *a*—*c*, 9, 10 *a*, *b*.

1815. DIANCHORA LATA, *J. Sowerby.* Min. Conch., vol. i, p. 184, pl. lxxx, fig. 2.
1822. — — *G. Mantell.* Foss. S. Downs, p. 205, pl. xxvi, fig. 21.
— — OBLIQUA, *Mantell.* Ibid., p. 206, pls. xxv, fig. 1; xxvi, fig. 12.
1836. SPONDYLUS LINEATUS, *A. Goldfuss.* Petref. Germ., vol. ii, p. 97, pl. cvi, fig. 3.
1839. — — *H. B. Geinitz.* Char. d. Schicht. u. Petref. des sächs. Kreidegeb., pt. 1, p. 25, pl. xx, fig. 39.
1841. — — *F. A. Römer.* Die Verstein. des nord-deutsch. Kreidegeb., p. 59.
— — LATUS, *Römer.* Ibid., p. 59.
? — — OBLIQUUS, *Römer.* Ibid., p. 60.
1842. — LATUS, *H. B. Geinitz.* Char. d. Schicht. u. Petref. des sächs.-böhm. Kreidegeb., pt. 3, p. 82.

[1] "Palæontologia Indica," 'Cret. Fauna S. India,' vol. iii (1871), p. 449, pl. xxxiii, fig. 8; pl. xxxiv, fig. 2.

1842. SPONDYLUS OBLIQUUS, *Geinitz.* Char. d. Schicht. u. Petref. des sächs.-böhm. Kreidegeb., pt. 3, p. 82.
1846. — (DIANCHORA) OBLIQUUS, *A. E. Reuss.* Die Verstein. d. böhm. Kreideformat., pt. 2, p. 36, pl. xl, fig. 4.
— — — LINEATUS, *Reuss.* Ibid., p. 36, pl. xl, figs. 7–9.
? 1847. — — — *J. Müller.* Petref. der Aachen. Kreidef., pt. 1, p. 34.
1850. — LINEATUS, *H. B. Geinitz.* Das Quadersandst. oder Kreidegeb. in Deutschl., p. 194 (*partim*).
— — OBLIQUUS, *Geinitz.* Ibid., p. 194 (*partim*).
— — LINEATUS, *A. d'Orbigny.* Prodr. de Pal., vol. ii, p. 254.
— — LATUS, *J. de C. Sowerby,* in *F. Dixon.* Geol. Sussex, p. 356 (p. 386, ed. 2), pl. xxviii, figs. 30, 31.
? — — LINEATUS, *A. Alth.* Geogn.-pal. Beschreib. von Lemberg (Haidinger's Naturwiss. Abhandl., vol. iii, pt. 2), p. 250.
1854. — LATUS, *J. Morris.* Cat. Brit. Foss., ed. 2, p. 182.
? — — OBLIQUUS, *Morris.* Ibid., p. 182.
? 1868. — LINEATUS, *E. Eichwald.* Lethæa Rossica, vol. ii, p. 421.
? 1869. — — *E. Favre.* Moll. Foss. de la Craie des Envir. de Lemberg, p. 158.
1870. — STRIATUS, *F. Römer.* Geol. von Oberschles., p. 315, pl. xxxvii, figs. 3, 4.
1872. — LATUS, *H. B. Geinitz.* Das Elbthalgeb. in Sachsen (Palæontographica, vol. xx), pt. 1, p. 187, pl. xlii, figs. 4—6; pt. 2, p. 32, pl. viii, figs. 18—21.
? 1877. — — *A. Fritsch.* Stud. im Gebiete der böhm. Kreideformat. II, Die Weissenberg. u. Malnitz. Schicht., p. 139.
1881. — ÆQUICOSTATUS, *R. Etheridge,* in *W. H. Penning and A. J. Jukes-Browne.* Geol. Cambridge (Mem. Geol. Survey), p. 145, pl ii, fig. 5.
1882. — LATUS, *H. Schröder.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xxxiv, p. 262.
? 1885. — cf. LATUS, *B. Lundgren.* Spondylus-art. i Sveriges Kritsyst. (Sver. Geol. Undersök., ser. C, No. 69), p. 12, pl. ii, fig. 28.
1889. — LATUS, *A. Fritsch.* Stud. im Gebiete der böhm. Kreidef. IV, Die Teplitz. Schicht., p. 86, fig. 82.
? — — cf. LINEATUS, *O. Griepenkerl.* Senon. von Königslutter (Palæont. Abhandl., vol. iv), p. 39.
— — LATUS, *E. Holzapfel.* Die Mollusk. d. Aachen. Kreide. (Palæontographica, vol. xxxv), p. 244, pl. xxvii, figs. 11, 14.
1892 — — *E. Stolley.* Die Kreide Schleswig-Holsteins (Mitth. a. d. Min. Institut der Univ. Kiel, vol. i), p. 236.
1897. — — *R. Leonhard.* Die Kreidef. in Oberschles. (Palæontographica, vol. xliv), p. 50.
— — — *H. Woods.* Quart. Journ. Geol. Soc., vol. liii, p. 387.

Non 1842. SPONDYLUS LATUS, *A. Leymerie.* Mém. Soc. géol. de France, vol. v, p. 10, pl. vi, fig. 10.

Description.—Shell oval, rounded, more or less oblique, but sometimes nearly equilateral, of moderate size or small, height and length nearly equal. Right valve usually attached by its entire surface, and bearing concentric spiny lamellæ; when part of the valve is not attached it is ornamented with numerous radial ribs; the whole of the interior also shows numerous small radial ribs.

Left valve inflated, sometimes with undulating surface; growth-lines few and not strongly marked; the radial ribs are numerous, small, regular, flattened or rounded, without spines, and of equal size, except when new ribs are occasionally introduced; the ribs are separated by grooves of the same or less width, and in these are seen very faintly marked transverse ribs, which sometimes pass on to the radial ribs. Umbo small, pointed. Near the umbo some of the radial ribs, at regular intervals, are stronger than the others, and bear short spiny processes. Ears smooth.

Measurements:

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	
Length . . .	25	25	24	23	21	26	34	40	43	23	mm.
Height . . .	26	25	24	23	20	27	36	37	39	23	„

(1—4) zone of *A. quadratus*, East Harnham, Salisbury.
(5) „ „ West Harnham, Salisbury.
(6, 7) zone of *M. cor-anguinum*, Gravesend.
(8, 9) zone of *H. subglobosus*, Cherry Hinton; (8) is the type of *S. æquicostatus*, Eth.
(10) Lower Chalk, Fulbourn Asylum.

Affinities.—The numerous smooth ribs serve to distinguish this species. *S. striatus*, Sowerby, from the Warminster Greensand, etc., is a much larger form, shorter in proportion to its height, and with the umbonal region more produced.

The form from the Lower Chalk, described by Etheridge as *S. æquicostatus*, cannot, I think, be separated from this species; the type (Pl. XXII, fig. 1) appears to differ somewhat from *S. latus*, but this is on account of its being an old individual; other smaller examples found on the same horizon are inseparable from *S. latus* found in higher zones of the Chalk. The Lower Chalk forms are in several cases somewhat larger than any that I have seen in the Middle or Upper Chalk. Two specimens from the Chalk Marl of Dover and Folkestone probably belong to this species, but more examples are needed before a definite determination can be made.

Types.—The type, from the Chalk of Lewes, and the specimen figured by Dixon, are in the British Museum. I have not seen the types of *Dianchora obliqua*, Mantell, which came from Lewes and Brighton; nor his figured specimen of *S. latus*. The type of *S. æquicostatus*, Etheridge, is in the Woodwardian Museum.

Distribution :

(i) *Lower Chalk :* Fulbourn Asylum. Zone of *H. subglobosus* of Shelford, Cherry Hinton, and cutting east of South Cave Station.

(ii) *Middle Chalk :* Lewes. Melbourn Rock near Hitchin. Zone of *R. Cuvieri* of Dover. Zone of *Terebratulina gracilis* of Dowlands (near Rousdon), the Dorset coast, Dover, the Sussex coast, Whyteleaf (Warlingham), St. Giles' Hill (Winchester), Hitchin, Worsted Lodge, and Mutlow Hill (Cambs). Zone of *Holaster planus* of Chapel Rock (Pinhay), Dover, the Sussex coast, Cheveley, and Linton. Chalk Rock (*Reussianum*-zone) of Brixton, Winchester, Cuckhamsley, Thickthorn Hill, and Boxmoor.

(iii) *Upper Chalk :* Zone of *M. cor-testudinarium* of Dover, the Sussex coast, and Balsham. Zone of *M. cor-anguinum* of Thanet, St. Margaret's, the Sussex coast, Charlton, Gravesend, Strood, Northfleet, and near Hitchin. Zone of *Marsupites* of Thanet and the Sussex coast. Zone of *A. quadratus* of Hensting Farm, Marwell Road, and Hensley Lane (all near Winchester), East and West Harnham (near Salisbury), and the Sussex coast. Zone of *B. mucronata* of the Dorset coast.

SPONDYLUS SERRATUS, sp. nov. Plate XXI, figs. 6 *a*—*c*, 7 *a*—*c*.

Description.—Shell rounded, outline rather irregular, slightly inequilateral; height and length nearly equal.

Right valve flattened or slightly concave, with numerous parallel, concentric, and spiny laminæ and faint radial ribs.

Left valve moderately convex, except in small forms; ornamented with numerous small ribs, which are of equal size except on the earlier parts of the shell, where new ribs are being introduced; all the ribs bear many small spines, placed regularly, but on the old parts of the shell the ribs may be nearly smooth. The grooves are broader than the ribs, moderately deep, and crossed by well-marked but somewhat irregular, transverse, thread-like ribs. Ears with four or five ribs.

Measurements :

	(1)	(2)	(3)
Length . . .	20 . .	23 . .	32 mm.
Height . . .	19·5 . .	23 . .	29 ,,

(1) Upper Chalk (*Uintacrinus*-bed), Devizes Road, Salisbury.
(2) Upper Chalk, locality unknown.
(3) Upper Chalk (*Uintacrinus*-bed), Newgate, Thanet.

Affinities.—This is similar in form to *S. latus*, but is distinguished by the small and regular spines, and the broader grooves between the ribs. *S. Royanus*, d'Orbigny,[1] differs from this species in having stronger ribs at regular intervals, and in being proportionately higher.

S. asper, Goldfuss,[2] is similar in form, but the spines are coarser, fewer, and less regular.

S. occultus, Geinitz,[3] is a very small (7 mm.) form, which may be closely related to *S. serratus*, but the ribs appear to be more unequal and to bear tubercles which are in contact, instead of spiny processes distinctly separated from one another.

Remarks.—This is a very rare species; I have seen only five examples which could be definitely referred to it.

Distribution.—*Marsupites*-zone (*Uintacrinus*-bed) of Devizes Road, near Salisbury, and the Thanet coast.

SPONDYLUS DUTEMPLEANUS, *d'Orbigny*, 1847. Plate XXII, figs. 11 *a*, *b*, 12 *a*, *b*, 13, 14; Plate XXIII, figs. 1—5.

1833. DIANCHORA SPINOSA, *S. Woodward.* Geol. Norfolk, p. 48, pl. v, fig. 24.
1847. SPONDYLUS DUTEMPLEANUS, *A. d'Orbigny.* Pal. Franç. Terr. Crét., vol. iii, p. 672, pl. cccclx, figs. 6—11.
1850. — — — Prodr. de Pal., vol. ii, p. 254.
1869. — — *E. Favre.* Moll. Foss. de la Craie de Lemberg, p. 159, pl. xiii, figs. 14, 15.
1870. — — *F. J. Pictet and G. Campiche.* Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 5), p. 262.
1887. — DUTEMPLEI, *A. Peron.* Hist. du Terr. de Craie (Bull. Soc. Sci. hist. et nat. de l'Yonne, ser. 3, vol. xii), p. 166.
1889. — DUTEMPLEANUS, *E. Holzapfel.* Die Mollusk. d. Aachen. Kreide. (Palæontographica, vol. xxxv), p. 244, pl. xxvii, figs. 8—10.
1891. — — *J. Böhm.* Die Kreidebild. des Fürbergs, etc. (Palæontographica, vol. xxxviii), p. 88.
1892. — — *E. Stolley.* Die Kreide Schleswig-Holsteins (Mitth. a. d. Min. Inst. Kiel, vol. i), p. 236.

Non 1875. — — ?, *A. J. Jukes-Browne.* Quart. Journ. Geol. Soc., vol. xxxi, p. 297.

Description.—Shell oval, slightly oblique, usually inflated, rounded ventrally, pointed and produced in the umbonal region. Right valve sometimes with greater,

[1] 'Pal. Franç. Terr. Crét.,' vol. iii (1847), p. 671, pl. cccclx, figs. 1—5.

[2] 'Petref. Germ.,' vol. ii (1836), p. 96, pl. cvi, fig. 1.

[3] "Das Elbthalgeb. in Sachsen" ('Palæontographica,' vol. xx, pt. 1), p. 207, pl. xlvi, fig. 1. (N.B.—Enlarged about three times.)

sometimes less inflation than the left; the attached part bears concentric toothed lamellæ; the free surface has numerous regular, nearly equal radial ribs, separated by narrow grooves; in some cases the ribs carry short spines placed rather irregularly, and sometimes slender transverse ribs are seen.

Left valve usually regularly convex, with numerous slightly unequal ribs, which are occasionally a little wavy. The ribs are separated by grooves, generally of greater, but sometimes of the same width. The spines on the ribs are hollow, usually short, sometimes perpendicular to the surface, sometimes sloping ventrally; they may be developed rather irregularly, or larger spines may be borne on slightly stronger ribs at regular intervals; between these ribs are three or two slightly smaller ribs, with sometimes smaller spines. Faintly marked transverse ribs occur in the grooves, and sometimes extend on to the ribs. Ears smooth, except for growth-lines.

Measurements of left valve:

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	
Length .	20	22·5	23	23	26	17	22	27	24	mm.
Height .	23	25	25	26·5	30	19·5	26	30	27	,,

(1—5) zone of *A. quadratus*, East Harnham.
(6—8) ,, ,, West Harnham.
(9) Chalk of Trimingham.

Affinities.—*S. Omalii*, d'Archiac,[1] appears to be a more oblique form with fewer ribs. The form referred by d'Orbigny[2] to *S. hystrix* is larger than *S. Dutempleanus*, and has the spines confined to the neighbourhood of the umbo. Specimens from the Cenomanian of Devon and Orbiquet (Normandy) agree with the Turonian and Senonian examples, except that the ribs are a little more widely separated. Similar Cenomanian forms from St. Fargeau (Yonne) and St. Sauveur (Yonne) have also been referred to *S. Dutempleanus* by d'Orbigny and by Peron.

S. fimbriatus, Goldfuss,[3] is very similar to *S. Dutempleanus;* judging from the figures alone, the only difference appears to be in the fewer spines on the ribs.

A specimen, described and figured by Sowerby[4] as *Lima? spinosa*, is perhaps an example of *S. Dutempleanus.* I have not been able to find the original, and the locality is not stated.

Remarks.—In the majority of specimens seen the spines have been more or less completely broken in the process of clearing away the matrix. Examples from

[1] 'Mém. Soc. géol. de France,' vol. ii (1847), p. 312, pl. xv, fig. 11.

[2] 'Pal. Franç. Terr. Crét.,' vol. iii (1847), pl. ccccliv, figs. 1—9.

[3] 'Petref. Germ.,' vol. ii (1836), p. 97, pl. cvi, fig. 2. A specimen was referred to this species by Dixon ('Geol. Sussex,' p. 356, pl. xxviii, fig. 34).

[4] F. Dixon, 'Geol. Sussex' (1850), p. 347, pl. xxviii, fig. 33; p. 382 of ed. 2.

the Trimingham Chalk appear to have the spines placed more closely together than in other zones. The convexity of the valves varies considerably. The largest examples seen came from the *B. mucronata* zone of Norwich and Sheringham. A few imperfect specimens obtained from the Chalk Marl of Folkestone probably belong to this species.

Types.—From the Senonian of Epernay, St. Sauveur, and Auxon.

Distribution.—Cenomanian (Bed 11) of Maynard's Cliff, Sidmouth. Zone of *R. Cuvieri* of the Sussex coast. Zone of *Terebratulina gracilis* of St. Giles' Pit, near Winchester, and Dover. Zone of *H. planus* of Twyford Down, near Winchester, and Chapel Rock, Pinhay. Zone of *M. cor-testudinarium* of Dover. Zone of *M. cor-anguinum* of the Thanet coast, St. Margaret's, and the Sussex coast. *Uintacrinus*-band of Kingsgate (Margate). Zone of *Marsupites* of the Thanet and Sussex coasts. Zone of *Actinocamax quadratus* of Hursley (Winchester), East and West Harnham (Salisbury), and the Sussex coast. Zone of *B. mucronata* of Norwich, Sheringham, Clarendon (Salisbury), Ballard, and Studland. Chalk of Trimingham.

SPONDYLUS SPINOSUS (*Sowerby*), 1814. Plate XXIII, figs. 6—11; Plate XXIV, figs. 1—7.

1814. PLAGIOSTOMA SPINOSA, *J. Sowerby*. Min. Conch., vol. i, p. 177, pl. lxxviii, figs. 1—3.
? 1819. SPONDYLUS PODOPSIDEUS, *Lamarck*. Anim. sans Vert., vol. vi, p. 194.
? — PLAGIOSTOMA SULCATA, *Lamarck*. Ibid., p. 161.
1820. PECTINITES ACULEATUS, *E. T. v. Schlotheim*. Die Petrefactenkunde, p. 228.
1822. PLAGIOSTOMA SPINOSA, *G. Mantell*. Foss. S. Downs, p. 203, pl. xxvi, fig. 10.
— — BRIGHTONIENSIS, *G. Mantell*. Ibid., p. 204, pl. xxv, fig. 15.
— — SPINOSA, *A. Brongniart*. Descr. géol. des Envir. de Paris, pp. 251, 320, 600, pl. iv, fig. 2.
1825. PACHYTOS SPINOSUS, *Defrance*. Dict. Sciences nat., vol. xxxvii, p. 207, pl. lxxviii, fig. 2; pl. lxxix, fig. 1.
? — — STRIATUS, *Defrance*. Ibid., p. 207.
1827. PLAGIOSTOMA SPINOSUM, *S. Nilsson*. Petrif. Suecana, p. 25.
1833. — — *S. Woodward*. Geol. Norfolk, p. 40, pl. v, fig. 25 (? young).
1836. SPONDYLUS SPINOSUS, *A. Goldfuss*. Petref. Germ., vol. ii, p. 95, pl. cv, fig. 5.
— — DUPLICATUS, *A. Goldfuss*. Ibid., vol. ii, p. 95, pl. cv, fig. 6.
1837. PLAGIOSTOMA SPINOSUM, *W. Hisinger*. Lethæa Suecica, p. 54, pl. xv, fig. 4.
— SPONDYLUS SPINOSUS, *H. G. Bronn*. Lethæa Geog., p. 684 (ed. 2), p. 280 (vol. ii, pt. 5, ed. 3), pl. xxxii, fig. 6.

1839. Spondylus spinosus, *H. B. Geinitz.* Char. d. Schicht. u. Petref. das sächs. Kreidegeb., pt. 1, p. 24.

— — duplicatus, *Geinitz.* Ibid., p. 25.

1841. — spinosus, *F. A. Römer.* Die Verstein. des norddeutsch. Kreidegeb., p. 58.

— — duplicatus, *Römer.* Ibid., p. 58.

1842. Lima brightoniensis, *F. v. Hagenow.* Rügen'schen Kreideverstein. Neues Jahrb. für Min., etc., 1842, p. 556.

1846. Spondylus spinosus, *H. B. Geinitz.* Grundr. der Verstein., p. 474.

— — (Pachytos) spinosus, *A. E. Reuss.* Die Verstein. der böhm. Kreideformat., pt. 2, p. 36.

1847. — spinosus, *A. d'Orbigny.* Pal. Franç. Terr. Crét., vol. iii, p. 673, pl. ccccl xi, figs. 1—4.

1848. — — *H. G. Bronn.* Index Palæont., vol. i, p. 1189.

1850. — — *H. B. Geinitz.* Das Quadersandst. oder Kreidegeb. in Deutschland, p. 196.

— — — *A. d'Orbigny.* Prodr. de Pal., vol. ii, p. 254.

? — — — *A. Alth.* Geog.-pal. Beschreib. der Umgeb. von Lemberg (Haidinger's Naturwiss. Abhandl., vol. iii, pt. 2), p. 250.

1852. — — *R. Kner.* Denkschr. d. k. Akad. d. Wissensch. Math.-nat. Cl., vol. iii, p. 318.

1854. — — *J. Morris.* Cat. Brit. Foss., ed. 2, p. 182.

— — brightoniensis, *Morris.* Ibid., p. 182.

1855. — spinosus, *G. Cotteau.* Moll. Foss. de l'Yonne, p. 118.

1859. — æqualis, *E. Hébert.* Bull. Soc. géol. de France, ser. 2, vol. xvi, p. 149.

1860. — subspinosus, *H. Coquand.* Descript. Départ. de la Charente, vol. ii, p. 142. (Non d'Archiac, 1848.)

1868. — spinosus, *E. Eichwald.* Lethæa Rossica, vol. ii, p. 420.

? 1869. — — *E. Favre.* Moll. Foss. de la Craie de Lemberg, p. 158.

1870. — — *F. Römer.* Geol. von Oberschles., p. 315, pl. xxxiv, fig. 11.

1871. — superbus, *H. Willett.* Cat. Cret. Foss. Brighton Mus., p. 35.

1872. — spinosus, *H. B. Geinitz.* Das Elbthalgeb. in Sachsen (Palæontographica, vol. xx, pt. ii), p. 31, pl. ix, figs. 1—3.

1876. — — *D. Brauns.* Die Senon. des Salzberges (Zeitschr. f. d. gesammt. Naturwiss., vol. xlvi), p. 391.

1877. — — var. duplicatus, *A. Fritsch.* Stud. im Geb. der böhm. Kreidef. II. Die Weissenberg. u. Malnitz. Schicht, p. 138, fig. 132.

1881. Lima spinosa, *R. Etheridge.* In Penning and Jukes-Browne's Geol. Cambridge (Mem. Geol. Survey), pp. 65, 69, 72.

1882. Spondylus æqualis, *B. Lundgren.* Bull. Soc. géol. de France, ser. 3, vol. x, p. 458.

1885. SPONDYLUS ÆQUALIS, *Lundgren.* Spondylusart. i Sverig. Kritsyst. (Sverig Geol. Undersök., ser. C, No. 69), p. 5, pl. i, figs. 1—3.

1889. — — *O. Griepenkerl.* Senon von Königslutter (Palæont. Abhandl., vol. iv), p. 38.

— — SPINOSUS, *E. Holzapfel.* Die Mollusk. Aachen. Kreide (Palæontographica, vol. xxxv), p. 243, pl. xxvii, figs. 12, 13.

— — — *A. Fritsch.* Stud. im Gebiete der böhm. Kreideformat. IV. Die Teplitzer Schicht, p. 85, fig. 81.

1897. — — *H. Woods.* Quart. Journ. Geol. Soc., vol. liii, p. 385.

— — — *R. Leonhard.* Kreideformat. in Oberschles. (Palæontographica, vol. xliv), p. 50.

— — ÆQUALIS, *A. Hennig.* Revis. Lamell. i Nilsson's 'Petrif. Suecana' (Kön. Fysiogr. Sällsk. i Lund. Handl.,N. F., vol. viii), p. 25.

1898. — SPINOSUS, *G. Müller.* Mollusk. Untersen. von Braunschweig u. Ilsede (Abhandl. d. k. preuss. geol. Land., n. F., pt. 25), p. 23, pl. iv, fig. 4.

Description.—Shell regular, ovate, slightly inequilateral, rounded ventrally, more or less pointed and produced in the umbonal region, where the margins are only slightly curved. Valves sometimes equally convex, but the right usually flattened; convexity greatest in the median line, towards the umbo.

Right valve a little larger than the left, with the dorsal part of the posterior border longer than the corresponding part of the anterior border. Ribs stronger than those of the left valve, separated by deep narrow grooves; the grooves are crossed by rather irregular linear ridges. In some specimens almost every rib is divided into two parts by a narrow median furrow—the furrows starting, in different specimens, at varying distances from the umbo; in others only a few ribs (often near the centre of the valve or near the anterior and posterior borders) are so divided; or all the ribs may be undivided. Long slightly curving spines, with a groove on their upper surfaces, are borne at intervals by some of the ribs—frequently by eight, and grow out radially, those near the margin of the valve extending outwards in all directions roughly parallel to the plane of the valves; the spines near the anterior and posterior margins are the strongest. The ribs bearing spines are often not divided by a groove.

Left valve with from 26 to 51 regular, rounded ribs, occasionally bearing short spines; the grooves between the ribs may be wider or narrower than the ribs, and are crossed by many rather irregular linear ridges, which sometimes extend on to the ribs. The ribs may be (1) all of uniform size, separated by broader grooves, and are then relatively few in number and stout; or (2) the stronger ribs may alternate regularly with smaller ribs introduced in the grooves at varying distances from the umbo, thus increasing the total number of ribs at the margin of the valve; or (3) only a few smaller ribs occur here and there between the larger. The first is associated with undivided ribs on the right valve; the second with all the ribs divided; the third with a few ribs divided—the divided ribs of the right valve corresponding in position with the small intercalated rib of the left valve. Rarely one or two ribs on the left valve may be divided. In old specimens rather strong growth-lines placed near together occur near the margin of the valve, giving it a frilled appearance. Near the umbones the ribs sometimes have a serrated appearance, due to the presence of short, close-set, spiny processes. Ears on both valves with growth-lines only or with faintly marked radial ribs also near the umbones; at the inner border the ear is limited by a ridge (often indistinct on the left valve), and between this and the commencement of the regular series of radial ribs on the valve is a smooth area.

Measurements of the left valve.

	Zone of *T. gracilis.*							Zone of *H. planus.*													
Length (in millimetres)	49	48	47	47	35	34	...	57	53	49	47	46	45	44	42	42	41	40	38	33	30
Height „ „	53	50	51	49	38	39	...	59	59	57	52	49	48	46	48	49	44	43	39	34	31
Number of main ribs	33	43	27	30	33	27	...	34	33	33	29	33	28	31	34	28	30	33	30	31	32
Number of small intermediate ribs	9	8	8	11	5	8	...	14	10	9	22	36	14	18	9	10	8	6	0	6	1

	Chalk Rock.				Zone of *M. cor-testudinarium.*							Zone of *M. cor-anguinum.*						
Length	51	46	37	...	52	41	41	38	35	34	...	72	62	55	51	51	50	47
Height	62	50	41	...	55	47	45	43	38	36	...	83	69	57	56	55	60	53
Number of main ribs	30	33	26	...	30	26	25	25	25	28	...	30	35	34	26	31	27	29
Number of small intermediate ribs	11	11	8	...	10	14	14	10	12	2	...	4	17	15	0	8	14	7

	Zone of *Marsupites testudinarius.*														
Length	53	53	53	47	47	47	45	44	43	43	43	42	40	37	35
Height	60	59	56	50	47	52	51	49	54	49	46	47	44	40	41
Number of main ribs	30	29	31	29	29	37	28	28	29	28	26	26	27	27	35
Number of small intermediate ribs	4	6	19	0	0	12	0	0	0	0	1	1	0	3	13

	Zone of *A. quadratus.*							Zone of *B. mucronata.*		Trimingham Chalk.	
Length	55	40	33	29	27	26	...	52	...	36	31
Height	65	42	36	31	30	28	...	56	...	40	32
Number of main ribs	35	28	27	27	31	29	...	32	...	30	27
Number of small intermediate ribs	13	16	0	4	2	11	...	0	...	4	0

Remarks.—The amount of convexity of the two valves together, and also the relative convexities of right and left valves, varies considerably in different examples, and is to some extent associated with differences in the ribbing. On the right valve the variation in the ribs consists (1) in the presence or absence of a narrow furrow on the rib—giving the appearance of a split rib,—and (2) in the period at which this furrow is introduced. Coincident with the beginning of the furrow on this valve is the introduction of a small intermediate rib between two main ribs on the left valve, so placed that at the margin of the valve the small furrow of the right valve fits into the small rib of the left valve. The number of the small intermediate ribs and the period at which they are introduced vary considerably in different specimens; in some cases they are quite absent, in others only a few occur, or they may appear in almost every groove. When these intermediate ribs are absent, the other ribs appear to be stronger and are equal in size, and separated by broad and deep grooves; the form named *S. æqualis* by Hébert belongs, I believe, to this group. Another form, with many intermediate ribs, was named *S. duplicatus* by Goldfuss; this, however, has been regarded by most later writers (Geinitz, Reuss, d'Orbigny, Brauns, etc.) as inseparable from *S. spinosus.* In the cases where the intermediate ribs are introduced at an early period, they become towards the margin of the shell almost or quite as large as the other ribs, so that the shell appears to bear a large number of rather small ribs, and differs greatly in appearance from the forms with no intermediate ribs. Between these different varieties every transition seems to occur, but certain types, as noted below, are more abundant in some zones than in others.

The form described by Hébert as *S. æqualis*[1] was found in the *B. mucronata* Chalk of Meudon. It was stated to differ from *S. spinosus*, Sowerby, in having (1) equal ribs (*i. e.* no intermediate ribs) on the left valve, and undivided ribs on the right valve; (2) the two valves of equal convexity; (3) spines on both valves. Hébert gave no figures, but Lundgren has figured specimens from Kopinge, which, however, do not show the spines. I believe that *S. æqualis* is only one of the varieties of *S. spinosus.* Forms found in the Upper Chalk of England (especially in the *B. mucronata* and *Marsupites* zones) agree in the first and second of the features above mentioned, and also in rare cases show spines on the left valve, although never so well developed as those on the right. This form, as already stated, passes into the one with many intermediate small ribs. It will, however, probably be convenient to refer to the two extremes as the *æqualis*-type and the *duplicatus*-type respectively.

Plagiostoma brightoniensis, Mantell, seems to be an old individual belonging to the *æqualis*-type; it occurs chiefly in the *M. cor-anguinum* zone. Near the margin of the left valve intermediate ribs are introduced, and at this part on both valves growth-lines are well marked and close together, giving something of a frilled appearance.

S. obesus, d'Orbigny,[2] from the Senonian, appears to be only a variety of

[1] It is recorded by Barrois from the *B. mucronata* zone of Studland Bay and Norwich. See 'Rech. Terr. Crét. Supér.' (1876), pp. 103, 163.

[2] 'Pal. Franç. Terr. Crét.,' vol. iii (1847), p. 675, pl. cccclxi, figs. 5—7.

S. spinosus, having the valves rather more convex than usual and the ribs on the ears a little more distinct.

Two small specimens in Dr. Blackmore's collection from the *A. quadratus* zone of East Harnham (length 6 mm.), and the *B. mucronata* zone of Clarendon (length 6·5 mm.), are probably young individuals of *S. spinosus*.

S. superbus, Willett, MS., is an example of the *æqualis*-type from the Upper Chalk (probably *Marsupites* zone) of Seaford.

The inner layer of the shell, and also the area and teeth, have been removed by solution from the specimens of *S. spinosus* and other species of *Spondylus* found in the Chalk of England.[1]

A large number of good specimens of *S. spinosus* are preserved in most museums and collections, but unfortunately, in the majority of cases, the zones from which they were obtained are not definitely known, and consequently, in order to determine whether any of the varieties are characteristic of particular zones, I have had to rely mainly on the collections kindly lent me by Drs. Blackmore and Rowe, and Messrs. Jukes-Browne, W. Hill, G. E. Dibley, and J. Scanes, and on my own collecting. Similarly, in selecting specimens for figuring, I have chosen those of which the exact horizon is known even when finer examples of the same type, but of uncertain zone, were at hand. In order to work out satisfactorily the zonal characters of *S. spinosus*, a much larger number of carefully collected specimens than I have had at my disposal would be required, and the following notes on the forms found in successive zones must, therefore, be regarded as of a preliminary nature only.

T. gracilis-zone.—The common forms (Pl. XXIII, fig. 6) have the valves flattened. Ribs on the left valve are generally slender and separated by broad grooves; intermediate (small) ribs are seen in all cases, and, as a rule, are moderately numerous. Forms with the left valve more convex occur rather rarely (Pl. XXIII, fig. 7).

H. planus-zone and Chalk Rock.—Valves, especially the left, are more convex than in the preceding zone; ribs rather stouter (Pl. XXIII, figs. 8—10). Some forms having few or no intermediate ribs occur (Pl. XXIII, fig. 8).

M. cor-testudinarium-zone.—Commonly the left valve is very convex, and the intermediate ribs are introduced early and become nearly as large as the others (Pl. XXIII, fig. 11). Less common are forms with only a few intermediate ribs.

M. cor-anguinum-zone.—Convexity of the two valves is generally more nearly equal. Intermediate ribs are generally small and not numerous, and the main ribs stout (Pl. XXIV, figs. 1, 2). The old individuals of this type, named *Plagiostoma*

[1] For a more detailed account of this, with references to previous writers on the subject, see Woods, 'Quart. Journ. Geol. Soc.,' vol. liii (1897), p. 386.

brightoniensis by Mantell, occur chiefly in this zone, but occasionally in the previous zone (Pl. XXIV, fig. 3).

Marsupites-zone.—Two types occur : (i) with few or no intermediate ribs and the valves of nearly equal convexity (Pl. XXIV, figs. 4, 6); (ii) with many intermediate ribs of nearly the same size as the main ribs, and valves of nearly equal convexity : this is not so common as the first type (Pl. XXIV, fig. 5).

A. quadratus-zone.—The same two types occur. Only a few examples have been seen, the average size being apparently less (Pl. XXIV, fig. 7).

B. mucronata-zone.—No intermediate ribs in the examples seen (similar to Pl. XXIV, fig. 4).

Trimingham Chalk.—Two rather small examples are in Mr. A. C. Savin's collection, one without intermediate ribs, and the other having four. Another specimen is in Mr. R. M. Brydone's collection.

Types.—Sowerby's types from Brighton and Northfleet are in the British Museum. I have not seen the specimen figured by Mantell as *Plagiostoma spinosa*, nor the type of *P. brightoniensis*. *S. superbus*, Willett, MS., is in the Brighton Museum. The types of *S. duplicatus*, Goldfuss, came from the Senonian of Quedlinburg and Coesfeld.

Distribution.—*S. spinosus* ranges from the zone of *Rhynchonella Cuvieri* to zone of *B. mucronata*. A few of the localities are given below.

i. Zone of *R. Cuvieri.*—Dover.

ii. Zone of *Terebratulina gracilis.*—Dowlands (near Rousdon). Whitecliff (Seaton). Hooken (near Beer Head). St. Giles's Hill and Twyford Down (Winchester). East Knoyle (Wilts). The Sussex coast. Dover. Whyteleaf (Warlingham). Dunton Green. Preston (Hitchin). Luton.

iii. Zone of *Holaster planus.*—Chapel Rock (Pinhay). St. Giles's Hill (Winchester). The Sussex coast. Dover. Cuxton. Borstal. Cheveley (Newmarket). Three quarters of a mile north-west of West Wratting (Cambs).

iv. Chalk Rock.—West Wycombe. Princes Risborough. Cuckhamsley. Boxmoor. Luton. Clothall (Herts). Quickwood (Herts). Reed and Newsells (Royston). Underwood Hall (Dullingham). Barkway. Great Chesterford.

v. Zone of *Micraster cor-testudinarium.*—West of Beer Harbour. North of Alton Line Junction. The Sussex coast. Dover. Chatham. Purley. Balsham.

vi. Zone of *Micraster cor-anguinum.*—Hungry Down, Blandford. Mitcheldever (upper part of zone). Eaton Lane and Winnal Road (Winchester). The Sussex coast. St. Margaret's. Thanet. Gravesend.

vii. Zone of *Marsupites testudinarius.*—Witherington, near Salisbury (lower part of zone). Devizes Road, near Salisbury (*Uintacrinus*-band). The Sussex and Thanet coasts. Margate.

viii. Zone of *Actinocamax quadratus.*—The Dorset coast. East and West

Harnham (Salisbury). Hursley. Hensting Farm (Winchester). The Sussex coast.

ix. Zone of *Belemnitella mucronata.*—Studland Bay. ? Winchester. Norwich. Sheringham.

x. Trimingham Chalk.

Genus—Plicatula, *Lamarck*, 1801.

('Syst. Anim. sans Vert.,' p. 132.)

Plicatula placunea, *Lamarck*, 1819. Plate XXV, figs. 1—4.

1819. Plicatula placunea, *Lamarck.* Anim. sans Vert., vol. vi, p. 186.
1822. Spondylus ? strigilis, *A. Brongniart.* Descript. géol. Envir. de Paris. In *Cuvier,* Ossem. foss., ed. 2, vol. ii, pp. 333, 613, pl. ix, fig. 6.
1826. Plicatula placunata, *Defrance.* Dict. Sciences nat., vol. xli, p. 400.
1842. — placunæa, *A. Leymerie.* Mém. Soc. géol. de France, vol. v, pp. 16, 27, pl. xiii, fig. 2.
— — — *P. Mathéron.* Catal. Foss. des Bouches-du-Rhône, p. 189.
1845. — — *E. Forbes.* Quart. Journ. Geol. Soc., vol. i, p. 249.
1847. — placunea, *A. d'Orbigny.* Pal. Franç. Terr. Crét., vol. iii, p. 682, pl. cccclxii, figs. 11—18.
1850. — — *d'Orbigny.* Prodr. de Pal., vol. ii, pp. 84, 119.
— — — *Ewald.* Zeitschr. d. deutsch. geol. Gesellsch., vol. ii, p. 470.
1853. — — *F. J. Pictet and W. Roux.* Moll. Foss. Grès verts de Genève, p. 518, pl. xlvii, fig. 5.
1854. — — *J. Morris.* Cat. Brit. Foss., ed. 2, p. 180.
1855. — placunæa, *G. Cotteau.* Moll. Foss. de l'Yonne, p. 118.
1858. — placunea, *F. J. Pictet and E. Renevier.* Foss. Aptien de la Perte du Rhône, etc. (Matér. Pal. Suisse, ser. 2), p. 136.
— — — *J. A. Eudes-Deslongchamps.* Les Plicat. du Calvados (Mém. Soc. Linn. Norm., vol. xi), p. 102, pl. xvii, figs. 1, 2.
1859. — — *J. Vilanova-y-Piera.* Mém. géog.-agric. de Castellon, pl. ii, fig. 16.
1865. — — *H. Coquand.* Aptien de l'Espagne, p. 158.
1866. — — *E. Eichwald.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xviii, p. 271.
1868. — — — Lethæa Rossica, vol. ii, p. 414.
1871. — — *F. J. Pictet and G. Campiche.* Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 5), pp. 268, 271.

1875.	PLICATULA PLACUNEA,	*J. Phillips.*	Geol. Yorks., ed. 3, pt. 1, p. 244.
1900.	— —	*A. Wollemann.*	Die Biv. u. Gastrop. des deutsch. u. holländ. Kreide. (Abhandl. d. k. preuss. geol. Land., n. F., pt. 31), p. 23.

Description.—Shell very oblique, oval, projecting and pointed at the umbones; length greater than height. Left valve flat or slightly concave; right valve convex. Both valves ornamented with strong angular ribs, usually eight to ten in number, bearing tubular overlapping spines; between these large ribs smaller ones are introduced, and bear spiny processes. Near the margin of the shell, in old individuals, the two sets of ribs may become of nearly equal size. The ribs are crossed by concentric, usually faintly marked lamellæ, and at intervals by well-marked growth-lines.

Measurements:

	(1)	(2)	(3)	(4)
Length . .	36	27	25	19 mm.
Height[1] .	33	24	24·5	20 „

(1—4) from Hythe.

Affinities.—This is distinguished from *P. inflata*, Sowerby, and *P. Carteroniana*, d'Orbigny, by greater development of spines and the presence of the smaller ribs.

Distribution.—Hythe Beds of Hythe, Lympne, St. Martha's (East Shalford), Sevenoaks, and Maidstone. ? Ferruginous Sands of Shanklin. ? Speeton Clay. Recorded by Fitton (1847) from the *Perna*-bed of Atherfield.[2]

PLICATULA CARTERONIANA, *d'Orbigny*, 1847. Plate XXV, figs. 5 *a*, *b*, 6 *a*, *b*, 7—12.

1847.	PLICATULA CARTERONIANA,	*A. d'Orbigny.*	Pal. Franç. Terr. Crét., vol. iii, p. 680, pl. cccclxii, figs. 5—7.
1850.	— —	*d'Orbigny.*	Prodr. de Pal., vol. ii, p. 83.
1854.	— —	*J. Morris.*	Cat. Brit. Foss., ed. 2, p. 180.
1871.	— CARTERONI,	*F. J. Pictet and G. Campiche.*	Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 5), pp. 265, 271, pl. clxxxiii, figs. 3, 4.
1883.	— —	*W. Keeping.*	Foss., etc., Neoc. Upware and Brickhill, p. 110, pl. v, fig. 4.
1896.	— CARTERONIANA,	*A. Wollemann.*	Zeitschr. d. deutsch. geol. Gesellsch., vol. xlviii, p. 835.

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[1] Measured obliquely from the umbo to the middle of the ventral margin.

[2] I have not been able to find the type or other specimens of *Plicatula inæquidens*, Sharpe, from the Lower Greensand of Faringdon, 'Quart. Journ. Geol. Soc.,' vol. x (1853), p. 197, pl. vi, fig. 4.

1900. Plicatula Carteroniana, *Wollemann*. Die Biv. u. Gastr. d. deutsch. u. holländ. Neoc. (Abhandl. d. k. preuss. geol. Land., n. F., pt. 31), p. 22.

Description.—Shell oval, somewhat triangular, oblique; height greater than length. Right valve much inflated, ornamented with usually eight to ten sharp, prominent ribs, which are slightly curved, bear short spiny processes, and are separated by broad furrows; well-marked growth-lines occur at intervals. Left valve flat or slightly concave; ribs less prominent, more rounded, and broader than on the right valve, separated by narrow furrows.

Measurements:

	(1)	(2)	(3)
Length	17	13	11 mm.
Height[1]	21	16	14 ,,

(1—3) from Upware.

Types.—From the Neocomian of Maisons, near the Écorces (Doubs). The specimen figured by Keeping is in the Woodwardian Museum.

Distribution.—Hythe Beds of Hythe and (Bargate Stone) of St. Catherine's Hill (Guildford). Sandgate Beds of Sevenoaks. Lower Greensand of Brickhill, Potton, and Upware.

Plicatula æquicostata, *Keeping*, 1883.

1883. Plicatula æquicostata, *W. Keeping*. Foss., etc., Upware and Brickhill, p. 111, pl. v, fig. 5.

Description.—Shell small, ovate, oblique, high, very inequivalve, margins rounded. Right valve much inflated, umbonal part prominent, with a small area for attachment; ornamented with numerous (about fifty) small, regular, rounded ribs, which curve slightly, are of nearly equal size, and are separated by narrow grooves; these ribs are crossed by small concentric lamellæ, and occasionally by stronger growth-lines. Left valve flat or slightly concave, with similar ornamentation, but the ribs apparently fewer and broader.

Measurements:

	(1)	(2)
Length	9	16 mm.
Height	14	19·5 ,,
Thickness	8·5	11 ,,

(1, 2) from Upware. (1) the type.

[1] Measured obliquely.

Affinities.—This species appears to be closely allied to *P. imbricata*, Koch and Dunker,[1] from the Hilsthon of the Elligser Brink, but is distinguished by the left valve being flat or concave. The shell is also very similar in form to *P. Carteroniana*, and may even prove to be only a worn example of that species.

Remarks.—The only undoubted specimens which I have seen are the three rather imperfectly preserved examples on which the species was founded.

Types.—In the Woodwardian Museum.

Distribution.—Lower Greensand of Upware.

PLICATULA GURGITIS, *Pictet and Roux*, 1853. Plate XXV, figs. 13 *a*, *b*, 14—21.

1823. PLICATULA PECTINOIDES, *J. de C. Sowerby* (non *Lamarck*). Min. Conch., vol. v, p. 5, pl. ccccix, fig. 1.
1847. — RADIOLA, *A. d'Orbigny*. Pal. Franç. Terr. Crét., vol. iii, p. 683 (*partim*), pl. cccclxiii, figs. 6, 7 (*non* 1—5).
1850. — — — Prod. de Pal., vol. ii, p. 139 (*partim*).
1853. — GURGITIS, *F. J. Pictet and W. Roux*. Moll. Foss. Grès verts de Genève, p. 517, pl. xlvii, fig. 4.
1854. — PECTINOIDES, *J. Morris*. Cat. Brit. Foss., ed. 2, p. 180.
? 1855. — RADIOLA, *G. Cotteau*. Moll. Foss. de l'Yonne, p. 118.
1871. — GURGITIS, *F. J. Pictet and G. Campiche*. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 5), p. 272.
1875. — PECTINOIDES, *A. J. Jukes-Browne*. Quart. Journ. Geol. Soc., vol. xxxi, p. 297.

Non 1846. PLICATULA PECTINOIDES, *A. E. Reuss*. Die Verstein. d. böhm. Kreidef., pt. ii, p. 37, pl. xxxi, figs. 16, 17 (= *P. Barroisi*, Peron).
— — — — *J. de C. Sowerby*. Trans. Geol. Soc., ser. 2, vol. v, p. 328, pl. xxii, figs. 6, 9 (= *P. peregrina*, d'Orbigny).

Description.—Shell oval, more or less triangular, umbonal part generally produced; margins rounded, the postero-dorsal being often concave. Inequivalve: right valve sometimes only slightly, but generally very convex, somewhat flattened near the umbones; left valve concave, sometimes flat. Right valve ornamented with numerous narrow, sharp, radial ribs, curving and slightly irregular, separated by broad spaces. The ribs bear many spines, having usually a roughly concentric arrangement, and being longest near the margins of the valves. Concentric

[1] 'Norddeutsch. Oolithgeb.' (1837), p. 50, pl. vi, fig. 3; G. Böhm, 'Zeitschr. der deutsch. geol. Gesellsch.,' vol. xxix (1877), p. 236; A. Wollemann, "Die Biv. u. Gastrop. des deutsch. u. holländ. Neoc." ('Abhandl. d. k. preussisch geol. Landesanst.,' n. F., part 31, 1900), p. 23.

lamellæ and well-marked growth-lines are present. The ribs vary in number considerably in different specimens, but are always more numerous near the ventral margin than near the umbo, owing to the intercalation of new ribs. Left valve ornamented with similar but usually broader and more rounded ribs, crossed by numerous concentric lamellæ.

Measurements :

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	
Length . .	53	48	47	39	36	33	31	30	25	22	22	17	mm.
Height[1] . .	48	44	46	51	40	38	28	36	28	30	29	20	,,
Number of ribs at margin of right valve .	39	34	25	29	23	19	19	24	24	26	28	11	

(1—7, 11, 12) from the Gault of Folkestone; (8—10) from the Gault near Cambridge.

Affinities.—See *P. inflata* (p. 140).

Remarks.—This species was described by Sowerby as *Plicatula pectinoides* (Lamarck). The type of Lamarck's species came from the Lias of Metz,[2] and is quite distinct from the Cretaceous species; the latter must, therefore, be known as *P. gurgitis*, Pictet and Roux.

Types.—The types of *P. pectinoides*, Sowerby, from the Gault near Cambridge, appear to have been lost.

Distribution.—Gault of Folkestone (zones i—iii, vi, viii, x, xi), of Ford (near Aylesbury), and of Barnwell (Cambridge). Cambridge Greensand (derived from the Gault). Red Limestone of Hunstanton. Upper Greensand of the Isle of Wight.

PLICATULA MINUTA, *Seeley*, 1866. Plate XXV, figs. 22—25.

1866. PLICATULA MINUTA, *H. G. Seeley*. Ann. Mag. Nat. Hist., ser. 3, vol. xvii, p. 176.

Remarks.—The ornamentation of this small form is of the same type as that of *P. gurgitis*, but the ribs are perhaps more numerous than at the umbo of that species. Comparison, however, is difficult, since the umbo of *P. gurgitis* is seldom well preserved. It seems probable that *P. minuta* is only the young form of *P. gurgitis*, but since the smallest known example of the latter is very much larger

[1] Measured obliquely from the umbo to the middle of the ventral margin.

[2] *Placuna pectinoides*, Lamarck, 'Anim. sans Vert.,' vol. vi (1819), p. 224. *Plicatula pectinoides*, Defrance, 'Dict. Sciences nat.,' vol. xli (1826), p. 400; Deshayes and Milne Edwards, Lamarck's 'Anim. sans Vert.,' ed. 2, vol. vii (1836), p. 178; d'Orbigny, 'Prodr. de Pal.,' vol. i (1849), p. 238.

than the largest of the former, it is at present impossible to trace a passage from one to the other.

Types.—From the Red Limestone of Hunstanton, in the Woodwardian Museum.

Distribution.—Cambridge Greensand. Red Limestone of Hunstanton and Speeton.

PLICATULA INFLATA, *Sowerby*, 1823. Plate XXVI, figs. 1—11.

1819.	PLICATULA	RADIOLA, *Lamarck.*	Anim. sans. Vert., vol. vi, p. 185 (? *partim*).
1822.	—	SPINOSA, *G. Mantell.*	Foss. S. Downs, p. 129, pl. xxvi, figs. 13, 16, 17 (non *spinosa*, Sowerby).
1823.	—	INFLATA, *J. de C. Sowerby.*	Min. Conch., vol. v, p. 6, pl. ccccix, fig. 2.
1836.	—	— *A. Goldfuss.*	Petref. Germ., vol. ii, p. 102, pl. cvii, fig. 6.
—	—	RADIOLA, *Lamarck.*	Anim. sans Vert., ed. 2 (by Deshayes and Milne Edwards), vol. vii, p. 177 (? *partim*).
? 1846.	—	INFLATA, *A. E. Reuss.*	Die Verstein. der böhm. Kreideformat., pt. 2, p. 37.
1847.	—	RADIOLA, *A. d'Orbigny.*	Pal. Franç. Terr. Crét., vol. iii, p. 683 (*partim*), pl. cccclxiii, figs. 1—5 (*non* 6, 7).
—	—	SPINOSA, *d'Orbigny.*	Ibid., p. 685, pl. cccclxiii, figs. 8—10.
1850.	—	RADIOLA, *A. d'Orbigny.*	Prodr. de Pal., vol. ii, p. 120.
1852.	—	— *R. Kner.*	Denkschr. d. k. Akad. d. Wissensch. Math.-nat. Cl., vol. iii, p. 319, pl. xvii, fig. 9.
1853.	—	— *F. J. Pictet and W. Roux.*	Moll. Foss. Grès verts de Genève, p. 516, pl. xlvii, fig. 3.
1854.	—	INFLATA, *J. Morris.*	Cat. Brit. Foss., ed. 2, p. 180.
1855.	—	RADIOLA, *G. Cotteau.*	Moll. Foss. de l'Yonne, p. 118.
1858.	—	— ?, *J. A. Eudes-Deslongchamps.*	Mém. Soc. Linn. de Normand., vol. xi, p. 103, pl. xvii, figs. 3—8.
? —	—	INFLATA ?, *Eudes-Deslongchamps.*	Ibid., p. 100, pl. xvi, figs. 31—33.
—	—	— *F. J. Pictet and E. Renevier.*	Foss. Terr. Aptien (Matér. Pal. Suisse, ser. 1), p. 137.
1859.	—	— *A. v. Strombeck.*	Zeitschr. der deutsch. geol. Gesellsch., vol. xi, p. 37.
1863.	—	— —	Ibid., vol. xv, p. 109.
1865.	—	— *H. Coquand.*	Mon. Aptien de l'Espagne, p. 159.
1871.	—	— *F. J. Pictet and G. Campiche.*	Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 5), p. 269.
1882.	—	— *R. Windmöller.*	Jahrb. d. k. geol. preussisch Geol. Landesanst.' (1881), p. 21.

1882.	PLICATULA SPINOSA,	*J. Kiesow.*	Schrift der Nat. Gesellsch. in Danzig, n. F., vol. v, p. 241.
1885.	— INFLATA,	*F. Nötling.*	Die Fauna d. baltisch. Cenoman. (Palæont. Abhandl., vol. ii), p. 15, pl. ii, fig. 3.
1887.	— —	*A. Peron.*	Hist. du Terr. de Craie (Bull. Soc. Sci. Hist. et Nat. de l'Yonne, ser. 3, vol. xii), p. 169, pl. ii, fig. 3.
1889.	— —	*A. Fritsch.*	Stud. im Gebiete der böhm. Kreideformat. IV. Die Teplitz. Schicht, p. 86, fig. 84.
1895.	— —	*E. Tiessen.*	Zeitschr. der deutsch. geol. Gesellsch., vol. xlvii, p. 477.
? 1897.	— —	*A. Fritsch.*	Stud. im Gebiete der böhm. Kreideformat. VI. Die Chlomeker Schicht, p. 68, fig. 88.

Description.—Shell oval or somewhat triangular—more distinctly oval in large specimens; very oblique, margins rounded. Right valve moderately convex, the convexity increasing considerably with age, so that in old specimens the later part of the valve curves considerably from the less convex earlier part. Left valve flat or concave. Right valve ornamented with regular, radial, slightly curved ribs, which are usually few in number, and bear short recumbent spines, which are longer at the anterior and posterior margins; a few new ribs may be introduced between the older ones. Left valve with similar ribs and spines.

Measurements :

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	
Length .	18	22	23	24	25	27	28	37	45	45	49	mm.
Height[1] .	22	23	21	26	28	27	30	38	41	47	50	„

(2) from the Lower Chalk, Ventnor.
(8) from the Chalk Marl, Haslingfield.
(9) from the *H. subglobosus* zone, Cherry Hinton.
Others from the Totternhoe Stone, Burwell.

Affinities.—From a comparison of specimens of *P. radiola*, d'Orbigny, from the Aptian, with specimens of *P. inflata,* Sowerby, from the English Cenomanian, Pictet, Renevier, and Campiche came to the conclusion that the two forms could not be regarded as distinct species. My own observations lead me to endorse the opinion of those writers—that examples of the same size are inseparable. In the Cenomanian, however, the specimens often reach a larger size than any I have seen from the Lower Cretaceous; in such cases the ventral part of the valve is nearly smooth, or has only indistinct ribs. Figures of a large and also a small form from the Chalk are given by Goldfuss, and good figures of an Aptian specimen by Pictet and Roux. Peron has named some very small forms from the Cenomanian *P. Cotteaui,* and considers that *P. spinosa,* d'Orbigny, is an example

[1] Measured obliquely from the umbo to the middle of the ventral margin.

of the same. He admits, however, that *P. Cotteaui* is practically inseparable from *P. radiola*, d'Orbigny, and gives the name chiefly because it occurs on a different horizon. Peron considers that *P. Cotteaui* is distinct from *P. inflata*: after the examination of a large series of specimens of different ages I am unable to accept that view, especially in consideration of the large amount of variation which occurs in the very closely allied species *P. gurgitis*. *P. inflata* is distinguished from *P. gurgitis* by the fewer and more regular ribs and the fewer spines; also by the ribs being absent or indistinct on the ventral part of the valves in large specimens. Some specimens of *P. inflata*, with more numerous ribs, approximate to certain examples of *P. gurgitis* which have fewer ribs than usual; this is more particularly seen in some examples from the Upper Greensand.

Remarks.—The number and strength of the ribs vary in different examples; large specimens are sometimes almost smooth (*e.g.* Pl. XXVI, fig. 9).

Since two forms were included by Lamarck under the name *P. radiola*, and since uncertainty exists as to which of them his name should be applied to, I follow Pictet, Renevier, and Campiche in retaining the name *inflata* given by Sowerby.

Types.—*P. inflata* is from the Cenomanian near Cambridge; the specimens cannot now be found. The type of *P. spinosa*, Mantell, is in the British Museum.

Distribution.—Upper Greensand near Nursted and (Chert Series) of the Isle of Wight. Rye Hill Sand of Warminster. Chloritic Marl of Maiden Bradley and the Isle of Wight. Grey Chalk of Folkestone. Chalk Marl of Ventnor, Folkestone, Reach, Burwell, Haslingfield, Harlton, Speeton, etc. Zone of *Holaster subglobosus* of Hitchin, Totternhoe, Arlsey, Isleham, Burwell, Cherry Hinton, Fulbourn, Shelford, Louth, Withcall, Speeton, etc.

I have seen no examples from the English Lower Cretaceous which could be definitely referred to this species, but Topley (1875) has recorded *P. inflata* from the Hythe and the Sandgate Beds.

PLICATULA BARROISI, *Peron*, 1887. Plate XXVI, figs. 12—18.

1846. PLICATULA PECTINOIDES, *A. E. Reuss* (non *Sowerby*). Die Verstein. der böhm. Kreideformat., pt. ii, p. 37, pl. xxxi, figs. 16, 17.
1850. — NODOSA, *A. d'Orbigny*. Prodr. de Pal., vol. ii, p. 254 (*partim*).
1872. — — *H. B. Geinitz*. Das Elbthalgeb. in Sachsen (Palæontographica, vol. xx), pt. ii, p. 32, pl. ix, fig. 5.
1878. — — *C. Barrois*. Terr. Crét. des Ardennes (Ann. Soc. géol. Nord, vol. v), p. 391.

1887. PLICATULA BARROISI, *A. Peron.* Hist. du Terr. de Craie (Bull. Soc. Sci. Hist. Nat. de l'Yonne, ser. 3, vol. xii), p. 167, pl. ii, figs. 5—7.
1889. — NODOSA, *A. Fritsch.* Stud. im Gebiete der böhm. Kreideformat. IV. Die Teplitz. Schicht, p. 86, fig. 83.
1895. — *cf.* NODOSA, *B. Lundgren.* Mollusk. i *Mammill.*-och *Mucron*-zonerna i nordöstra Skåne (K. Svenska Vet.-Akad. Handl., n. s., vol. xxvi, No. 6), p. 41.
1897. — BARROISI, *H. Woods.* Quart. Journ. Geol. Soc., vol. liii, p. 388, pl. xxvii, figs. 18, 19.

Description.—Shell small, ovate, rounded, a little oblique. Right valve inflated, with the apical part truncated by the attached surface, which is often fairly large. Left valve flattened or slightly concave, often with a subcircular opening near the umbo. Both valves ornamented with more or less numerous, strong, nearly smooth and rounded ribs, separated by deep and well-marked grooves; the ribs may bifurcate near the margins of the valves, and new ribs may be intercalated. Strongly marked growth-lines occur at intervals, and also concentric lamellæ, the latter being most distinct on the left valve.

Measurements:

	(1)	(2)	(3)	(4)
Length	5·75	5·5	5·0	4·5 mm.
Height	6·0	6·0	5·75	5·5 ,,

(1—4) from the Chalk Rock, near Winchester.

Remarks.—This species was described and figured by Reuss as *P. pectinoides*, Sowerby, but it differs greatly from Sowerby's species. D'Orbigny referred it to *P. nodosa*, Dujardin;[1] Geinitz and Fritsch followed the same course. Barrois, although using the name *P. nodosa*, stated that Dujardin's figure was very incomplete, and consequently his specimens could not be identified as belonging definitely to that species. Peron subsequently pointed out that the species under consideration differs considerably from *P. nodosa*, Dujardin; the latter being about four times larger, more elevated, and ornamented with large, simple, widely separated ribs. He therefore described and figured it as a new species—*P. Barroisi.*

Types.—Reuss's specimens came from the Pläner-Kalk and Pyrope Sand of Irziblitz, and from the Pläner-Mergel of Weberschan. Peron's figured specimens came from the Upper Turonian of Valmy.

Distribution.—Zone of *R. Cuvieri* of the Devon coast. Zone of *T. gracilis* of the Devon coast and Dover. Zone of *H. planus* of Dover, the Sussex coast, Twyford (Winchester), etc. Chalk Rock of Winchester, etc. Zone of *M. cor-*

[1] 'Mém. Soc. géol. de France,' vol. ii (1837), p. 228, pl. xv, fig. 14.

testudinarium of Dover and the Sussex coast. Zone of *M. cor-anguinum* of the Thanet coast, the North Foreland, St. Margaret's, and the Sussex coast. *Uintacrinus* band of Kingsgate. *Marsupites* zone of the Sussex and Thanet coasts. Zone of *B. mucronata* of Clarendon, near Salisbury.

Plicatula sigillina, *Woodward*, 1864. Plate XXVI, figs. 19—22.

? 1852. Spondylus dichotomus, *A. Buvignier*. Statist. géol., etc., de la Meuse, Atlas, p. 25, pl. xix, figs. 16, 17.
1864. Plicatula sigillina, *S. P. Woodward*. Geol. Mag., vol. i, p. 112, pl. v, figs. 1—5.

Description.—Shell small, semi-oval or semicircular in outline, a little oblique. Hinge margin long. Right valve attached by nearly the whole of its surface; interior with slightly raised radial ribs, somewhat irregular, becoming more numerous at the sharp raised margin; beyond this margin is a broad smooth sloping border bounded by a raised edge, outside which are, in some cases, radial ribs. Left valve slightly convex, ornamented with well-marked concentric lamellæ.

Measurements :

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	
Length .	14	15	15	6·5	11	16	9	17	18	21	mm.
Height [1] .	12	15	17	6	10	12	9	16	16	18	,,

(1—3) *M. cor-testudinarium* zone, Chatham.
(4—6) *M. cor-anguinum* zone, Gravesend.
(7—10) *B. mucronata* zone, Hartford Bridge, Norwich.

Affinities.—The form from the Gault of Clermont and Les Islettes (Argonne, Meuse), described by Buvignier as *Spondylus dichotomus*, is probably identical with this species; it is especially like examples of *P. sigillina* from the Cambridge Greensand and the Gault of Folkestone.

P. sigillina differs from the other Cretaceous *Plicatulæ* here described in being attached by almost the entire surface of the right valve, and in the absence of radial ribs or folds on the left valve; in these respects it resembles the completely fixed forms of the recent species *P. philippinarum*, Hanley.

Remarks.—This species occurs attached to *Echinocorys*, *Inoceramus*, *Belemnitella*, and other fossils. The fixed valve is common in the Norwich Chalk and the Cambridge Greensand. The left valve is much less frequently found than the right, and at present appears to be known only from the Upper Chalk and the *H. planus* zone. The inner layer of the shell has undoubtedly disappeared, and

[1] Measured obliquely.

consequently the character of the hinge and the adductor impression cannot be seen. A small oyster, as noted by Dr. S. P. Woodward, is often found in the Chalk attached to echinoids, etc., and is similar in general appearance to *Plicatula sigillina;* but it is easily distinguished by its triangular ligament-pit and clearly marked adductor impression, by the absence of ribs from the interior of the attached valve, and by the more porous structure of the shell.

Types.—One of the types (Woodward's fig. 1) from Grays is in the British Museum. The others, from the Upper Chalk of Norwich and Grays, I have not seen.

Distribution.—Upper Gault (zones x and xi) of Folkestone. Cambridge Greensand. Grey Chalk of Dover. Zones of *R. Cuvieri*, *T. gracilis*, and *H. planus* of Dover and the Sussex coast. Zone of *M. cor-testudinarium* of Chatham, Dover, and the Sussex coast. Zone of *M. cor-anguinum* of Gravesend, the Thanet coast, Kingsgate Castle, St. Margaret's, and the Sussex coast. Zone of *Marsupites* of the Thanet and Sussex coasts. *Uintacrinus*-band of Devizes Road (near Salisbury). Zone of *A. quadratus* of the Dorset and Sussex coasts. Zone of *B. mucronata* of the Dorset coast, Hartford Bridge, etc. (near Norwich).

PLATE XX.

TRIGONIA (*continued*).

FIGS.

1, 2. *T. scapha*, Agassiz. (P. 73.)

1. Lower Greensand (probably Snettisham ironstone nodules), West Norfolk. The type of *T. hunstantonensis*, Seeley. Woodwardian Museum. Right valve.
2. Snettisham Clay, one third of a mile south-west of Snettisham Church. Museum of Practical Geology. Portion of left valve. Drawn from a wax cast of an external mould.

Genus—MYOCONCHA, *Sowerby*.

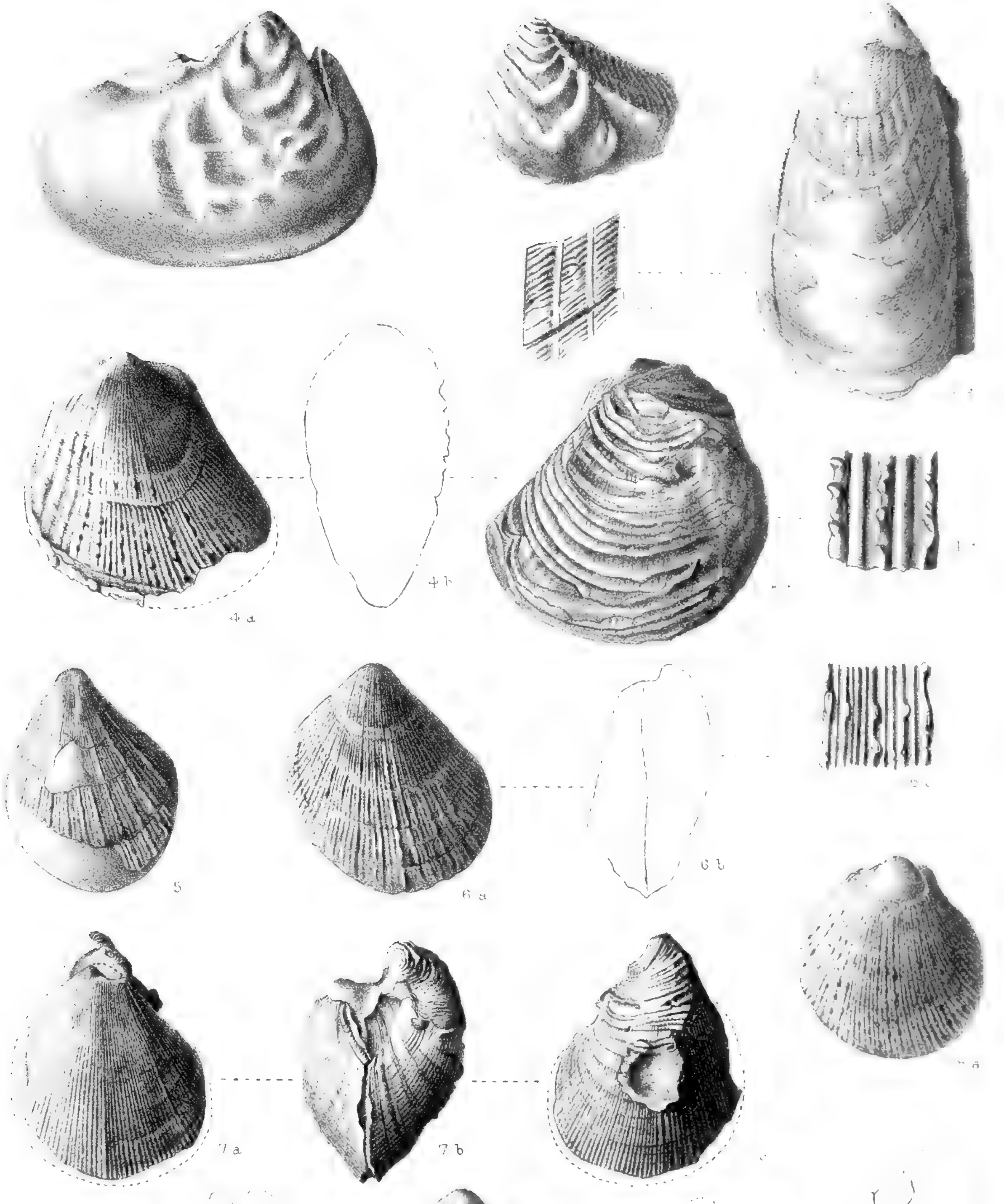
3. *M. cretacea,* d'Orb. Chloritic Marl, Maiden Bradley. Woodwardian Museum. *a*, right valve ; *b*, ornamentation of same × 3. (P. 114.)

Genus—SPONDYLUS, *Linnæus*.

4. *S. Roemeri,* Desh. *Perna*-bed, Atherfield. Woodwardian Museum. *a*, left valve (umbo slightly restored) ; *b*, outline from the posterior end ; *c*, right valve ; *d*, ornamentation of left valve × 3. (P. 116.)

5—11. *S. gibbosus,* d'Orb. Cambridge Greensand (derived from the Upper Gault), Cambridge. Woodwardian Museum. (P. 117.)

5, 6 *a*. Left valves ; 6 *b*, anterior outline ; 6 *c*, ornament of left valve × 2.
7 *a*. Left valve ; *b*, posterior of both valves ; *c*, right valve.
8 *a*. Left valve ; *b*, part of same × 2.
9 *a*. Left valve ; *b*, anterior outline.
10. Left valve.
11. Posterior outline of a specimen with talon-like right valve.



J.A.Brock del
A.T.Hollick lith

PLATE XXI.

SPONDYLUS (*continued*).

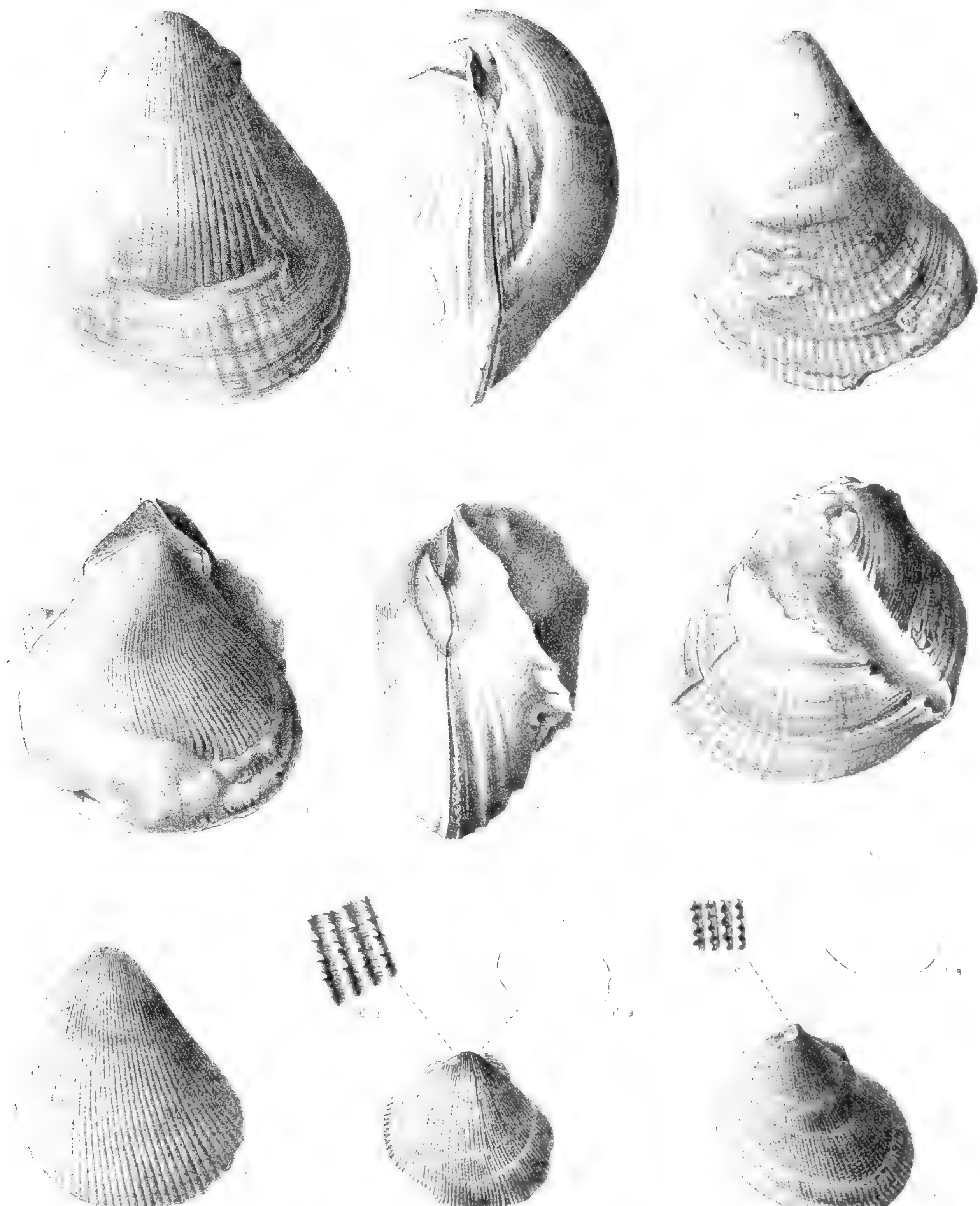
FIGS.

1—5. *S. striatus* (Sow.). Rye Hill Sand, Warminster. (P. 119.)

1. Museum of Practical Geology, No. 6836. *a*, left valve; *b*, anterior view.
2. Woodwardian Museum. Left valve.
3. British Museum. *a*, left valve and projecting umbo of right; *b*, posterior view.
4. Wiltshire Collection, Woodwardian Museum. Right valve with only a small surface of attachment.
5. York Museum. Left valve.

6, 7. *S. serratus*, Woods. (P. 124.)

6. Dr. Blackmore's Collection. *Uintacrinus*-band of *Marsupites* zone, Devizes Road, Salisbury. Left valve. *a*, outline, natural size; *b*, × $1\frac{1}{2}$; *c*, ornament × 6.
7. British Museum. Upper Chalk. Left valve. *a*, outline, natural size; *b*, × $1\frac{1}{2}$; *c*, ornament × 4.



T.A. Brock del.
A.T. Hollick lith.

West Newman imp.

AMELLI

PLATE XXII.

SPONDYLUS (*continued*).

FIGS.

1—10. *S. latus* (Sowerby). (P. 121.)

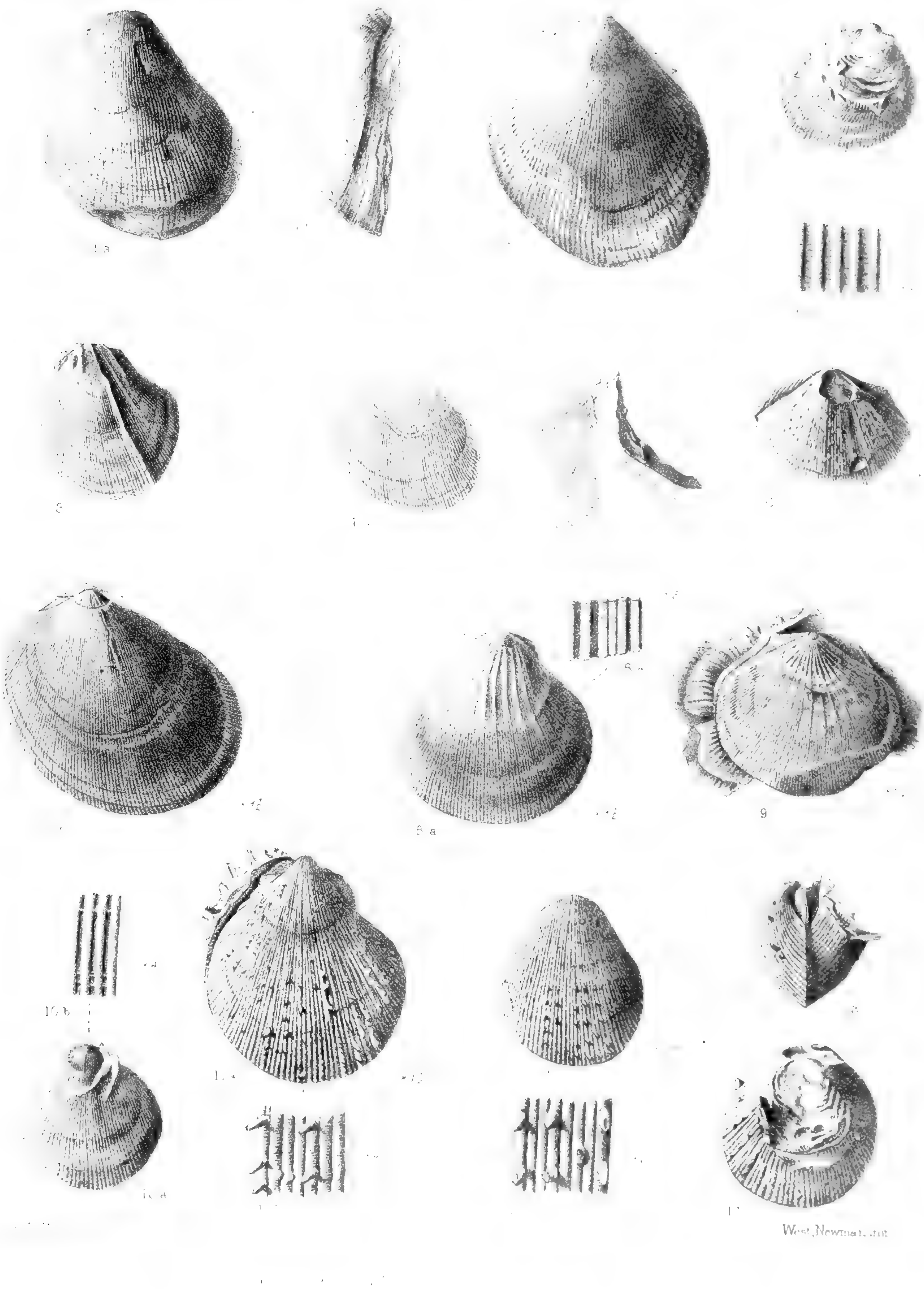
1. Woodwardian Museum. The type of *S. æquicostatus*, Eth. Zone of *Holaster subglobosus*, Cherry Hinton. 1 *a*, left valve; 1 *b*, posterior view of the same.
2. Same collection, horizon, and locality. *a*, left valve; *b*, portion of same just ventral to centre of valve, × 4.
3. Woodwardian Museum. Lower Chalk, Fulbourn. Left valve.

4—9. Dr. Blackmore's Collection. Zone of *A. quadratus*. 4—8, East Harnham; 9, West Harnham, near Salisbury.

4. *a*, left valve, with part of right projecting; *b*, posterior view of both valves.
5. Right valve.
6. Left valve. Part near the umbo × 2.
7. Left valve × $1\frac{1}{2}$.
8. Left valve. *a*, × $1\frac{1}{2}$; *b*, posterior outline; *c*, ornamentation × 5.
9. Left valve, with umbo and marginal parts of right valve × $1\frac{1}{2}$.
10. Woodwardian Museum (Coll. Mr. W. Hill). Zone of *H. subglobosus*, cutting east of South Cave Station, Yorkshire. *a*, left valve; *b*, ornamentation × 4.

11—14. *S. Dutempleanus*, d'Orb. Zone of *A. quadratus*. Dr. Blackmore's Collection. 11—13, East Harnham. 14, Whaddon cutting. (P. 125.)

11. *a*, left valve × $1\frac{1}{2}$; *b*, ornamentation × 4.
12. *a*, left valve; *b*, ornamentation × 3.
13. Posterior view of both valves.
14. Right valve.



West, Newman. lith

PLATE XXIII.

Spondylus (*continued*).

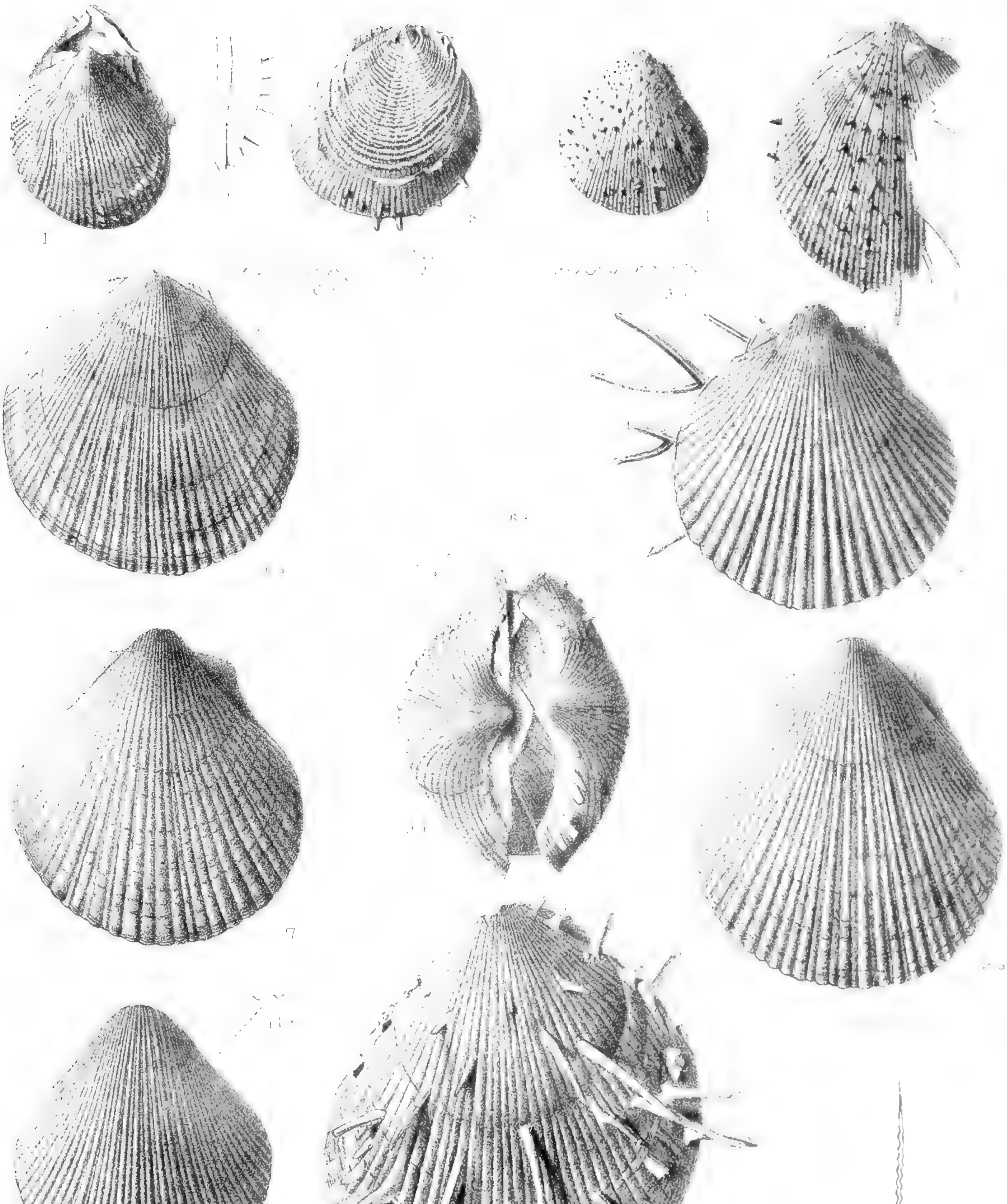
Figs.

1—5. *S. Dutempleanus*, d'Orb. (P. 125.)

1. *A. quadratus* zone, Whaddon cutting. Dr. Blackmore's Collection. Left valve and umbo of right × $1\frac{1}{2}$.
2. *A. quadratus* zone, East Harnham, Salisbury. Dr. Blackmore's Collection. Anterior outline showing spines on left valve.
3. *B. mucronata* zone, Norwich. Norwich Museum. Right valve.
4. Chalk of Trimingham. Museum of Practical Geology (Coll. Mr. C. Reid). Left valve.
5. *B. mucronata* zone, Norwich. Norwich Museum. Part of left valve.

6—11. *S. spinosus* (Sow.). (P. 127.)

6. *T. gracilis* zone, Luton. Woodwardian Museum (Coll. Mr. W. Hill). *a*, left valve; *b*, anterior outline; *c*, section of ribs of left valve near the mid-ventral border × 2.
7. *T. gracilis* zone, East Knoyle. Woodwardian Museum (Coll. Mr. Jukes-Browne).
8. *H. planus* zone, Cheveley. Woodwardian Museum. Left valve, with spines projecting from the right valve.
9. Same zone, etc. *a*, left valve; *b*, dorsal view; *c*, section of ribs of left valve near the mid-ventral border × 2.
10. Same zone, etc. *a*, right valve (umbo slightly imperfect); *b*, section of ribs of right valve near the mid-ventral border × 2.
11. *M. cor-testudinarium* zone, Chatham. Woodwardian Museum (Coll. Mr. Jukes-Browne). *a*, left valve; *b*, anterior outline; *c*, ribs of left valve near the mid-ventral border × 2.



T.A.Brock del.
A.T.Hollick lith.

West Newman imp.

CRETACEOUS LAMELLIBRANCHIA

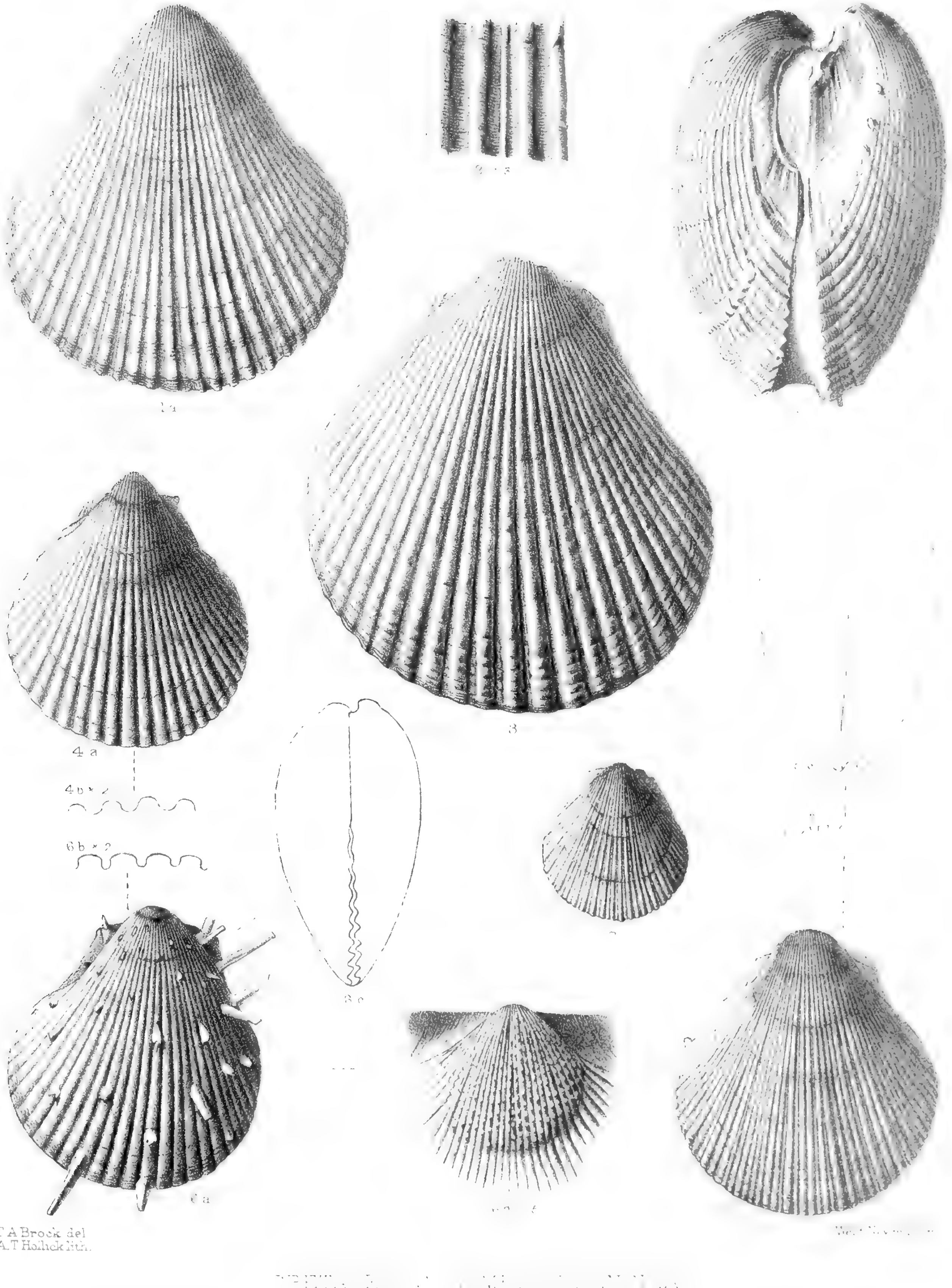
PLATE XXIV.

Spondylus spinosus (Sow.) (*continued*). (P. 127.)

FIGS.

1. Upper part of *M. cor-anguinum* zone, Mitcheldever. Dr. Blackmore's Collection. *a*, left valve; *b*, posterior view.
2. *M. cor-anguinum* zone, Fletcher's pit, Gravesend. Woodwardian Museum. Small portion of left valve near the middle of the ventral border × 3.
3. *M. cor-anguinum* zone, Hungry Down, Blandford. Woodwardian Museum (Coll. Mr. Jukes-Browne). Left valve, umbo slightly imperfect.
4. Lower part of *Marsupites* zone, Witherington. Dr. Blackmore's Collection. *a*, left valve; *b*, section of ribs of the same near the mid-ventral border × 2.
5. Same horizon, locality, and collection. *a*, left valve; *b*, section of ribs of left valve near the mid-ventral border × 2; *c*, posterior outline.
6. *Marsupites* zone, Margate. Dr. Rowe's Collection. *a*, right valve; *b*, section of ribs of right valve near the mid-ventral border × 2; *c*, posterior outline; *d*, umbo of left valve × 5.
7. *A. quadratus* zone, West Harnham, Salisbury. Dr. Blackmore's Collection. Left valve.

PLATE XXIV.



T A Brock del
A.T Holleck lith.

PLATE XXV.

Genus—PLICATULA, *Lamarck.*

FIGS.

1—4. *P. placunea*, Lam. Hythe Beds, Lympne. Museum of Practical Geology, No. 6781. 1, 2, 4, right valves; 1 *b*, anterior outline; 3, left valve. (P. 134.)

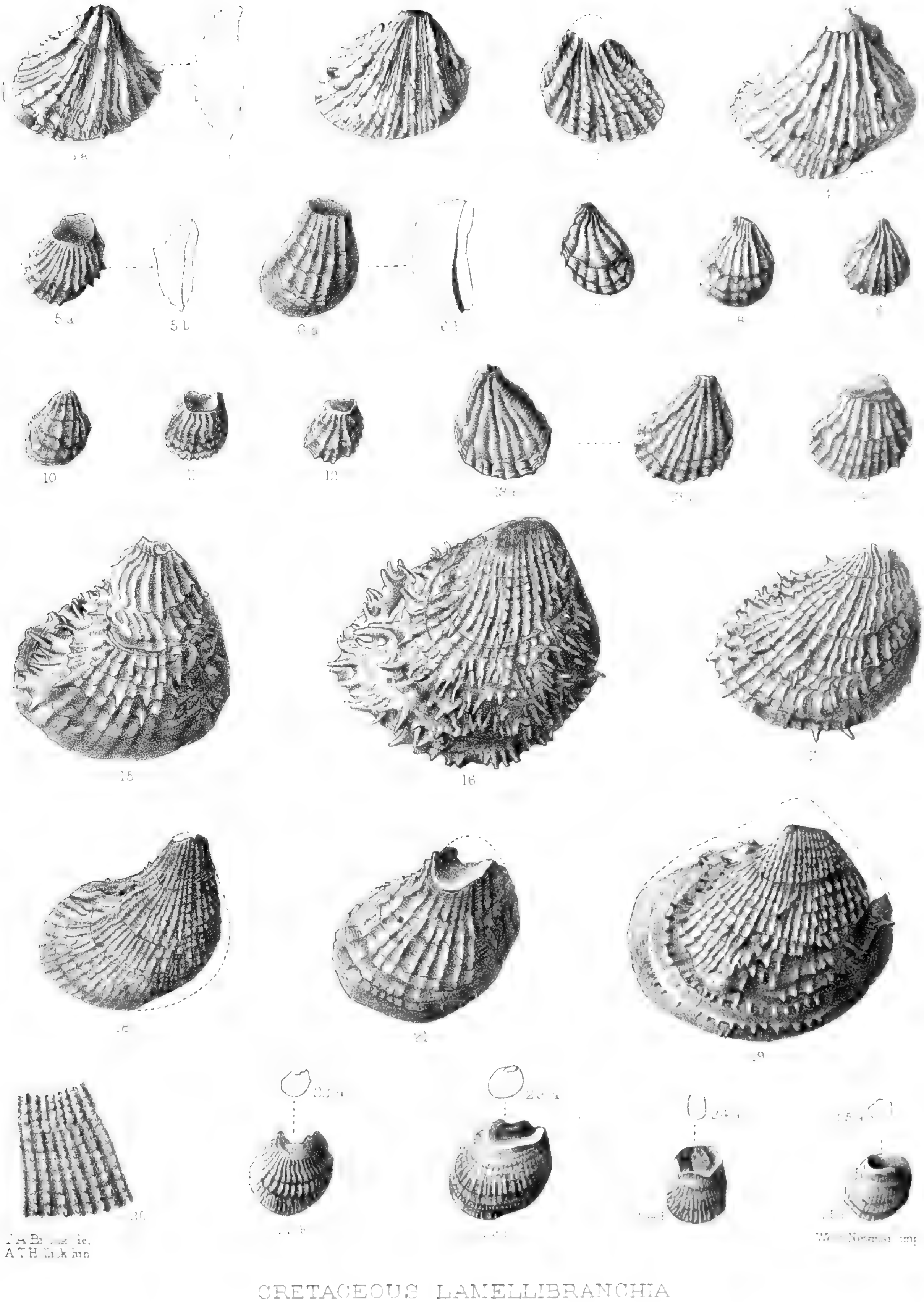
5—12. *P. Carteroniana*, d'Orb. Lower Greensand, Upware. Right valves, except fig. 7 (left valve); 5*b*, 6*b*, anterior outlines. Figs. 6—9, Woodwardian Museum. Figs. 5, 10—12 in Mr. J. F. Walker's Collection. (P. 135.)

13—21. *P. gurgitis*, Pict. and Roux. Gault, Folkestone, except figs. 18, 21. (P. 137.)

13—15. Wiltshire Collection. Right valves; 13 *b*, left valve.
16, 17. York Museum. Right valves.
18. Woodwardian Museum. Gault, Cambridge. Right valve.
19. York Museum. Right valve.
20. Part of left valve of 19.
21. Woodwardian Museum. Cambridge Greensand (derived from the Gault).

22—25. *P. minuta*, Seel. (P. 138.)

22, 24. Woodwardian Museum. Cambridge Greensand.
23. Wiltshire Collection. Red Limestone, Speeton.
25. ,, ,, Red Limestone, Hunstanton. *a*, outline, natural size; *b*, × 3.



W. Newman imp.

CRETACEOUS LAMELLIBRANCHIA

PLATE XXVI.

PLICATULA (*continued*).

FIGS.

1—11. *P. inflata*, Sow. Woodwardian Museum, Cambridge. Right valves (except fig. 7). (P. 139.)

1—3, 5. Totternhoe Stone, Burwell.
4. Lower Chalk, Burwell.
6. Totternhoe Stone, Arlesey.
7. ,, ,, Reach. Left valve.
8. ,, ,, Burwell.
9. Lower Chalk, Burwell.
10. Chalk Marl, Haslingfield.
11. *H. subglobosus* zone, Cherry Hinton.

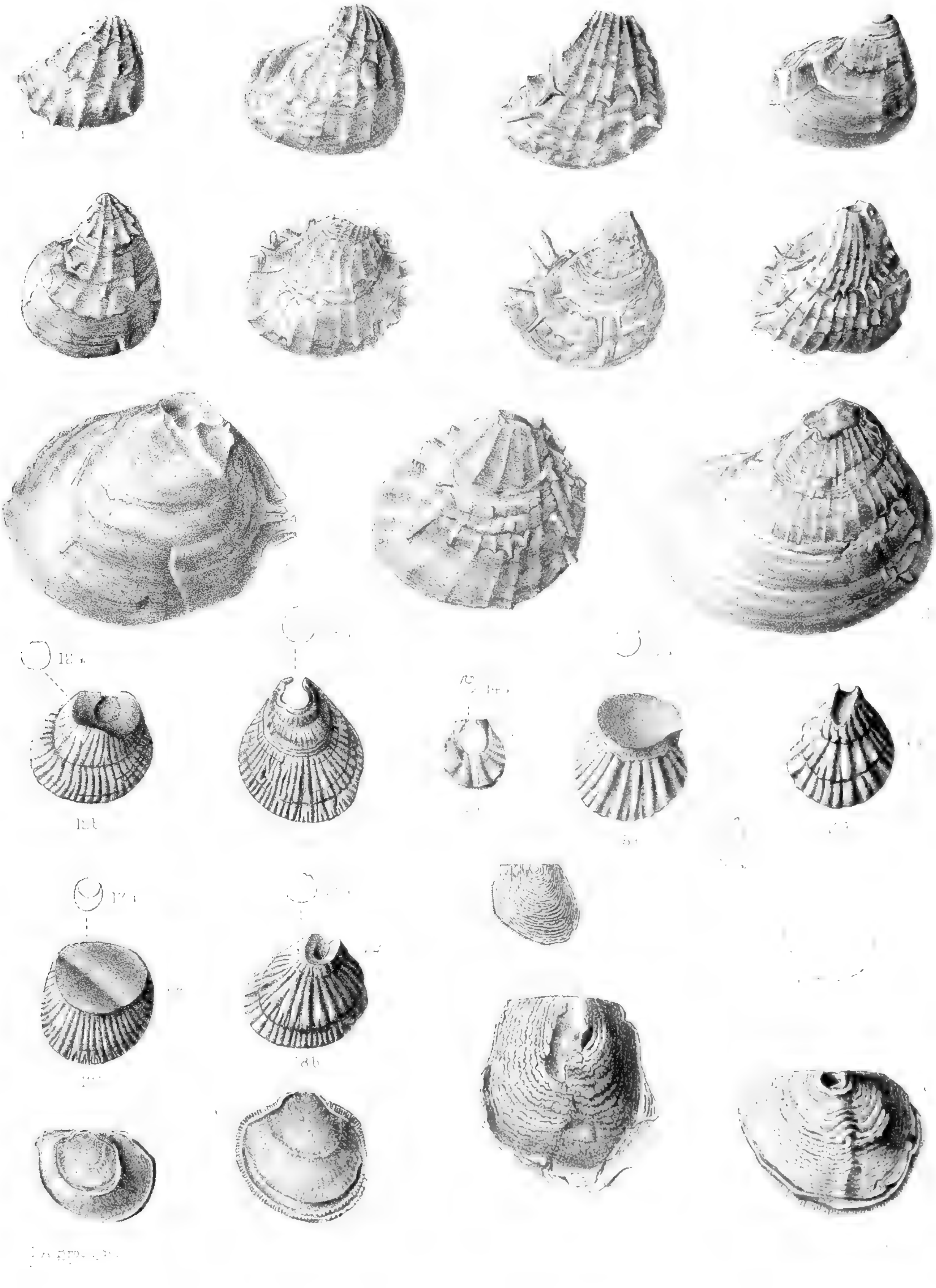
12—18. *P. Barroisi*, Peron. Right valves, except figs. 13, 14. (P. 141.)

12. *H. planus* zone, Dover. Dr. Rowe's Collection. *a*, natural size; *b*, × 4.
13. *H. planus* zone, Twyford. Woodwardian Museum. Left valve, *a*, natural size; *b*, × 4.
14. Top of *M. cor-anguinum* zone, North Foreland. Dr. Rowe's Collection. Left valve, *a*, natural size; *b*, × 4.
15. *H. planus* zone, Dover. Dr. Rowe's Collection, *a*, natural size; *b*, × 4.
16. *Uintacrinus*-band, Kingsgate, Margate. Dr. Rowe's Collection. *a*, natural size; *b*, × 4.
17. *H. planus* zone, Twyford. Woodwardian Museum. *a*, natural size; *b*, × 4.
18. Chalk Rock, near Winchester. Mr. R. M. Brydone's Collection. *a*, natural size; *b*, × 4.

19—22. *P. sigillina*, Woodw. (P. 143.)

19. *B. mucronata* zone, Hartford Bridge, Norwich. Woodwardian Museum. *a*, interior of right valve; *b*, central part of same × 2.
20. Top of *M. cor-testudinarium* zone, Chatham. Dr. Rowe's Collection. Left valve.
21. Same horizon, etc. Left valve × 2.
22. *M. cor-testudinarium* zone, Chatham. Museum of Practical Geology, No. 179. Left valve. *a*, natural size; *b*, × 2.

PLATE XXVI.



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A MONOGRAPH

OF THE

BRITISH CARBONIFEROUS LAMELLIBRANCHIATA.

BY

WHEELTON HIND, M.D., B.S.Lond., F.R.C.S., F.G.S.,

MEMB. SOC. GEOL. BELG.

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A MONOGRAPH

OF THE

BRITISH CARBONIFEROUS LAMELLIBRANCHIATA.

VOL. II.

Family PINNIDÆ.

Genus PINNA, *Linné*, 1758.

CONCHYLIOLITHUS (PINNITES), *Martin*, 1809. Petrific. Derbiensia, p. 14.

The generic characters of *Pinna* need no description here. It is of interest to note the length of time that this genus has existed.

PINNA FLABELLIFORMIS, *Martin*, 1809. Plate II, figs. 1—6; Plate IV, fig. 1.

CONCHYLIOLITHUS (PINNITES) FLABELLIFORMIS, *Martin*, 1809. Petrific. Derb., p. 14, pl. vi, figs. 1, 2.
— NUDUS, *Martin*, 1809. Ibid., Syst. Arrangem., p. 14.
PINNA COSTATA, *Phillips*, 1836. Geol. Yorks., pt. ii, p. 211, pl. vi, fig. 2.
— FLABELLIFORMIS, *de Koninck*, 1843. Descr. Anim. Foss. Terr. Carb. Belg., p. 124, pl. v, fig. 1.
— — var. INÆQUICOSTATA, *Portlock*, 1843. Rep. Geol. Londonderry, p. 437.
— — *Morris*, 1843. Cat. Brit. Foss., 1st edit., p. 98.
— — *M'Coy*, 1844. Synops. Carb. Foss. Ireland, p. 85.

PINNA INÆQUICOSTATA, *M'Coy*, 1844. Synops. Carb. Foss. Ireland, p. 86.
— FLEXICOSTATA, *M'Coy*, 1844. Ibid., p. 85, pl. xix, fig. 1.
— FLABELLIFORMIS, *Bronn*, 1848. Nomencl. Palæont., p. 978.
— — *Brown*, 1849. Illust. Foss. Conch., p. 169, pl. lxvii, fig. 19.
— — *d'Orbigny*, 1850. Prodrome Paléont., vol. i, p. 135.
— — *Morris*, 1854. Cat. Brit. Foss., 2nd edit., p. 180.
— FLEXICOSTATA, *Morris*, 1854. Ibid., p. 180.
— FLABELLIFORMIS, *M'Coy*, 1855. Brit. Pal. Foss., p. 498.
— FLEXICOSTATA, *M'Coy*, 1855. Ibid., p. 499, pl. iii E, figs. 11—13.
— FLABELLIFORMIS, *Griffith*, 1860. J. Geol. Soc. Dublin, vol. ix, p. 93.
— FLEXICOSTATA, *Griffith*, 1860. Ibid., p. 94.
— INÆQUICOSTATA, *Griffith*, 1860. Ibid., p. 94.
— FLABELLIFORMIS, *Eichwald*, 1860. Lethæa Rossica, vol. i, p. 985, pl. xxxviii, fig. 23.
— — *Wardle*, 1863. Sleigh's Ancient Hist. Leek, pl. iii, fig. 5.
— — *Young and Armstrong*, 1871. Trans. Geol. Soc. Glasgow, vol. iii, suppl. p. 47.
— — *Armstrong, Young, and Robertson*, 1876. Cat. West. Scott. Foss., p. 52.
— FLEXICOSTA, *Armstrong, Young, and Robertson*, 1876. Ibid., p. 52.
— SPATULA, *Roemer*, 1876. Lethæa Palæoz. Atlas, taf. xliv, fig. 10.
— FLABELLIFORMIS, *Bigsby*, 1878. Thesaurus Devonico-Carboniferus, p. 293.
— FLEXICOSTATA, *Bigsby*, 1878. Ibid., p. 293.
— FLABELLIFORMIS, *de Koninck*, 1885. Ann. Mus. Roy. Hist. Nat. Belg., tom. xi, p. 164, pl. xxvii, figs, 1, 2.
— — *Etheridge*, 1888. Brit. Foss., pt. i, Palæozoic, p. 275.
— COSTATA, *Etheridge*, 1888. Ibid., p. 275.
— FLEXICOSTATA, *Etheridge*, 1888. Ibid., p. 275.
— INÆQUICOSTATA, *Etheridge*, 1888. Ibid., p. 275.

Specific Characters.—Shell large, transverse, elongate, triangular, compressed. The anterior end is obsolete, the inferior and superior borders almost meeting in front. The inferior margin descends downwards and backwards, and is almost straight; the posterior margin is almost truncate, slightly convex. The hinge-line is long and straight. The umbones small, terminal and pointed, almost obsolete. The valve is convex from above downwards, especially in front, but as the shell expands posteriorly the convexity diminishes.

Interior.—Casts of the interior show an elongate groove just below the superior margin for the internal ligament, and a well-marked groove just within the lower border for its anterior third. The adductor scar is large and round, placed far back on the dorsal slope. The internal surface above and below is smooth, but in the median portion of the valve is marked by radiating, rounded folds and sulci.

Exterior.—The surface is ornamented with radiating or subparallel ribs and sulci, often exhibiting, some little distance from the anterior end, some slight degree of sinuosity or interruption. These ridges are crossed by obscure lines of growth, which are concentric with the posterior border.

Dimensions.—Specimens may grow to an immense size. De Koninck figures a specimen which measures—

Antero-posteriorly	350 mm.
Dorso-ventrally	120 mm.
Thickness	40 mm.

Localities.—England: the Carboniferous Limestone of Narrowdale, Staffordshire; Castleton, Derbyshire; Cracoe and Thorpe, Yorkshire; Poolvash, Isle of Man. Shale above Great Scar and Middle Limestones, Wensleydale. Shale above Underset Limestone, Swaledale; Lowick, and Ironstone series of Redesdale, Northumberland. Scotland: the Upper Limestone series of Newfield, Arden, Bishopriggs; the Lower Limestone series of Beith and Hind og Glen; the McDonald Limestone, Muirkirk, Lugton Water, Waterland; Burn Anne; the Lower Limestone series of Fife; north of Laggan, Arran, twenty feet above the Hurlet Limestone; Upper Limestone series, Corrieshore; Maol-Doun, in shale below the Hurlet, Bute; Scolieburn, Edinburgh. Ireland: Carnteel and Benburb, co. Tyrone; Bunnowa, Easky, co. Sligo.

Observations.—Following de Koninck, I consider that the four species *P. flabelliformis*, Martin, *P. costata*, Phillips, *P. inæquicostata* and *P. flexicostata*, M'Coy, are one and the same species; the differences considered by these authors to be of specific value being mere irregularities in the surface ornament, often due to growth. *P. flexicostata*, M'Coy, is founded on a series of internal casts from Lowick, Pl. II, figs. 1, 6. These specimens are in the Woodwardian Museum, Cambridge, and are casts of the right and left valves.

Pl. II, fig. 2, is the type of M'Coy's *P. inæquicostata* (*op. supra cit.*), and consists of a section from the middle of the valve, also a cast. The specimen is in the Griffith Collection of the Museum of Science and Art, Dublin, and I am grateful to the authorities for permission to refigure the various types.

I have only been able to figure small and incomplete examples. The shell grows to a considerable size, as is shown by the very fine specimen figured by de Koninck (*op. supra cit.*, pl. xxvii, figs. 1 and 2). The author points out that the apical angle of all the various shells now referred to *P. flabelliformis* is practically identical, and that in consequence of the youth and preservation of the specimens, modifications of the ornament, due to age, have not been appreciated by previous observers; but even de Koninck did not recognise the fact that all the figured examples of *P. flexicostata* were casts of the interior.

The type of *P. inæquicostata*, Portlock, is refigured Pl. IV, fig. 1.

PINNA MUTICA, *M'Coy*, 1844. Plate I, figs. 1—6.

PINNA MUTICA, *M'Coy*, 1844. Synops. Carb. Foss. Ireland, p. 86, pl. xix, fig. 11.
— IVANISKIANA, *de Verneuil*, 1845. Géol. Russie d'Europe, vol. ii, p. 319, pl. xx, fig. 12.
— SPATULA, *M'Coy*, 1853. Ann. Mag. Nat. Hist., 2nd ser., vol. xii, p. 188.
— — *Morris*, 1854. Cat. Brit. Foss., 2nd edit., p. 180.
— — — 1855. Brit. Pal. Foss., p. 499, pl. iii E, figs. 9, 10.
Cf. — SUBSPATULATA, *Worthen*, 1875. Geol. Surv. Illinois, vol. vi, p. 524, pl. xxx, fig. 4.
— SPATULA, *Armstrong, Young, and Robertson*, 1876. Cat. West. Scott. Foss., p. 52.
— — *Bigsby*, 1878. Thesaurus Devonico-Carboniferus, p. 293.
AVICULOPINNA SPATULA, *de Koninck*, 1885. Ann. Mus. Roy. Hist. Nat. Belg., tom. xi, p. 167, pl. xxvii, figs. 7—9.
— D'ORBIGNYI, *de Koninck*, 1885. Ibid., p. 167, pl. xxvii, figs. 3, 4.
PINNA SPATULA, *Etheridge*, 1888. Brit. Foss., pt. 1, Palæozoic, p. 275.
— MUTICA, *Etheridge*, 1888. Ibid., p. 275.
AVICULOPINNA SPATULA, *Tornquist*, 1896. Fossilführ. Untercarb. Südvogesen, Abh. geol. Specialkarte Elsass-Lothr., Band v, Heft 5, p. 63, pl. xvii, fig. 13.

Specific Characters.—Shell transversely produced, triangularly elongate, only very slightly convex except near the anterior end. The anterior end is obsolete, and the shell terminates in this direction in a blunt point. The posterior border passes downwards and backwards, and is straight except posteriorly, where it curves bluntly upwards to join the posterior margin. It is truncate, bluntly rounded. The hinge-line is straight and long. The umbones appear to be obsolete and terminal. The convexity of the valve becomes less and less as the expanded posterior end is approached.

Interior.—The adductor muscle is large, shallow, oval, placed on the dorsal slope, remote from the posterior end, and a little below the hinge-line. There is a long groove parallel to and below the superior border for the internal ligament, and another broader groove just within the lower border for the anterior third of the valve. The hinge-line is thin and edentulous. Interior of shell smooth.

Exterior.—The surface is almost smooth, with very faint, broad, laminar lines of growth, parallel to the margins.

Dimensions.—Pl. I, fig. 1, one of the types of M'Coy's *Pinna spatula*, measures at least 150 mm. antero-posteriorly, and 40 mm. dorso-ventrally, at the posterior end.

Localities.—England: the Carboniferous Limestone of Castleton and Park Hill, Derbyshire; Hill Bolton, and beds above the Underset Limestone, Lunds Gill, Yorkshire; beds above the Underset Limestone, Farcote Gill, Swarth Fell, Westmoreland; Carboniferous Limestone, Poolvash, Isle of Man; Lowick and Redesdale Ironstone, Redesdale, Northumberland. Scotland: Glencartholm, Eskdale, Dumfriesshire; Lower Limestone series of Craigenglen, Auchenskeith; Lugton Water, Waterland; Gateside, Beith; Salton. Ireland: Arenaceous Limestone, Kilbride, Ballycastle, co. Mayo.

Observations.—The type, Pl. I, fig. 3, of M'Coy's *Pinna mutica* is preserved in the Griffith Collection, Science and Art Museum, Dublin. It is very imperfect and small, but there is no doubt that it is the same species as the shells described later as *P. spatula* by the same author (*op. supra cit.*). Pl. I, fig. 1, is the type of *P. spatula*, and is preserved in the Woodwardian Museum, Cambridge. This specimen is much crushed and imperfect in front. It would appear, judging from this specimen, that in a very elongate example the slope of the inferior border is much decreased towards the posterior end of the shell, and Pl. I, fig. 6, bears out this fact. The latter specimen is crushed, but shows that the shell had a moderately thick periostracum.

De Koninck describes three species of smooth Pinniform shells, which differ from each other only in size, convexity, and the angle formed by the upper and lower margins. It is a question whether these differences are of specific value, and are not merely due to growth. The three species are stated to be more or less rare, and to occur in the limestone of Visé. It is, however, true that a certain amount of variability in convexity and angularity is seen to occur, if a large number of specimens from any British locality be examined. None of our specimens give any indication of the peculiar umbones figured by de Koninck, which are considered by him to be so important that the group of shells is placed in the genus *Aviculopinna* of Meek, and Pl. I, fig. 6, which is perfect in front, would lead one to infer that the umbones figured by de Koninck do not exist. I have carefully examined many specimens with a view of ascertaining this point, but have been unable to obtain any evidence that the umbones were not terminal. I therefore for the present retain the species in the genus *Pinna*.

Pinna subspatulata, Worthen (*op. supra cit.*), probably belongs to M'Coy's species.

Family AVICULIDÆ.

Genus PTERONITES, *M'Coy* (pars), 1844.

PTERONITES, *M'Coy* (pars), 1844. Synops. Carb. Foss. Ireland, p. 81.
Non — *M'Coy*, 1852. Brit. Pal. Foss., p. 391.
AVICULOPINNA, *Meek*, 1867. Amer. J. Sci. and Arts, vol. xliv, p. 282.
— — 1872. Rep. U.S. Geol. Surv. Nebraska, p. 197.

Generic Characters.—Shell compressed, somewhat oblique, subtriangularly transverse, very inequilateral. Anterior end very small, sharp, and pointed; inferior border becoming more and more convex as it passes downwards and backwards; posterior border sinuous. Hinge-line the longest part of the valve, straight; umbones small, placed anteriorly but not terminal; valves obliquely swollen from the umbo towards the postero-inferior angle; posterior slope compressed, expanded, and subalate.

Interior unknown.

Exterior surface ornamented with concentric lines and folds, more apparent posteriorly and over the swollen part of the valve.

Observations.—The genus *Pteronites*, M'Coy, contains shells of two very distinct types, those with concentric and those with radiating ribs and striæ. The first species described by M'Coy under the generic heading *Pteronites* is *P. angustatus*, and this must therefore be regarded as the generic type; and *P. latus*, M'Coy, doubtless belongs to the same genus. The shells with radiating striæ, *P. sulcatus*, *P. persulcatus*, differ not only in ornament but in shape, being much more quadrate, having the posterior border less emarginate, the hinge-line comparatively much shorter, the dorsal slope much more compressed, and the anterior end smaller but more gibbose; the umbones were nearly terminal.

These characters are present in the *Actinopteria*, Hall, a genus well represented in the Devonian rocks of New York State, and I now refer these species to this genus. The genus *Pteronites* was adopted by Hall in this restricted sense, and he gives the following diagnosis:—"*Pteronites*, M'Coy. This genus is restricted to those species possessing the characters of the original types. Body very oblique; hinge-line longer than the body of the shell; wing and hinge extended posteriorly. Test marked by concentric striæ."

I have little or no hesitation in considering *Aviculopinna* of Meek as a synonym of *Pteronites*. He founded this genus for Pinniform shells with non-terminal umbones and a sinuous posterior border, both of which characters are well shown in his type *A. americana*. I am uncertain as to the correctness of de Koninck's reference of *Pinna spatula*, M'Coy, and other allied shells, to *Aviculopinna*. I have not yet been able to recognise in British specimens the characteristic features on which de Koninck relies for his change of genus.

Pteronites would therefore form a link between *Pinna* and *Leiopteria*, possessing a more Pinniform outline, but approaching the latter genus in the sulcation of the posterior border and long extended hinge-line.

PTERONITES ANGUSTATUS, *M'Coy*, 1844. Plate V, figs. 1—5.

PTERONITES ANGUSTATUS, *M'Coy*, 1844. Synops. Carb. Foss. Ireland, p. 81, pl. xiii, fig. 6.
— — *Morris*, 1854. Cat. Brit. Foss., 2nd edit., p. 181.
— — *Bigsby*, 1878. Thesaurus Devonico-Carboniferus, p. 295.
— NAVIFORMIS, *de Koninck*, 1885. Ann. Mus. Roy. Hist. Nat. Belg., tom. xi, p. 187, pl. xxx, fig. 26.
— SUBVENTRICOSUS, *de Koninck*, 1885. Ibid., p. 186, pl. xxx, fig. 25.
— ANGUSTATUS, *Etheridge*, 1888. Brit. Foss., pt. 1, Palæozoic, p. 276.

Specific Characters.—Shell small, very inequilateral, almost arciform, pointed behind and compressed in front. Anterior end very small but distinct, blunt. The lower border sweeps round from the antero-superior angle to the postero-superior angle without a break; but the anterior half is a segment of a greater circle than the posterior portion, and therefore appears flatter. The hinge-line is straight, the greatest antero-posterior diameter of the valve. The umbones are small, gibbose, slightly raised above the hinge-line, and placed very far forward but not quite terminal. The anterior part of the valve is obliquely swollen, but posteriorly the valves are much compressed and expanded; the posterior wing is not marked off from the rest of the valve. The hinge edge is rolled and thickened, marked off from the valve by an elongate narrow groove.

Exterior.—The surface is ornamented with regular equidistant ridges parallel to the margin, most marked over the oblique gibbosity, becoming almost obsolete in front and behind. These ridges are separated by smooth flattened spaces. Shell thin.

Dimensions.—Pl. V, fig. 1, a compressed specimen from Lawston Linns, Liddle Water, measures—

Antero-posteriorly	35 mm.
Dorso-ventrally	14 mm.

Localities.—England: the Carbonaceous series of Lewisburn, Northumberland; above the masses of Limestone on Calcareous Shale, Whitewell, Yorkshire; beds above the Underset Limestone, Goodham Gill, Swarth Fell. Scotland: Larriston Burn, Archerbeck Burn, four miles north-west of Canonbie; river Esk, north of Glencartholm, Dumfriesshire. Ireland: Arenaceous Shale, Bruckless, Dunkineely, co. Donegal.

Observations.—The specimen, Pl. V, fig. 5, of *Pteronites angustatus* in the Griffith Collection, Museum of Science and Art, Dublin, can, I think, hardly be the type specimen. The figure given by M'Coy is so good that it seems to me possible that some better example must have been used. The example in the Griffith Collection is a left valve, and M'Coy's figure appears as a right valve, but it must be remembered that M'Coy never reversed his figures on the stone, so that the opposite valve is always represented.

The posterior edge of this shell was remarkably thin, and often only the strong rolled hinge remains, so that the shell appears to have a long linear process posteriorly, which is not the case in perfect specimens.

P. angustatus is much smaller, more compressed, and less triangular than *P. latus*. It is not a common shell, and is always found in shaly beds, pointing to its mud-haunting habits. This species is found at a much lower horizon in Scotland than in England, but it is too rare a shell to construct a curve showing the successive periods at which it reached definite localities on its way south, as can be done in the case of various other Lamellibranchs (*vide* 'Quart. Journ. Geol. Soc.,' vol. lvii, p. 380). I have little hesitation in referring *Pteronites naviformis* and *P. subventricosus*, de Koninck, to this species.

PTERONITES LATUS, *M'Coy*, 1844. Plate V, figs. 6 and 7.

PTERONITES LATUS, *M'Coy*, 1844. Synops. Carb. Foss. Ireland, p. 81, pl. xiii, fig. 7.
— — *Morris*, 1854. Cat. Brit. Foss., 2nd edit., p. 181.
— — *Bigsby*, 1878. Thesaur. Devonico-Carboniferus, p. 295.
— — *Etheridge*, 1888. Brit. Foss., pt. 1, Palæozoic, p. 276.

Specific Characters.—Shell below medium size, compressed, transversely triangular. The anterior end is obsolete, and the front part of the valve is somewhat turned, the lower margin adpressed to form the cavity of the valve. The inferior border is slightly concave at first, then descends downwards and backwards, where it becomes convex and broadly curved, passing round into the posterior margin with a single sweep. The posterior margin is truncate, very slightly sinuous above the postero-superior angle, a right angle. The hinge-line is long and straight; the umbones are small, pointed, and terminal (subterminal in cast of the interior). The anterior part of the valve is narrow and convex, the posterior flattened and expanded. The posterior wing is relatively large, triangular, compressed, marked off from the rest of the valve by a straight shallow sulcus, which passes obliquely downwards and backwards from the umbo to the posterior border.

The hinge is edentulous, with two longitudinal grooves posteriorly.

Exterior.—The surface is almost smooth, ornamented with obscure flattened ribs and very shallow sulci, which are parallel to the margins.

Dimensions.—Pl. V, fig. 6, M'Coy's type specimen, measures—

Antero-posteriorly	36 mm.
Dorso-ventrally	19 mm.
From side to side (estimated) . . .	4 mm.

Localities.—England: the Carboniferous Limestone of Grassington, Yorkshire; Park Hill and Thorpe Cloud, Derbyshire. Ireland: the Carboniferous Limestone of Millicent, Clane, co. Kildare.

Observations.—Unfortunately few specimens of this shell have come to my notice. The original of Pl. V, fig. 5, is not perfect, and Pl. V, fig. 7, a specimen from Grassington, Yorkshire, in the museum of the Geological Survey, Jermyn Street, is imperfect posteriorly. The species has some resemblance to *Aviculopinna membranacea*, de Kon., but the peculiar curvature of the lines of growth posteriorly is not present in this latter species.

P. latus is much more regularly triangular and deeper from above downwards than *P. angustatus*. The lines of growth are much less distinctly marked. A single imperfect example has been obtained by me from Thorpe Cloud, and one from Park Hill, Derbyshire.

Genus LEIOPTERIA, *Hall*, 1884.

LEIOPTERIA, *Hall*, 1884. Pal. N. York, vol. v, pt. 1, p. xiii.
? LEPTODESMA, *Hall*, 1884. Ibid., p. xiii.

Generic Characters.—Very inequilateral. Shell triangularly oblique, more or less gibbose. Anterior superior angle right. Anterior end short, compressed, marked off from the tumid portion of the valve by the byssal sulcus; the posterior inferior part of the valve is flattened and rounded; the posterior margin concave; the hinge-line straight and more or less prolonged backward beyond the posterior margin as a thin, narrow rostrum. The dorsal slope is flattened, compressed, and expanded into a posterior wing.

Interior.—The anterior adductor muscle is small, round, deep, placed well within the concavity of the valve, remote from the margin. The posterior adductor larger, shallow, placed in the hollow of the dorsal slope, remote from the margin and hinge-line. Pallial line well marked, remote from the margin. Hinge with oblique teeth in front and parallel grooves posteriorly. Umbones small, anterior, but never terminal.

Exterior.—Surface marked with lines of growth and striæ, at times laminose, at others squamose. Shell thin.

Observations.—Phillips ('Geol. Yorks.,' pt. ii, 1836, p. 211) described three species of shells under the generic name *Gervillia*—*G. laminosa*, *G. lunulata*, and *G. squamosa;* and they possess a very marked external resemblance to this genus, but have not the series of perpendicular fossettes for the ligament in the cardinal area. On the other hand, they have a well-marked prolongation of the hinge-line to form a rostrum. A fourth species was referred to this genus, *G. inconspicua*, which was imperfect, and the type has unfortunately disappeared, so that it is impossible now to hazard a guess as to the identity of this specimen, but it has seemed to me that it might belong to *Sanguinolites striatolamellosus*.

De Koninck ('Descr. Anim. Foss. Belg.,' 1843, p. 129) and others referred Phillips's three species to *Avicula*, with which genus they have even a greater resemblance; but the hinge-plate is markedly different, for there seems to be no long lateral tooth, but a striated hinge-plate. *Bakewellia*, King, has a closely allied form, but has, according to that author, several cartilage pits in the hinge area, like *Perna* and *Gervillia*.

Pterinea, Goldfuss, also has certain characters in common, but the hinge-plate with two diverging lateral teeth and the thick shell are not present in *Leiopteria*.

Hall described two genera, *Leiopteria* and *Leptodesma*, which are very closely allied, if not the same genus. According to this author, "*Leptodesma*, in its prevailing forms, is similar to *Leiopteria*, except that the anterior end is always nasute and acute, instead of auriculate and rounded." In shape the British Carboniferous shells are certainly more nearly like the figured species of *Leptodesma* than *Leiopteria*, and have the elongate process posteriorly common to *Avicula* and the *former* genus. It seems doubtful to me if both generic names are necessary. It is interesting to note the very small differences between *Leiopteria* and recent forms of *Avicula*. Externally and in general shape the genera resemble each other very closely; the general plan of the hinge is the same, but the posterior lateral tooth is stronger, shorter, and more oblique in *Avicula*, and the cardinal teeth seem to be smaller and placed further forwards in *Leiopteria*. Indeed, had I not consulted one of the most eminent living conchologists on the point, I should have considered the differences of hinge character as of specific value only.

De Koninck has described twenty-one species of *Leiopteria* from the Carboniferous rocks of Belgium, of which eighteen are said to be new. A study of the figured specimens will show that many of these are young or immature forms of other species.

LEIOPTERIA LUNULATA, *Phillips*, sp., 1836. Plate II, figs. 7—11; Plate III, figs. 2, 3; Plate IV, figs. 4, 5, 8.

GERVILLIA LUNULATA, *Phillips*, 1836. Geol. Yorks., pt. ii, p. 211, pl. vi, fig. 12.
AVICULA LUNULATA, *de Koninck*, 1843. Descr. Anim. Foss. Belgique, p. 129, pl. iii, figs. 21 *a*, *b*.
— — *Morris*, 1843. Cat. Brit. Foss., 1st edit., p. 106.
— — *M'Coy*, 1844. Synops. Carb. Foss. Ireland, p. 84.
— LÆVIGATA, *M'Coy*, 1844. Ibid., p. 84, pl. xiii, fig. 23.
— INFORMIS, *M'Coy*, 1844. Ibid., p. 83, pl. xiii, fig. 21.
— RECTA, *M'Coy*, 1844. Ibid., p. 84, pl. xiii, fig. 24.
— ANGUSTA, *M'Coy*, 1844. Ibid., p. 83, pl. xiii, fig. 20.
— LUNULATA, *Brown*, 1849. Illust. Foss. Conch., p. 163, pl. lxvii, fig. 17.
— — *d'Orbigny*, 1850. Prodrome Paléont., vol. i, p. 137.
— — *Morris*, 1854. Cat. Brit. Foss., 2nd edit., p. 162.
— RECTA, *Morris*, 1854. Ibid., p. 162.
PTERINEA LUNULATA, *M'Coy*, 1855. Brit. Pal. Foss., p. 480.
— LÆVIGATA, *M'Coy*, 1855. Ibid., p. 479.
AVICULA LUNULATA, *Eichwald*, 1860. Lethæa Rossica, vol. i, p. 956, pl. xxxvii, fig. 16.
— — *Bigsby*, 1878. Thesaurus Devonico-Carboniferus, p. 287.
LEIOPTERIA LUNULATA, *de Koninck*, 1885. Ann. Mus. Roy. d'Hist. Nat. Belg., tom. xi, p. 188, pl. xxx, fig. 4.
AVICULA LUNULATA, *Etheridge*, 1888. Brit. Foss., pt. i, Palæozoic, p. 270.
— INFORMIS, *Etheridge*, 1888. Ibid., p. 270.
— LÆVIGATA, *Etheridge*, 1888. Ibid., p. 270.
— RECTA, *Etheridge*, 1888. Ibid., p. 271.
— ANGUSTA, *Etheridge*, 1888. Ibid., p. 270.

Specific Characters. — Shell inequilateral, obliquely lunulate, compressed. Anterior wing short, narrow, compressed, almost pointed. The anterior border is oblique, somewhat sinuous, and descends downwards and backwards. The lower border is broader and convex, passing up behind to meet the posterior margin, which is falciform and concave. The hinge-line is long and straight, produced backwards in a short, narrow process, which does not extend as far posteriorly as the posterior inferior angle. The umbones are small, raised slightly above the hinge-line, very little swollen, and placed far forwards, but not terminal.

The body of the shell is obliquely and somewhat lunulately swollen, flattened and expanded downwards near the posterior inferior angle. This convexity is gradual in front, but posteriorly it is marked off from the depressed and flattened posterior wing by a well-marked lunate convex ruga, which passes from the umbo to the postero-inferior angle.

Interior.—A large muscle-scar, subcentral. Hinge with small, oblique anterior teeth and elongated posterior lateral teeth. Pallial line entire.

Exterior.—The surface is ornamented with fine, close, concentric striæ and lines of growth, which follow the line of the posterior margin on the posterior ear, and terminate in the hinge-line.

Dimensions.—Pl. II, fig. 7, the type of Phillips's *Gervillia lunulata*, measures—

Antero-posteriorly	45 mm.
Dorso-ventrally	24 mm.
From side to side (estimated) . . .	10 mm.

Localities.—England: the Carboniferous Limestone of Castleton, Park Hill, Thorpe Cloud, Derbyshire; Settle, Hill Bolton, Cracoe, and Withgill, Yorkshire; Clitheroe, Lancashire; Poolvash, Isle of Man; the Underset Limestone, Farcote Gill and Goodham Gill, Swarth Fell. Scotland: the Upper Limestone series of Howrat, Dalry; Hurlet series, Maol Doun, Bute; Knockhill Quarry, Strathkiness, Fife. Ireland: the Carboniferous Limestone series of Millicent, Clane, co. Kildare; Doohyle, co. Limerick; Ballybriggan, co. Kerry; and Park Adelear, co. Cork.

Observations.—Fortunately the type of Phillips's *Gervillia lunulata* is preserved in the Gilbertson Collection, Natural History Museum, South Kensington, and I am permitted to refigure it by the kindness of the authorities, Pl. II, fig. 7. The specimen is a little imperfect in front, but otherwise is very well preserved.

I think *Avicula recta*, M'Coy, refigured Pl. II, fig. 8, and *A. lævigata*, Pl. II, fig. 11, represent the very young and adult forms of Phillips's species. The specimens are in the Griffith Collection of the Museum of Science and Art, Dublin, and the authorities have kindly permitted me to reproduce the specimens. The important characters which distinguish *L. lunulata* from other species of the genus are the peculiar shape, and the narrowed, almost pointed postero-inferior angle, the strongly marked-off posterior wing, and the acutely rounded, curved edge to the posterior slope.

L. hirundo, de Koninck, is more triangular and transverse, less oblique, and has a much longer process to the hinge-line posteriorly. It will be noted in *L. lunulata* that this process does not extend very far beyond the margin of the shell.

L. lunulata was well and fully described by M'Coy (*op. supra cit.*) under the generic name *Pterinea*. In remarks on the species *P. lævigata* he says, "This fine shell bears some resemblance to *Gervillia lunulata* of Phillips, but is easily distinguished by its greater size, wider posterior end, smooth surface, and the total absence of the steep posterior ridge, which in that species separates the posterior ear from the body of the shell." In the original specimen, Pl. II, fig. 11, this ridge is seen to be present and well marked. It is possible, therefore, that the types which served for the second description, said to come from Derbyshire, may have belonged to *L. grandis*, Pl. III, figs. 12—15. The smoothness of the surface depends largely on the preservation of the fossil and the wideness of the posterior end naturally, or the size or stage of growth. The writer of the notes on *L. M'Coyi* in de Koninck's great work also thinks that M'Coy confounded two different species under the title *P. lævigata*, and refers the shell described last to *L. M'Coyi;* but I am not prepared to say that the specimens figured by de Koninck as *L. M'Coyi* and *L. lunulata* are distinct.

Avicula angusta, M'Coy, Pl. IV, fig. 4, is a crushed and flattened specimen, which from its shape must, I think, belong to *L. lunulata*. *A. informis* is doubtless a portion of the cast of the interior of a left valve of the same species. It is to be noted that M'Coy's figure is very different indeed from that of the shell which is labelled as the type.

LEIOPTERIA HIRUNDO, *de Koninck*, 1885. Plate III, fig. 1.

LEIOPTERIA HIRUNDO, *de Koninck*, 1885. Ann. Mus. Roy. Hist. Nat. Belg., tom. xi, p. 188, pl. xxx, figs. 1 and 2.

Specific Characters.—Shell of medium size, obliquely convex, aviculoid. The anterior end is well marked, triangular, compressed, separated from the rest of the valve by a well-marked byssal groove. The antero-superior angle is a right angle, the anterior border small and bluntly pointed. The inferior border descends downwards and backwards in an almost straight line, but behind is bluntly rounded upwards to join the posterior margin, which is markedly falciform. The hinge-line is elongate and straight, produced backwards by a rolled rostrum. The umbones are tumid and small, only slightly raised and placed far forwards, about one-fifth the length of the hinge-line from the anterior end. The body of the valve is obliquely tumid, but the swelling rapidly diminishes in amount as the valve expands downwards and backwards. The posterior wing is compressed, triangular, marked off from the tumid portion of the valve by a straight, oblique, shallow sulcus, below which the gibbosity of the valve rises gradually.

Interior.—Apparently normal.

Exterior.—The surface is ornamented with numerous very regular, fine striæ and lines of growth, which are parallel to the contour of the margins. Shell very thin.

Dimensions.—Pl. III, fig. 1, a specimen from the Carboniferous Limestone of Castleton, measures—

Antero-posteriorly	40 mm.
Dorso-ventrally	23 mm.
From side to side (estimated) . . .	16 mm.

Localities.—The Carboniferous Limestone of Castleton, Derbyshire; Hill Bolton, Yorkshire.

Observations.—Speaking of *L. hirundo*, de Koninck states, "This species has the ventral border less arched than *L. lunulata*; it is not so high, and the posterior wing is more elongate." To these differences I would add that the line of separation of the wing and convex portion of the valve is straight and not arched, and the compression is more gradual, and does not extend so far backwards. The rostrum is much longer and stronger, and the anterior end comparatively longer and more pointed. The whole valve is more regularly triangular and less lunate.

On the other hand, the valve is less triangular, less compressed, and has a better marked-off and developed posterior wing than *L. Thompsoni*.

The species does not seem to be common, and at present I have only met with it at Castleton and Hill Bolton. De Koninck states that the species is very rare, and comes from the Carboniferous Limestone of Visé.

Leiopteria laminosa, *Phillips*, sp., 1836. Plate III, figs. 4—9; Plate IV, fig. 6.

Gervillia laminosa, *Phillips*, 1836. Geol. Yorks., pt. ii, p. 212, pl. vi, fig. 10.
— *Morris*, 1843. Cat. Brit. Foss., 1st edit., p. 108.
Avicula laminosa, *M'Coy*, 1844. Synops. Carb. Foss. Ireland, p. 84.
Gervillia laminosa, *Bronn*, 1848. Nomencl. Palæontol., p. 529.
— — *Brown*, 1849. Illust. Foss. Conch., p. 165, pl. lxvii, fig. 10.
Avicula laminosa, *d'Orbigny*, 1850. Prodrome Paléont., vol. i, p. 137.
— — *Morris*, 1854. Cat. Brit. Foss., 2nd edit., p. 162.
Gervillia laminosa, *R. Griffith*, 1862. J. Geol. Soc. Dublin, vol. ix, p. 93.
Non — — *Wardle*, 1863. Sleigh's Ancient Hist. Leek, pl. iii, fig. 4.
Avicula laminosa, *Bigsby*, 1877. Thesaurus Devonico-Carboniferus, p. 287.
Leiopteria laminosa, *de Koninck*, 1885. Ann. Mus. Roy. d'Hist. Nat. Belg., tom. xi, p. 190, pl. xxx, fig. 6.
— rostrata, *de Koninck*, 1885. Ibid., p. 192, pl. xxx, fig. 14.
Avicula laminosa, *Etheridge*, 1888. Brit. Foss., pt. 1, Palæozoic, p. 270.
— (Leiopteria) laminosa, *Tornquist*, 1896. Fossilführ. Untercarbon. Südvogesen, Abh. geol. Specialkarte Elsass.-Lothr., Band v, Heft 5, p. 15, pl. xvii, figs. 5, 6.

Specific Characters.—Shell of only medium size, obliquely gibbose, very inequilateral, irregularly subquadrate. The anterior end is very short, compressed, almost triangular in shape, blunt. The anterior border descends downwards and backwards; the inferior border is roundly curved, and the posterior concave. The hinge-line is straight, its upper border prolonged backwards and rolled, forming an elongated narrow process. The umbones are obtuse, hardly raised above the hinge-line, and placed far forwards, not terminal. The body of the shell is triangularly and obliquely gibbose, the gibbosity rising gradually both in front and behind, marked off posteriorly from the wing by an almost obsolete linear oblique depression. The postero-inferior part of the valve is broad and expanded. The posterior wing is triangular, with a falciform margin, compressed and expanded, and seems to extend further back than the postero-inferior angle. Byssal sulcus well marked.

Interior.—There is an excavated circular pit for the anterior adductor muscle. The pallial line is entire.

Exterior.—The surface is ornamented with concentric laminose lines and striæ of growth of irregular character. At times this condition is so much accentuated as to become subimbricating.

Dimensions.—Pl. III, fig. 6, the original of Phillips's species, measures -

Antero-posteriorly	38 mm.
Dorso-ventrally	32 mm.
From side to side (estimated) . . .	16 mm.

Localities.—England: the Carboniferous Limestone of Hill Bolton, Withgill, Scalber, and Settle, Yorkshire; Castleton, Thorpe Cloud, Park Hill, Derbyshire; Poolvash, Isle of Man. Scotland: Corrieburn, Kilsyth. Ireland: Clane, co. Kildare.

Observations.—The type specimen, Pl. III, fig. 6, is preserved in the Gilbertson Collection, Natural History Museum. It is a left valve, not quite perfect in front or at the posterior inferior part. As far as I am able to judge, this specimen represents the fully grown individual. Much less transverse and triangular than *L. Thompsoni*, the absence of any distinct lunate ridge, and the more quadrate form, distinguish the species from *L. lunulata*.

The size and extent of the posterior wing is to be noted. Unfortunately, owing to the extension and thinness of the anterior and posterior extremities, one or other is frequently missing. The type, Pl. III, fig. 6, shows a perfect posterior wing; Pl. III, fig. 7, a perfect anterior end. It is probable that several of de Koninck's species represent imperfect or immature forms of *L. laminosa*. *L. Phillipsii*, *L. gibbosa*, *L. rostrata*, *L. strangulata*, *L. intermedia*, and *L. virgula* seem to me to have much in common with the species. I think that there is good evidence that the shell was more quadrate in the younger stages of growth than when full grown—a fact which will account for some of the supposed species. In some of my specimens the rostrum seems to have been broken off or rubbed down during life. Casts of the interior would not show the peculiar shape of the posterior end, owing to the approximation of the opposing posterior wings; hence another source of error in determination of species. In incomplete specimens it is advisable to determine the shape of the shell by tracing the contour shown by one of the lines of growth, and allowing for the extension of the rostrum.

LEIOPTERIA SQUAMOSA, *Phillips*, sp., 1836. Plate I, figs. 7—10.

GERVILLIA SQUAMOSA, *Phillips*, 1836. Geol. Yorks., pt. ii, p. 212, pl. vi, fig. 9.
— — *Portlock*, 1843. Rep. Geol. Londonderry, p. 438.
— — *Morris*, 1843. Cat. Brit. Foss., 1st edit., p. 108.
AVICULA SQUAMOSA, *M'Coy*, 1844. Synops. Carb. Foss. Ireland, p. 84.
— GIBBOSA, *M'Coy*, 1844. Ibid., p. 83, pl. xiii, fig. 25.
GERVILLIA SQUAMOSA, *Bronn*, 1848. Nomencl. Palæont., p. 529.
— — *Brown*, 1849. Illustr. Foss. Conch., p. 165, pl. lxvii, fig. 18.
AVICULA SQUAMOSA, *Morris*, 1854. Cat. Brit. Foss., 2nd edit., p. 162.
— GIBBOSA, *Morris*, 1854. Ibid., p. 162.
— SQUAMOSA, *Bigsby*, 1878. Thesaurus Devonico-Carboniferus, p. 287.
— — *Etheridge*, 1888. Brit. Foss., pt. i, Palæozoic, p. 271.
— GIBBOSA, *Etheridge*, 1888. Ibid., p. 270.

Specific Characters.—Shell small, obliquely tumid, inequilateral, transversely broadly triangular. The anterior end is short, compressed, the margin rounded; its anterior superior angle a right angle, separated from the body of the valve by a byssal sulcus. The inferior border is broadly rounded, and ascends posteriorly to meet the posterior margin, which is markedly concave. The hinge-line is long and straight, produced backwards as a short rostrum. The umbones are small, tumid, oblique, pointed, placed far forwards, and not raised. The body of the valve is triangularly swollen, expanded and flattened below and behind; the dorsal slope is rapidly compressed and hollowed. Posterior wing narrow, elongate, and triangular.

Interior.—Anterior adductor scar small and round, remote from the anterior border. Posterior adductor scar shallow, larger, rounded, placed in the hollow of the dorsal slope, remote from the margin and hinge-line. Pallial line deep, entire, remote from the margin. Hinge normal.

Surface.—The external surface is adorned with concentric, equidistant lines, which are separated by well-marked grooves, and follow the contour of the valve, even over the posterior wing.

Dimensions.—Pl. I, fig. 7, from Castleton, measures—

Antero-posteriorly	28 mm.
Dorso-ventrally	15 mm.
From side to side	11 mm.

Localities.—England: the Carboniferous Limestone of Bolland (Phillips) and Hill Bolton, Yorkshire; Castleton and Thorpe Cloud, Derbyshire; Poolvash, Isle of Man; shales below the Millstone Grits, Congleton Edge, Cheshire. Ireland: the Carboniferous Limestone of Manor Hamilton, co. Leitrim. Scotland: the

Hurlet Limestone series, Bute; Garple Water, Wellwood, Muirkirk; Thornliebank.

Observations.—The type of Phillips's species is preserved in the Gilbertson Collection of the Natural History Museum, South Kensington, and is refigured, Pl. I, fig. 9, by the kindness of the authorities. It is a characteristic species, easily recognised by its surface ornament and shape, but in some species of *L. lunulata* the ornament, though much closer, approaches that of the species under discussion.

A. gibbosa, M'Coy, Pl. I, fig. 8, the type of which is preserved in the Griffith Collection, Museum of Science and Art, Dublin, is a cast of the interior, but the characteristic surface is preserved on the posterior wing, and therefore this specific name is regarded as a synonym.

L. squamosa was not recognised by de Koninck as occurring in Belgium, and does not appear to be very common in Great Britain.

LEIOPTERIA THOMPSONI, *Portlock*, sp., 1843. Plate III, figs. 10, 11; Plate IV, figs. 2, 3, 7, 12, 13.

PTERINEA THOMPSONI, *Portlock*, 1843. Rep. Geol. Londonderry, p. 431, pl. xxv, fig. 10.
AVICULA THOMPSONI, *M'Coy*, 1844. Synops. Carb. Foss. Ireland, p. 85.
? PTERINEA THOMPSONI, *Morris*, 1854. Cat. Brit. Foss., 2nd edit., p. 181.
GERVILLIA LAMINOSA, *Wardle*, 1863. Sleigh's Ancient Hist. Leek, pl. iii, fig. 4.
LEIOPTERIA TRIGONALIS, *de Koninck*, 1885. Ann. Mus. Roy. d'Hist. Nat. Belg., tom. xi, p. 191, pl. xxx, fig. 11.
— MODIOLARIS, *de Koninck*, 1885. Ibid., p. 193, pl. xxx, fig. 7.
— EMACIATA, *de Koninck*, 1885. Ibid., p. 195, pl. xxx, fig. 21.
PTERINEA THOMPSONI, *Etheridge*, 1888. Brit. Foss., pt. 1, Palæozoic, p. 276.

Specific Characters.—Shell below medium size, compressed, very inequilateral, transversely triangular. The anterior end, comparatively long for the genus, narrow, triangular, compressed, its extremity rounded, well marked off from the body of the valve by the byssal sinus. The inferior margin descends downwards and backwards, becoming well rounded behind, where it curves upwards into the posterior border, which is sinuous, convex below, somewhat concave above. The hinge-line is straight and long, slightly produced posteriorly. The umbones are small and inconspicuous, hardly raised above the hinge-line, and situated anteriorly. The body of the valve is obliquely and triangularly swollen, expanded, and flattened behind and below, not well marked off from the gradually compressed, elongate posterior wing.

Interior.—Anterior adductor muscle-scar small and round, single, remote from the anterior extremity. Hinge-line straight, narrow, with oblique teeth in front and grooved posteriorly. Pallial line remote from border, very slightly marked.

Exterior.—The surface is almost smooth, but under the microscope fine concentric lines and striæ of growth are visible.

Dimensions.—Pl. III, fig. 10, from the Carboniferous Limestone of Hill Bolton, measures—

Antero-posteriorly	40 mm.
Dorso-ventrally (at posterior end) . .	20 mm.
From side to side (estimated) . . .	10 mm.

Localities.—England: the Carboniferous Limestone of Settle and Hill Bolton, Yorkshire, and Lowick, Northumberland. Scotland: Potmetal Plantation, Fife; Upper Limestone series, Thornliebank. Ireland: smooth non-calcareous shale, Fermanagh.

Observations.—Portlock's figured specimen of *Pterinea Thompsoni*, Pl. IV, fig. 12, and two others from the same locality, are preserved in the museum of the Geological Survey, Jermyn Street. They are young specimens and crushed, but the characteristic contour is well preserved. The species seems to be fairly widely distributed, and it is common at Hill or El Bolton, Yorkshire. *Leiopteria Thompsoni* is more regularly and transversely triangular than any other species of the genus, and can in this way be easily recognised. De Koninck has figured and referred to three species, shells which I believe to be nothing more than different stages of growth of Portlock's shell. I have, therefore, regarded these names as synonyms. It will be noted, too, on referring to de Koninck's figures of *L. trigonalis* and *L. modiolaris*, that the former is incomplete in front, and the latter is imperfect behind, and that the contour of the lines of growth in the younger portion of the shell does not warrant the restoration of the outline as depicted. *L. navicula*, another of de Koninck's species, is said to differ from *L. modiolaris* simply in the surface markings, and it seems to me highly probable that it is the right valve of the other species. *L. emaciata* seems to be only a young example of the same species. The anterior end is, though narrow, well marked, and separated from the body of the valve by a constriction.

LEIOPTERIA GRANDIS, sp. nov. Plate III, figs. 12—15.

Specific Characters.—Shell above medium size; compressed, arcuate; very inequilateral; posterior inferior extremity much produced, flattened and expanded; aviculoid.

The anterior end is very small, almost obsolete, marked off from the shell by a byssal groove. The inferior border is very convex and extensive, sweeping round behind to join the posterior margin, which is lunate and also long. The hinge-line is short and straight, only very slightly produced behind the posterior margin. The umbones are very small, narrowed and flattened, not raised, and placed very far forwards, but not terminal. The body of the valve is lunately tumid above, expanded and flattened below and behind. The posterior wing is comparatively small, triangular, and much flattened, only slightly marked off from the convexity of the valve by an ill-defined groove.

Interior.—Unobserved.

Exterior.—The surface is covered with flattened subimbricating lamellæ, lines, and striæ of growth.

Dimensions.—Pl. III, fig. 14, from Castleton, measures—

Antero-posteriorly	118 mm.
Dorso-ventrally	65 mm.
From side to side (estimated) . . .	25 mm.

Localities.—England: the Carboniferous Limestone of Withgill, Yorkshire; Thorpe Cloud and Castleton, Derbyshire.

Observations.—This species is very common at Treycliff, Castleton, and also occurs at Cavedale Quarry. It is difficult to obtain perfect examples, owing to the size and flatness of the shell. Specimens in all stages of growth are to be found, but none have yet been obtained with the valves in contact.

The species is characterised not only by its size and flattened form, but by the smallness of the posterior wing and absence of the rostrum. Pl. III, fig. 14, from Cavedale Quarry, shows the peculiar shape of the adult, but unfortunately is incomplete at the umbo and anterior end. Pl. III, fig. 12, is that of a right valve, incomplete below, but showing the hinge-line and posterior slope. It is at present impossible to state whether the shell was equivalve or no.

Probably this species has been referred to *Pterinea lævigata*, M'Coy, but it does not possess the well-marked oblique ridge, and has a comparatively much smaller flattened posterior ear and no rostrum.

LEIOPTERIA LONGIROSTRIS, sp. nov. Plate IV, figs. 14, 15.

MODIOLA ROSTRATA, *Brown.* MS. nomen nudum. Shell in Manchester Museum, the Owens College.

Specific Characters.—Shell aviculoid, small; obliquely tumid, rhomboidal, with a very long rostrum. The anterior end is almost obsolete, compressed, the antero-superior angle a right angle; its border descends less obliquely than in other species; it is slightly convex; the lower border is convex, curving upwards behind to join the concave posterior margin. The hinge-line is straight, much produced, with a rolled rostrum, which extends far beyond the margin of the shell. The umbones are tumid but small, not raised, placed very far forwards, not terminal. The posterior wing is compressed, triangular, and elongate, gradually compressed from the body of the valve, which is regularly and obliquely swollen, but becomes compressed and expanded below and behind.

Interior.—The hinge-plate appears to be normal; other details not yet observed.

Exterior.—The surface is ornamented with smooth, concentric, somewhat irregular, rounded ribs and folds.

Dimensions.—Pl. IV, fig. 14, from the Black Limestone below Mam Tor, Castleton, measures—

Antero-posteriorly (including length of rostrum) .	23 mm.
Dorso-ventrally	8 mm.
From side to side	7 mm.

Localities.—England: the Pendleside series of Castleton, Derbyshire; Todmorden, (? Horsebridge Clough, Hebden Bridge); Flasby Fell and Pendle Hill, Yorkshire; Congleton Edge, Cheshire.

Observations.—Two specimens in the Manchester Museum, Owens College, labelled Todmorden, have the MS. name *Modiola rostrata*, a *nomen nudum*, and unfortunately de Koninck has adopted this specific name for another shell, so that I am unable to adopt Captain Brown's name.

The specimens have not the characteristic rostrum preserved, but it seems evident from the name that Captain Brown had observed this character. The most perfect specimens, Pl. IV, fig. 14, come from the Black Limestone below Mam Tor, near Castleton, and I have obtained the shell at several other places on the same horizon. *L. longirostris* occurs in the zone of *Posidonomya Becheri* and *Glyphioceras spirale*, *G. reticulatum*, and *G. bilingue*, and as far as I know is confined to that zone. The shell, when detached from the posterior wing, might be mistaken for *Posidoniella minor*, a species which is often found in association with it. The long posterior wing, the tumid body, obsolete anterior end, and ribbed surface are sufficient to define the species from others.

Leiopteria obtusa, *M'Coy*, sp., 1844. Plate V, figs. 15—17.

Lanistes obtusus, *M'Coy*, 1844. Synops. Carb. Foss. Ireland, p. 76, pl. xiii, fig. 9.
Modiola obtusa, *Etheridge*, 1888. Brit. Foss., pt. 1, Palæozoic, p. 285.

Specific Characters.—Shell small, triangularly ovate, gibbose, somewhat oblique and moderately inequilateral. The anterior end is small; the antero-posterior angle pointed and projecting forwards slightly. The border passes downwards and backwards in a curve, which is gradually extended till it passes round to meet the posterior border, which is sinuously curved and emarginate. The hinge-line is long and extended beyond the posterior margin, and straight. The umbones are small, pointed, incurved, and placed a little in front of the middle line. The shell is obliquely swollen from the umbones to the posterior inferior angle. In front of this swelling is a well-marked oblique constriction, which notches the lower border, more conspicuous in the right valve. The posterior slope is compressed, and expanded into a small falciform ear.

Interior.—Casts show the details of the hinge and interior to be normal.

Exterior.—The surface is very beautifully ornamented with several rather close, raised, concentric ridges, carried up over the dorsal slope and ear to the hinge-line; these are decussated by fine radiating lines, giving the shell a reticulated appearance.

Dimensions.—Pl. V, fig. 15, from Cunningham, Baidland, in the collection of Mr. J. Smith, of Kilwinning, measures—

Antero-posteriorly	3 mm.
Dorso-ventrally	2·5 mm.
From side to side	2·5 mm.

Localities.—Scotland: Lower Limestone series of Cunningham, Baidland and Law, Dalry; Potmetal Plantation, Kirkcaldy, Fife. Ireland.

Observations.—I have little hesitation in referring the shells in Mr. Smith's collection and a series in the Museum of the Geological Survey of Scotland to M'Coy's *Lanistes obtusus.* The peculiarly beautiful marking of the shell is too characteristic to mistake, in spite of the fact that I have been unable to find the type specimen. M'Coy's description is very graphic, and accurately describes Mr. Smith's shells.

The shells from Dalry are very perfectly preserved, Pl. V, figs. 16 and 17.

An enlarged view of these specimens is also given, to show the finely ornamented surface. The series from Potmetal Plantation show us casts of the interior, but the characteristic external markings are seen as hollow casts of the exterior.

The specimen in the Griffith Collection, now labelled as *Lanistes obtusus*, has apparently no connection with the figure, and belongs to quite another genus of shells.

LEIOPTERIA DIVISA, *M'Coy*, sp., 1844. Vol. I, Plate XIII, figs. 11—14.

Vide PARALLELODON DIVISUS, *Hind*, 1897. Mon. Brit. Carb. Lamell., vol. i, p. 172, pl. xiii, figs. 11—14.

Observations.—Further research has convinced me that my reference of this shell to *Parallelodon* was a mistake; the reference was made on account of the hinge characters. Further examination shows that the hinge is really not that of the *Parallelodon* type, but belongs to *Leiopteria*, and the shape and ornament of the shell are characteristic of this genus. One peculiarity is present, and that is the narrow oblique trench in the anterior part of the shell, which gives the name to the species, and which takes the place of the oblique compression always present in this situation in other members of the genus. An examination of a number of specimens seems to indicate that this groove is not always so well marked, and specimens occur, which do not appear to have suffered from crushing, in which hardly a trace of the trench can be seen. The object of this groove is not apparent.

Genus ACTINOPTERIA, *Hall*, 1884.

PTERONITES, *M'Coy* (pars), 1844. Synops. Carb. Foss. Ireland, p. 81.
ACTINOPTERIA, *Hall*, 1884. Pal. N. York, vol. v, pt. 1, Lamell., p. xii.

Generic Characters.—Shell more or less oblique, subquadrate. Anterior end very short, posterior end expanded and compressed, with a sinuous outline and a hollowed dorsal slope. Hinge-line straight. Umbones placed very far forwards, subterminal.

Interior.—Hinge-line edentulous (Hall).

Exterior.—The surface is marked with fine, not very conspicuous, concentric lines of growth, and ornamented with well-marked, close, radiating ribs. Shell thin.

Observations.—Hall defines his genus *Actinopteria* as follows:—" Characterised from *Pterinea* in the absence of a broad striated ligamental area, and strong cardinal and lateral teeth. Right valve subconvex; surface with fine rays." Miller ('N. Amer. Geol. and Pal.,' 1889, p. 459) seems to have put a different interpretation on this sentence, for he says *Actinopteria* is "distinguished from *Pterinea* by strong cardinal and lateral teeth, and no striations on the hinge-plate."

I have thought it well to remove the shells with radiating ribs referred by M'Coy to *Pteronites* to Hall's genus, to which they are evidently very closely related.

P. semisulcatus, M'Coy, is evidently a cast of the interior, and hence the peculiar markings and the absence of rays. Unfortunately *P. ventricosus*, M'Coy, is lost, and I am unable to recognise the species in any shells which I have examined.

In 1854 M'Coy re-described his genus *Pteronites*, and referred to it a *P. subradiatus* (Devonian) and *P. persulcatus*, a species founded upon a cast of the interior of a left valve.

When describing a new species in 1873 ('Geol. Mag.,' vol. x, p. 344) Mr. R. Etheridge, jun., sought to demonstrate the specific differences between the ribbed forms referred to *Pteronites* by M'Coy and two new species described by himself, by variations in the radiating ornamentation; but unfortunately he did not recognise that in at least two cases he was comparing the interior of the valve with the exterior. I am only able to accept one of Mr. Etheridge's species, *P. fluctuosus*.

The late Dr. John Young, of the Hunterian Museum, has demonstrated that the shells referred to *Pteronites*, M'Coy, possess a prismatic shell structure, and considers that they have a strong affinity to the Aviculidæ, in which family I have placed the genus *Actinopteria*.

ACTINOPTERIA PERSULCATA, *M'Coy*, sp., 1855. Plate IV, figs. 9—11; Plate V, fig. 14.

? LANISTES RUGOSUS, *M'Coy*, 1844. Synops. Carb. Foss. Ireland, p. 76, pl. x, fig. 8.
PTERONITES PERSULCATUS, *M'Coy*, 1851. Ann. Mag. Nat. Hist., 2nd ser., vol. vii, p. 170.
— — — 1855. Brit. Pal. Foss., p. 480, pl. 3 F, fig. 1.
— REGULARIS, *R. Etheridge, jun.*, 1873. Geol. Mag., vol. x, p. 298, pl. xii, fig. 6.
— PERSULCATUS, *Etheridge*, 1888. Brit. Foss., pt. 1, Palæozoic, p. 276.
— — *Tornquist*, 1896. Fossilführ. Untercarb. Südvogesen, Abh. geol. Specialkarte Elsass-Lothr., Band v, Heft 5, pl. xvii, figs. 1—3.

Specific Characters.—Shell of medium size, very inequilateral, equivalve, subrhomboidally trigonal, triangularly convex. The anterior end is almost obsolete, represented by a narrow compressed fold below the umbones. The lower border, at first concave, descends downwards and a little backwards for a considerable distance, when it becomes broadly curved, and passes round to meet the posterior margin. The posterior margin is obliquely truncate, slightly convex, the postero-superior angle a right angle. The hinge-line is long and straight. The umbones are small, very slightly raised, curved forwards, terminal. The body of the valve is convex and adpressed in front, flattened and expanded posteriorly. The posterior wing is large, triangular, separated from the valve by a broadly concave oblique sulcus. Hinge-plate with linear grooves, edentulous.

Interior.—Umbones of casts not quite anterior. Posterior adductor shallow and obscure, placed below the hinge-line, in the hollow of the dorsal slope, remote from the posterior end.

Exterior.—The surface is covered with coarse, rugged, irregular, flexuous, slightly interrupted, radiating ridges, which are a trifle more regular on the posterior wing. These ridges are crossed by very obscure occasional concentric lines of growth. Shell thin.

Dimensions.—Pl. IV, fig. 9, M'Coy's type specimen, in the Woodwardian Museum, Cambridge, measures—

Antero-posteriorly	28 mm.
Dorso-ventrally	28 mm.
Thickness of valve	5 mm.

A fine specimen, Pl. IV, fig. 10, from Eskerhouse, measures—

Antero-posteriorly	88 mm.
Dorso-ventrally	60 mm.
From side to side	27 mm.

Localities.—England: the Carboniferous Limestone of Hill Bolton, Hollin Gill, Hawes, Eskerhouse, Widdale Beck, Apperset, Yorkshire; Lowick and the Redesdale Limestone, Northumberland; Black and White Limestone of Derbyshire, Park Hill. Pendleside Series, Black Limestone, River Wharf, Burnsall; Dinckley Hall, River Ribble; Ravensclough, Thornley Hall, Holden (Bolland), Lancashire; Sulber Lathe, Flasby Fell, Yorkshire; Ford Village in River Hamps, Staffordshire; 300 feet below third grit, Congleton Edge, Cheshire. Scotland: Lesmahagow; the Upper Limestone series of Linnspout, Newcastle Glen and Corrieburn, Horwood; Lower Limestone series, Burn Anne, Cockmuir Bridge, Raven Crag, Kirkcaldy; High Blantyre, Teasses, Largo; Woolford Pit, Cobinshaw; Bilston Burn, Dryden. First Limestone, Shore at Abden; Esperston Quarry, South, near Borthwick; No. 16 Mine, Addiewell, West Calder; Lennoxburn, Old Quarry, Haddington; Quarry Hebershaw Farm, Penicuick.

Observations.—Pl. IV, fig. 9, is M'Coy's type, from Lowick. It is the cast of a left valve, which accounts for the absence of radiating ribs in the anterior part of the valve. This specimen is not perfect posteriorly, consequently the contour of the posterior end and the comparative dimensions cannot be ascertained. The peculiar radiating ribs are represented inside the valve, but not so finely as outside.

Pl. IV, fig. 10, is a fine bivalve example from the Carboniferous Limestone of Eskerhouse, near Grassington, almost complete, but the valves have slipped slightly over each other. The specimen is in the collection of the Geological Survey, Jermyn Street, and shows the more correct contour of the valve, and also that the umbones are terminal in the testiferous fossil, but subterminal in casts of the interior.

This species is most commonly found in beds of shale, but when it does occur in limestone attains a very large size.

I consider that *P. regularis*, Etheridge, jun., was probably a weathered cast of *A. persulcata.*

P. sulcatus, as figured by M'Coy, is more transversely triangular, and the ribs are finer and straighter, but I believe that this species was founded on the upper fragment of *A. persulcata.*

ACTINOPTERIA FLUCTUOSA, *R. Etheridge, jun.*, sp., 1873. Plate V, figs. 8—12.

PTERONITES FLUCTUOSUS, *R. Etheridge, jun.*, 1873. Geol. Mag., vol. x, p. 345, pl. xii, fig. 1.
— — *R. Etheridge*, 1888. Brit. Foss., pt. 1, Palæozoic, p. 276.

Specific Characters.—Shell small, transversely trigonal, gibbose. The anterior end is very short, almost pointed. The lower border descends downwards and backwards, becoming curved and broadly rounded into the posterior border, which is very slightly convex. The hinge-line is straight. The umbones are small, gibbose, pointed, raised, placed far forwards, but not terminal. The valves are obliquely swollen, but become expanded and compressed posteriorly. The posterior wing is well marked and compressed.

Interior unknown.

Exterior.—The umbonal region is marked by concentric lines of growth, and is more or less smooth, but nearer its margin the concentric lines are decussated by well-marked radiating ribs, which are often flexuous. The anterior portion of each valve is free from radiating ribs. Posterior wing marked by straight, strong, radiating ribs. Shell thin.

Dimensions.—Pl. V, fig. 8, the type of R. Etheridge's species, measures—

Antero-posteriorly	9 mm.
Dorso-ventrally	6 mm.

Localities.—Scotland: Crossbank, Crossford; Clecklimon, Kilbride; Campsie, Craigen Glen; Beith and Waterland, Ayrshire; Raven Crag, Teasses, and First Limestone on shore east of Kinghorn, Fife; West Quarry, Salton.

Observations.—This species was established by R. Etheridge, jun., for some very small shells, which had a peculiar surface ornament. He lays stress on the specific character of the smoothness of the umbonal region, and the freedom from radiating ribs of the anterior end. I would add that the concentric lines of growth are more strongly marked in this species than in others. Pl. V, fig. 9, is a specimen of the left valve, from Beith, in the collection of Mr. J. Smith, of Kilwinning. This is an uncrushed example, and shows the great comparative gibbosity of the valve. Etheridge's type, a right valve, Pl. V, fig. 8, is probably flattened, but it may be that the right valve was flatter than the left.

Two slabs of specimens from Craigen Glen, Campsie, are in the collection of the Geological Survey, Jermyn Street.

Actinopteria sulcata, *M'Coy*, sp., 1844. Plate V, fig. 13.

Pteronites sulcatus, *M'Coy*, 1844. Synops. Carb. Foss. Ireland, p. 82, pl. xiii, fig. 5.
— — *Morris*, 1854. Cat. Brit. Foss., 2nd edit., p. 181.
— — *Bigsby*, 1878. Thesaurus Devonico-Carboniferus, p. 295.
— — *Etheridge*, 1888. Brit. Foss., pt. 1, Palæozoic, p. 277.

Specific Characters.—Shell small, transversely triangular; compressed anterior end; pointed umbones, small; ornamented by several narrow radiating ribs.

Locality.—Manor Hamilton, co. Leitrim, Ireland.

Observations.—Pl. V, fig. 13, is the type of M'Coy's *P. sulcatus*, and I quote the species and figure the type for what it is worth. The shell is very imperfect, and is very probably a portion of a specimen of *A. persulcata*, M'Coy, sp. A specimen, whose similar shape is entirely due to the incompleteness of the shell from Scotland, is figured, Pl. V, fig. 14, and I am quite of opinion that M'Coy founded his first species on an imperfect specimen.

Genus Posidonomya, *Bronn*, 1837.

Posidonia, *Bronn*, 1828. Zeitsch. f. Min., vol. i, p. 262.
Posidonomya, *Bronn*, 1835–7. Leth. Geogn., p. 88.

Generic Description.—Shell of moderate size, ovate, oblique, compressed, with an anterior rounded ear and a compressed expanded posterior ear. Hinge-line straight; umbones small, pointed, placed anterior to the centre of the hinge-line. Shell obliquely but very moderately convex.

Interior.—Unknown.

Exterior.—Surface ornamented with numerous concentric grooves and ridges, occasionally decussated by radiating lines. Periostracum well developed.

Observations.—Bronn originally proposed the name *Posidonia* for this genus, but, finding that this name had been given to a genus of plants, subsequently changed it to *Posidonomya*, the type of the genus being *Posidonomya Becheri*. Portlock referred to this genus a very small shell, which is probably a crustacean. M'Coy described two new species, one of which is retained; the other, *P. costata*, seems to me to be referable to *Posidoniella minor*, Bronn. I, however, refigure the type now preserved in the Museum of Science and Art, Dublin, Pl. VI, fig. 10.

De Koninck separated the shell *Posidoniella vetusta*, which had generally been referred to the genus *Posidonomya*, on very good grounds, which have been noted, p. 86, Vol. I of this monograph.

It is to be regretted that details of the hinge-plate and interior have not yet been noted.

M'Coy in 1844 (and again in 1853, 'Brit. Pal. Foss.,' p. 521), following Deshayes, thought that the genus *Posidonomya* might be the "internal plate of an animal allied to *Aplysia*," and referred the genus to the Gasteropoda. In the later work he gives his reasons for such a view at length. I have, however, not been able to accept this view, and retain the genus in the Lamellibranchiata, the presence of a periostracum and the occasional preservation of both valves affording sufficient evidence of the real affinities of the shell.

POSIDONOMYA BECHERI, *Bronn*, 1837. Plate VI, figs. 11—15.

POSIDONIA BECHERI, *Bronn*, 1828. Zeitsch. für Min., vol. i, p. 262.
POSIDONOMYA BECHERI, *Bronn*, 1835-7. Leth. Geogn., p. 88, taf. 2, fig. 18.
POSIDONIA BECHERI, *Goldfuss*, 1863. Petrefact. German., pt. ii, p. 112, pl. cxiii, fig. 6.
— — *Sowerby, J. de C.*, 1840. Trans. Geol. Soc., 2nd ser., vol. v, pt. 3, pl. lii, figs. 2—4.
— TUBERCULATA, *Sowerby, J. de C.*, 1840. Ibid., pl. lii, fig. 5.
— LATERALIS, *Sowerby, J. de C.*, 1840. Ibid., pl. lii, fig. 1.
— BECHERI, *Phillips*, 1841. Pal. Foss. Cornwall, etc., p. 45, pl. xx, fig. 73.
— TUBERCULATA, *Phillips*, 1841. Ibid., p. 44, pl. xx, fig. 72.
— LATERALIS, *Phillips*, 1841. Ibid., p. 45, pl. xx, fig. 74.
POSIDONOMYA BECHERI, *Morris*, 1843. Cat. Brit. Foss., 1st edit., p. 117.
— LATERALIS, *Morris*, 1843. Ibid., p. 118.

Posidonomya tuberculata, *Morris*, 1843. Cat. Brit. Foss., 1st edit., p. 118.
Posidonia Becheri, *M'Coy*, 1844. Synops. Carb. Foss. Ireland, p. 78.
— lateralis, *M'Coy*, 1844. Ibid., p. 78.
— similis, *M'Coy*, 1844. Ibid., p. 79, pl. xii, fig. 2.
— tuberculata, *M'Coy*, 1844. Ibid., p. 79.
— ? — 1844. Ibid., p. 79, pl. xii, fig. 3.
— Becheri, *Cumming*, 1848. The Isle of Man, App. Q, p. 356.
— lateralis, *Cumming*, 1848. Ibid., p. 356.
— Becheri, *Brown*, 1849. Ill. Foss. Conch., p. 168, pl. lxi**, fig. 35.
— tuberculata, *Brown*, 1849. Ibid., p. 168, pl. lxi**, fig. 34.
— lateralis, *Brown*, 1849. Ibid., p. 168, pl. lxi***, fig. 2.
Posidonomia Becheri, *d'Orbigny*, 1850. Prodrome Paléont., vol. i, p. 138.
Posidonomya Becheri, *Bronn and Roemer*, 1852–4. Lethæa Geogn., p. 400, pt. i, pl. iii, fig. 10 *a*.
— — *Morris*, 1854. Cat. Brit. Foss., 2nd edit., p. 180.
— lateralis, *Morris*, 1854. Ibid., p. 181.
— tuberculata, *Morris*, 1854. Ibid., p. 181.
Posidonia Becheri, *M'Coy*, 1855. Brit. Pal. Foss., p. 521.
— — var. *a* tuberculata, *M'Coy*, 1855. Ibid., p. 522.
— lateralis, *M'Coy*, 1855. Ibid., p. 522.
Posidonomya Becheri, *Woodward*, 1856. Man. Mollusca, p. 417, pl. xvi, fig. 22.
— — *Eichwald*, 1860. Lethæa Rossica, vol. i, p. 942, pl. xxxvii, fig. 14.
— — *Baily*, 1875. Figs. Char. Brit. Foss., p. 114, pl. xxxix, fig. 4.
— — *Roemer*, 1876. Lethæa Palæoz., taf. xxxviii, figs. 2 *a*—*c*.
— — *Bigsby*, 1878. Thesaurus Devonico-Carboniferus, p. 293.
— lateralis, *Bigsby*, 1878. Ibid., p. 293.
— tuberculata, *Bigsby*, 1878. Ibid., p. 293.
— — *von Koenen*, 1879. Neues Jahrbuch Min. Geol. Pal., p. 334, pl. vi, fig. 8.
— — *Fischer*, 1887. Man. de Conchyliologie, p. 959, pl. xvi, fig. 22.
— — *Etheridge*, 1888. Brit. Foss., pt. 1, Palæozoic, p. 276.
— lateralis, *Etheridge*, 1888. Ibid., p. 276.
— similis, *Etheridge*, 1888. Ibid., p. 276.
— tuberculata, *Etheridge*, 1888. Ibid., p. 276.

Specific Characters.—Shell of medium size, expanded and somewhat compressed, obliquely subovate, obliquely pectiniform. The anterior border is well rounded, and forms a blunted angle with the hinge-line. It curves downwards and backwards, and passes with a continuous sweep round the lower border with a gradual increase in the degree of convexity till, passing round into the posterior border, the convexity again becomes greater. The posterior border is almost straight for the greater part of its extent, and forms a well-marked obtuse angle with the hinge-line. The hinge-line is straight, much shorter than any other transverse diameter of the valve. The umbones are small, convex, pointed, not raised above the hinge-line, and placed a little anterior to the centre of the hinge-line. The valve is very gently and obliquely convex from side to side and above downwards, the convexity being best marked in the subumbonal region. The posterior edge is flattened, and forms a narrow but deep wing.

Interior.—Unknown.

Exterior.—The surface is ornamented with numerous elevated concentric ribs, triangular in section, separated by grooves; both ribs and grooves become broader and further apart as the lower margin is approached. The ribs become obsolete on the posterior wing, which appears to be striated. The shell possessed a thickish periostracum, which is often seen as wrinkles, and may give rise to obscure radiating striæ. Shell thin.

Dimensions.—Pl. VI, fig. 14, a specimen from Budle, which has its normal convexity preserved, measures—

Antero-posteriorly	82 mm.
Dorso-ventrally	48 mm.
From side to side (estimated) . . .	4·5 mm.

Localities.—England: in the series of Black Limestones and Shales which succeed the Carboniferous Limestone (the Pendleside Series); Poolvash, Isle of Man; Cold Coates Quarry, N.W. and Black Hall Quarry, west of Chipping; Holden, near Bolton-by-Bowland; Flasby and Sulber Lathe; between Hill Skelterton and Butterhaw; in river Wharf at Burnsall; Park Head Quarry, Lothersdale; Newton Gill, east of Long Preston. Above the Gayle Limestone, Raygill, Hawes, half a mile east of Gawker Lathe, Yorkshire. Lancashire: Pendleside series of Dinckley Hall, river Ribble, south-west of Clitheroe. About the same horizon, Mam Tor; river Dove, near Glutton Bridge, and at Tissington, and in the White Limestone, Trey Cliff, Castleton, Derbyshire. Staffordshire: in the Pendleside series of Morredge at Mixon Hey and Wetton. In the Culm measures of Venn and Swimbridge, Lew Trenchard, and Trescot, Devonshire. Black Shales, Budle Bay, Northumberland.

Ireland: the Upper Limestone Shales of Loughshinny and Garristown, co. Dublin; Navan and Trim, co. Meath; Foynes Island, co. Limerick; Kinsale Head, co. Cork.

Observations.—This shell is generally found crushed, but a few specimens show that the shell was possessed of a certain amount of convexity, Pl. VI, fig. 13. Early observers considered that three species of this shell could be differentiated, but subsequent examination has shown that the characters relied upon for specific determination were common to all; for example, the tuberculated character of *P. tuberculata* is due to the preservation of the decussating lines, which therefore appear as points on the concentric ridges. The apparent differences between *P. Becheri* and *P. lateralis* are due to different degrees of growth, *P. lateralis* being a much younger shell. Cumming enumerates still another species, which I regard as a still younger form, *P. gracillima*. Fortunately this is a *nomen nudum*, there being no figure or description.

The horizontal distribution of *P. Becheri* is wide, but its vertical occurrence is very limited. It occurs plentifully in the Black Limestone series (Pendleside series of myself and Mr. Howe, 'Quart. Journ. Geol. Soc.,' 1901, vol. lvii) which succeeds the massive White Limestone in the Midlands, South-west Yorkshire, the Isle of Man, and Ireland. It was expected that this species would prove to be restricted to, and therefore typical of, that zone; but the species occurs in the shales below the Hardraw Scar Limestone, and in connection with the Gayle Limestone in Wensleydale, and in the Carboniferous Limestone massif of Castleton, Derbyshire. But there still remains the fact that the shell occurs most plentifully and very widely in the zone of the Pendleside Limestone series. This series has, however, such a well-marked and peculiar fauna of Cephalopoda and other species of Lamellibranchiata that the somewhat earlier appearance of *P. Becheri* in certain localities does not affect the main question of the value of the Pendleside series as a stratigraphical horizon.

Unfortunately no details of the hinge or interior of *P. Becheri* have yet been seen, and there is no evidence whether or no there was a byssus. It is very rare, indeed, to find specimens uncrushed, but it is certain that they possessed a considerable amount of convexity.

The number and size of the concentric ridges and grooves vary considerably, but shells with close frequent ridges are rarer than those whose ridges are fewer and more remote. Phillips says (*op. supra cit.*), "In general the concentric ribs on these individuals are fewer than on those which we refer to *P. Becheri*, though in this particular much variation occurs."

POSIDONOMYA CORRUGATA, *R. Etheridge, jun.*, 1873. Plate VI, figs. 1—5.

ANOMIA CORRUGATA (*nomen nudum*), *Armstrong and Young*, 1871. Trans. Geol. Soc. Glasgow, vol. iii, Appendix, p. 45.

POSIDONOMYA CORRUGATA, *Armstrong, Young, and Robertson*, 1876. Cat. West. Scott. Foss., p. 52.

— — *R. Etheridge, jun.*, 1873. Mem. Geol. Surv., expl. sheet 32, Scotland, p. 103.

— — — 1874. Geol. Mag., dec. 2, vol. i, p. 304, pl. xiii, figs. 4—6.

— — *Etheridge*, 1878. Brit. Foss., pt. 1, Palæozoic, p. 276.

Specific Characters.—Shell of medium size, irregularly subquadrate, compressed, very slightly oblique, very inequivalve. There is a small anterior ear, making the anterior superior angle a right angle. The border then descends downwards and slightly forwards. The lower border is bluntly rounded and extended. The posterior margin straight, somewhat oblique. The posterior superior angle obtuse. The hinge-line straight, the shortest transverse diameter of the valve. The umbones are small, tumid, pointed, placed anteriorly. The body of the valve is gently swollen, compressed posteriorly to form a narrow posterior dorsal slope.

Interior.—Unknown.

Exterior.—The surface is covered by irregular, concentric wrinkles and flattened folds, crossed by obscure radiating wrinkles or ribs, more marked towards the median and lower portion of the valve. Periostracum moderately thick.

Dimensions.—Pl. VI, fig. 4, measures—

Antero-posteriorly	13 mm.
Dorso-ventrally	12 mm.

Localities.—England: the Pendleside series, river Ribble, Dinckley Hall, Lancashire. Scotland: in the East Kilbride district in the shale above, and in the Calderwood cement-stone Old Quarry, south of Arkleston Print Works, Paisley; Jamestonburn and No. 9 Pit, Blair, Dalry; Thornliebank; Burn, near Little Brodlie Smithy, Ayrshire. Ireland: the Upper Limestone Shales of Garristown and Loughshinny.

Observations.—This species was described and figured by R. Etheridge, jun. (*op. supra cit.*). The shell is very often found crushed, when it may be mistaken for *Posidoniella lævis* or *P. minor.* The possession of an anterior ear, however, at once distinguishes Etheridge's species from either of these.

It appears that this species was at first referred to *Anomia* (*op. supra cit.*). Like other members of the genus, it possesses a strong and well-marked periostracum.

POSIDONOMYA RADIATA, sp. nov. Plate VI, figs. 6—9.

Specific Characters.—Shell below medium size, obliquely subcircular, very moderately convex, equivalve, somewhat inequilateral. The anterior end is compressed and expanded into the form of a small triangular ear at the antero-superior angle, which is almost a right angle. The border passes downwards with a regular curvature, and passing without break into the convex lower margin. The posterior border is almost straight and oblique. The postero-inferior angle marked, but very obtuse. The postero-superior angle also obtuse. The hinge-line is straight, the shortest transverse diameter of the valve. The umbones are obtuse, flattened, the beaks lying a little in front of the centre of the hinge-line.

The valves are gently convex, separated behind from the dorsal slope by an angular fold, so rapid is compression of the narrow triangular dorsal slope.

Interior unknown.

Exterior.—The surface is covered by fine regular concentric striæ and lines of growth, crossed in the anterior two-thirds by obsolete radiating striæ, and thus has a crenulate appearance. In the posterior third the radiating lines become stronger and stronger as they pass backwards, so that they form several well-marked raised angular ribs on that part of the valve just anterior to the posterior slope.

Dimensions.—Pl. VI, fig. 8, from Glencartholm, measures—

Antero-posteriorly	16 mm.
Dorso-ventrally	15 mm.
From side to side	3 mm.

Locality.—Scotland: the Calciferous Sandstone series of Glencartholm, Eskdale, Dumfries.

Observations.—This is a very small shell which is not at all uncommon in the scorpion beds of Glencartholm, Eskdale. The shell, when not thoroughly exposed at the hinge, has the appearance of a cardiform shell, but the square hinge and small ears demonstrate its real affinities. I have referred the shell to *Posidonomya* on account of the oblique character and angulated dorsal slope, but in the absence of details of the interior it is impossible to be actually certain. *P. radiata* is not likely to be mistaken for any other Carboniferous bivalve, but it may be mentioned here that the species has no connection with *P. costata*, M'Coy. I am very doubtful if this shell deserves the name "costata," for the radiating ribs are most probably quite accidental, and due to foldings and pleats in the thick periostracum. These folds are irregular in number and distribution, and examination with a lens shows that M'Coy was not correct in stating that there were "four longitudinal, distant, well-defined mesial folds." The shell probably belongs to *Posidoniella minor*, Brown, 1841, of which this name must be considered a synonym. It was obtained at Rush, co. Dublin, and I refigure the type of M'Coy's species now preserved in the Griffith Collection, Museum of Science and Art, Dublin, Pl. VI, fig. 10.

POSIDONOMYA MEMBRANACEA, *M'Coy*, 1844. Plate V, figs. 18—23.

POSIDONOMYA MEMBRANACEA, *M'Coy*, 1844. Synops. Carb. Foss. Ireland, p. 78, pl. xiii, fig. 14.
— — *d'Orbigny*, 1851. Prod. Paléont., vol. i, p. 138.
— — *Morris*, 1854. Cat. Brit. Foss., 2nd edit., p. 181.
— — *Baily*, 1875. Figs. Char. Brit. Foss., p. 114, pl. xxxix, fig. 5.
— — *Bigsby*, 1878. Thesaurus Devonico-Carboniferus, p. 293.
— — *Etheridge*, 1888. Brit. Foss., pt. 1, Palæozoic, p. 276.

Specific Characters.—Shell compressed, obliquely ovate, narrow transversely, deep from above downwards. The anterior ear is small and rectangular. The antero-inferior border is convex and produced, curving bluntly below to join the elongate, oblique, almost straight posterior margin, both margins being subparallel. The hinge-line is short, straight, the postero-superior angle very obtuse. The umbones are small, slightly convex, not raised, subcentral, but inclining to the anterior side. The shell was gently arched from before backwards and above downwards. The posterior ear is triangular, compressed and small.

Interior.—Unknown.

Exterior.—The surface is ornamented with concentric wrinkles and folds of growth, crossed by fine, somewhat obscure, radiating lines which pass from the umbones to the lower border; the lines are more apparent on the posterior ears. Shell thin, periostracum well marked.

Dimensions.—Pl. V, fig. 22, from Garristown, co. Dublin, measures—

From anterior superior to posterior inferior angle . 37 mm.
Length of hinge-line . . . . 15 mm.

Localities.—England: Yorkshire, the Pendleside series or shales with Limestone, river Wharf, below Linton Church; Lancashire, Clough above Little Mearly Hall, Pendle Hill, and river Ribble, south-west of Dinckley Hall near Clitheroe; Mixon Hey Brook, near Leek, Staffordshire. Ireland: the Upper Limestone shales of Skerries; Garristown; Newtown; Courtlough, co. Dublin; Bala, co. Mayo.

Observations.—This species was figured and described in 1844 by M'Coy. The type, Pl. V, fig. 18, is preserved in the Griffith Collection, Museum of Science and Art, Dublin. It was obtained from Skerries, co. Dublin, and is much compressed. A number of specimens are in the museum of the Geological Survey of Ireland, from the Upper Limestone shales of co. Dublin, but unfortunately all the specimens are crushed. M'Coy states (*op. supra cit.*) that "specimens frequently occur nearly three inches in their longest diameter."

The narrow obliquely elongate shape of the shell and the irregular wrinkles on the surface at once distinguish the species from *P. Becheri*. It is interesting to note that the two species are found in the same series of rocks in both England and Ireland.

When young it is not improbable that *P. membranacea* may be confounded with *Posidoniella lævis*, but the subcentral beaks and possession of an anterior ear and greater obliquity can be relied upon as characteristic features in the former.

I can find no record of this species having been obtained previously in England. I, some years ago, obtained many specimens in much the same condition as those from co. Dublin, in the bank of the river Wharf, south of the stepping-stones at Linton, Yorkshire. Fragments of goniatites and *Posidonomya Becheri* were obtained with it, and more recently I have seen many specimens from the same horizon at Pendle Hill, Dinckley Hall, and Holden.

Mr. R. Etheridge, sen., indicates that *P. membranacea* occurs in the Lower Limestone shales, Carboniferous Limestone, Upper Limestone shales (Yoredales), and Millstone Grit series, but unfortunately he neither gives his authorities nor quotes localities. I doubt the occurrence of the shell except in the Pendleside series (the Upper Limestone shales of the Irish survey).

Posidonomya lamellosa, *de Koninck*, 1851. Plate VI, figs. 16—18.

Posidonomya lamellosa, *de Koninck*, 1851. Descr. Anim. Foss. Belg, Supplément, p. 683, pl. lvii, fig. 5.
— **obliqua**, *de Koninck*, 1885. Ann. Mus. Roy. Hist. Nat. Belg., tom. xi, p. 182, pl. xxxi, figs. 21, 22.

Specific Characters.—Shell below medium size, equivalve, somewhat inequilateral, gibbose, obliquely ovate. The anterior border is almost straight, descending downwards and forwards; the inferior border is broad and convexly curved; the posterior border is almost straight and oblique. The hinge-line is short and straight, the antero-superior and postero-superior angles being well marked and rather larger than right angles. The umbones are obtuse, pointed, incurved, and placed in the anterior third of the hinge-line. The valve is regularly but obliquely swollen, with the antero-superior and postero-superior angles compressed into small ears, the posterior being much the larger.

Interior.—Unknown.

PLATE I.

Fig. 1.—*Pinna mutica.* The type of M'Coy's *Pinna spatula* preserved in the Woodwardian Museum, Cambridge. Incomplete in front. From the Carboniferous Limestone of Derbyshire. (Page 4.)

Fig. 2.—*Pinna mutica.* A left valve showing the posterior adductor muscle-scar. Same Collection. (Page 4.)

Fig. 3.—*Pinna mutica.* The fragment on which M'Coy founded the species from Kilbride, Ballycastle, co. Mayo. In the Griffith Collection, Museum of Science and Art, Dublin. (Page 4.)

Fig. 4.—*Pinna mutica.* Portion of a left valve, showing the rolled hinge-edge. From Cavedale, Castleton. My Collection. (Page 4.)

Fig. 5.—*Pinna mutica.* A right valve from the Carboniferous Limestone of Cavedale, Castleton. My Collection. (Page 4.)

Fig. 6.—*Pinna mutica.* A fine but compressed specimen from the Calciferous Sandstone series of Glencartholm, Dumfries. My Collection. (Page 4.)

Fig. 7.—*Leiopteria squamosa.* A right valve from the Carboniferous Limestone of Castleton, Derbyshire, with 7 *a*, a view from above. My Collection. (Page 16.)

Fig. 8.—*Leiopteria squamosa.* The type of *Avicula gibbosa*, M'Coy, from the Upper Limestone, Manor Hamilton, co. Leitrim. In the Griffith Collection, Museum of Science and Art, Dublin. (Page 16.)

Fig. 9.—*Leiopteria squamosa.* The type of Phillips's *Gervillia squamosa*, preserved in the Gilbertson Collection, Natural History Museum, South Kensington. (Page 16.)

Fig. 10.—*Leiopteria squamosa.* A left valve from the Carboniferous Limestone of Castleton, Derbyshire. My Collection. (Page 16.)

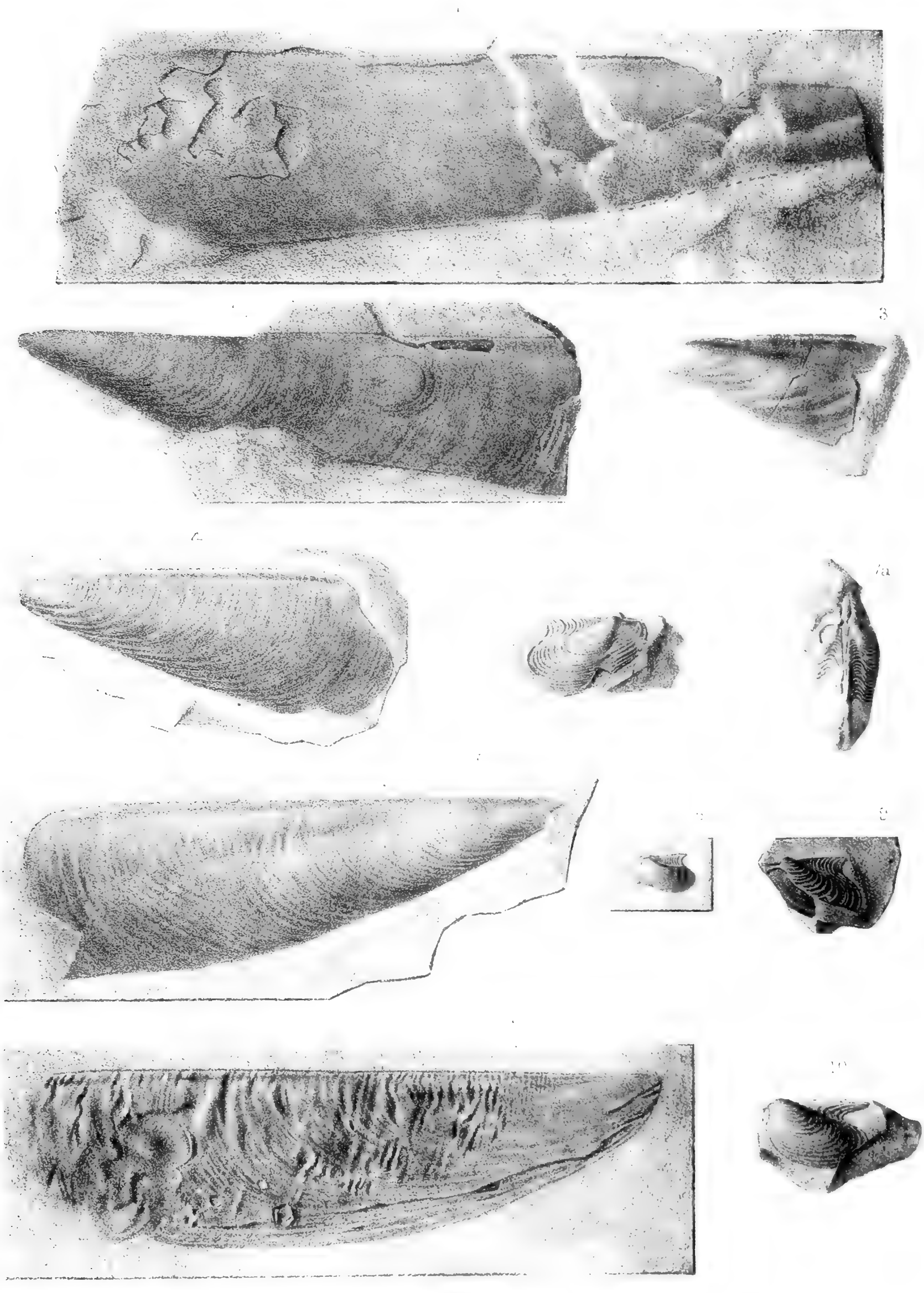

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PLATE II.

Fig. 1.—*Pinna flabelliformis.* One of the types of M'Coy's *Pinna flexicostata* from Lowick. In the Collection of the Woodwardian Museum, Cambridge. (Page 1.)

Fig. 2.—*Pinna flabelliformis.* The type of *P. inæquicostata*, M'Coy. Preserved in the Griffith Collection, Museum of Science and Art, Dublin. (Page 1.)

Fig. 3.—*Pinna flabelliformis.* The type of Phillips's *Pinna costata*, preserved in the Gilbertson Collection, Natural History Museum, South Kensington. (Page 1.)

Fig. 4.—*Pinna flabelliformis.* The cast of a left valve from Lowick. In the Collection of the Woodwardian Museum, Cambridge. (Page 1.)

Fig. 5.—*Pinna flabelliformis.* A semi-decorticated specimen from the Carboniferous Limestone of Narrowdale, Staffordshire. My Collection. (Page 1.)

Fig. 6.—*Pinna flabelliformis.* One of M'Coy's types of *P. flexicostata*, a cast of the interior, from Lowick. In the Collection of the Woodwardian Museum, Cambridge. (Page 1.)

Fig. 7.—*Leiopteria lunulata.* The type of Phillips's *Gervillia lunulata.* Preserved in the Gilbertson Collection, Natural History Museum, South Kensington. (Page 11.)

Fig. 8.—*Leiopteria lunulata.*—The type of M'Coy's *Avicula recta.* A young condition of the shell. Preserved in the Griffith Collection, Museum of Science and Art, Dublin. (Page 11.)

Fig. 9.—*Leiopteria lunulata.*—A specimen showing the anterior end. From the Carboniferous Limestone of Castleton, Derbyshire. My Collection. (Page 11.)

Fig. 10.—*Leiopteria lunulata.* A large example from the Carboniferous Limestone of Clane, co. Kildare, in the Collection of the Woodwardian Museum, Cambridge. (Page 11.)

Fig. 11.—*Leiopteria lunulata.* The type of *Avicula lævigata*, M'Coy. From Millicent, Clane, co. Kildare. In the Griffith Collection, Museum of Science and Art, Dublin. (Page 11.)

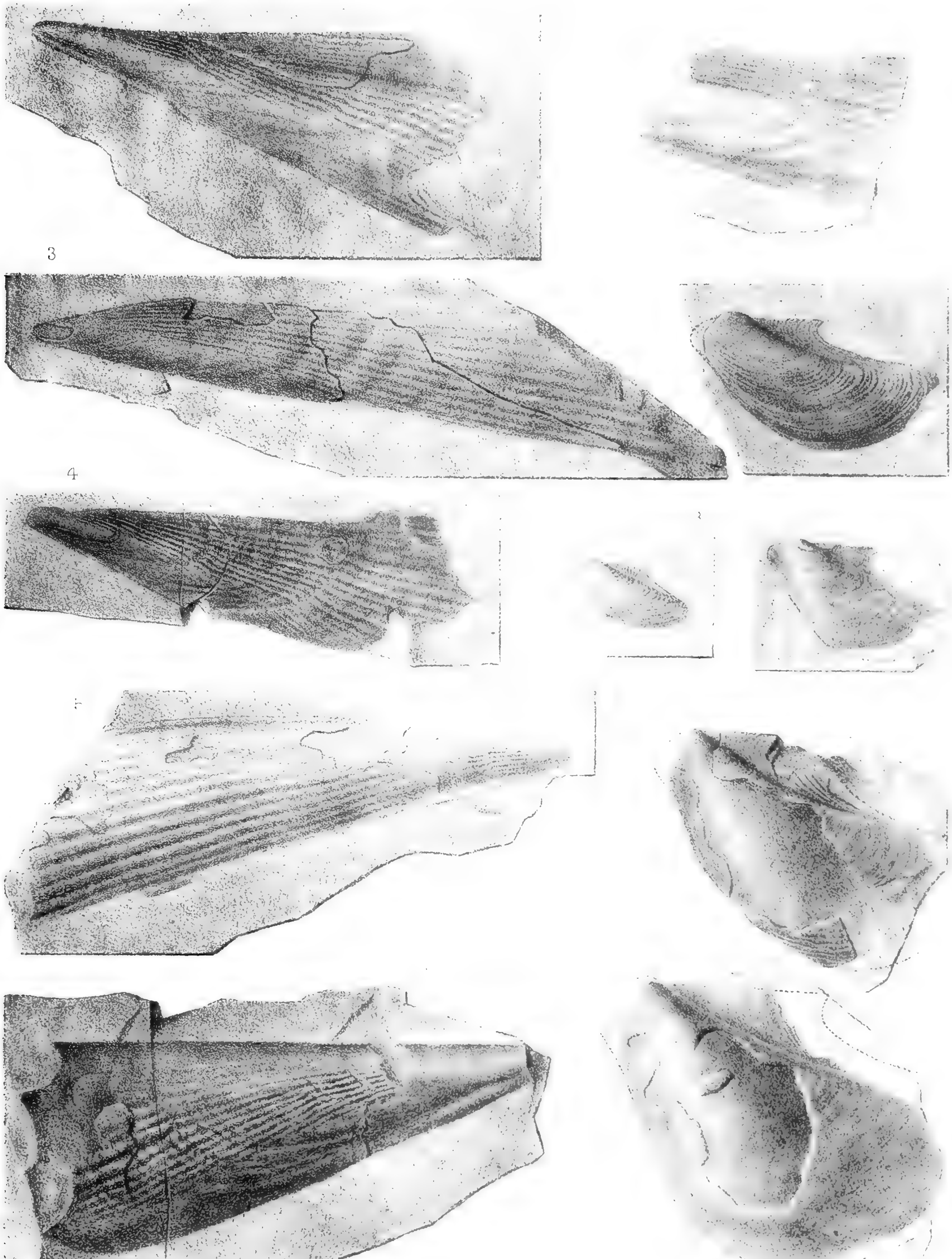

PLATE III.

Fig. 1.—*Leiopteria hirundo.* An almost complete left valve. From the Carboniferous Limestone of Castleton. My Collection. (Page 13.)

Figs. 2, 3.—*Leiopteria lunulata.* Casts of the interior of left valves. From the Shelly Limestone of Poolvash, Isle of Man. My Collection. (Page 11.)

Fig. 4.—*Leiopteria laminosa.*—A left valve. From the Carboniferous Limestone of Castleton, Derbyshire. (Page 14.)

Fig. 5.—*Leiopteria laminosa.*—A young specimen. From Hill Bolton, Yorkshire. My Collection. (Page 14.)

Fig. 6.—*Leiopteria laminosa.* The type of Phillips's *Gervillia laminosa*, preserved in the Gilbertson Collection, Natural History Museum, South Kensington. (Page 14.)

Fig. 7.—*Leiopteria laminosa.* A specimen from the Limestone of Lowick. In the Woodwardian Museum, Cambridge. (Page 14.)

Figs. 8, 9.—*Leiopteria laminosa.* Two medium-sized specimens. From the Carboniferous Limestone of Castleton, Derbyshire. My Collection. (Page 14.)

Fig. 10.—*Leiopteria Thompsoni.* A full-grown specimen. From Hill Bolton, Yorkshire. My Collection. (Page 17.)

Fig. 11.—*Leiopteria Thompsoni.* The cast of a left valve. Same locality and Collection. (Page 17.)

Fig. 12.—*Leiopteria grandis.* The hinge-line and posterior part of a right valve. From the Carboniferous Limestone of Castleton. My Collection. (Page 19.)

Fig. 13.—*Leiopteria grandis.* The cast of the interior of the left valve. Same locality and Collection. (Page 19.)

Fig. 14.—*Leiopteria grandis.* A full-grown example of a left valve. Same locality and Collection. (Page 19.)

Fig. 15.—*Leiopteria grandis.* Portion of the left valve. Same locality and Collection. (Page 19.)

Hind, Carboniferous Lamellibranchiata.

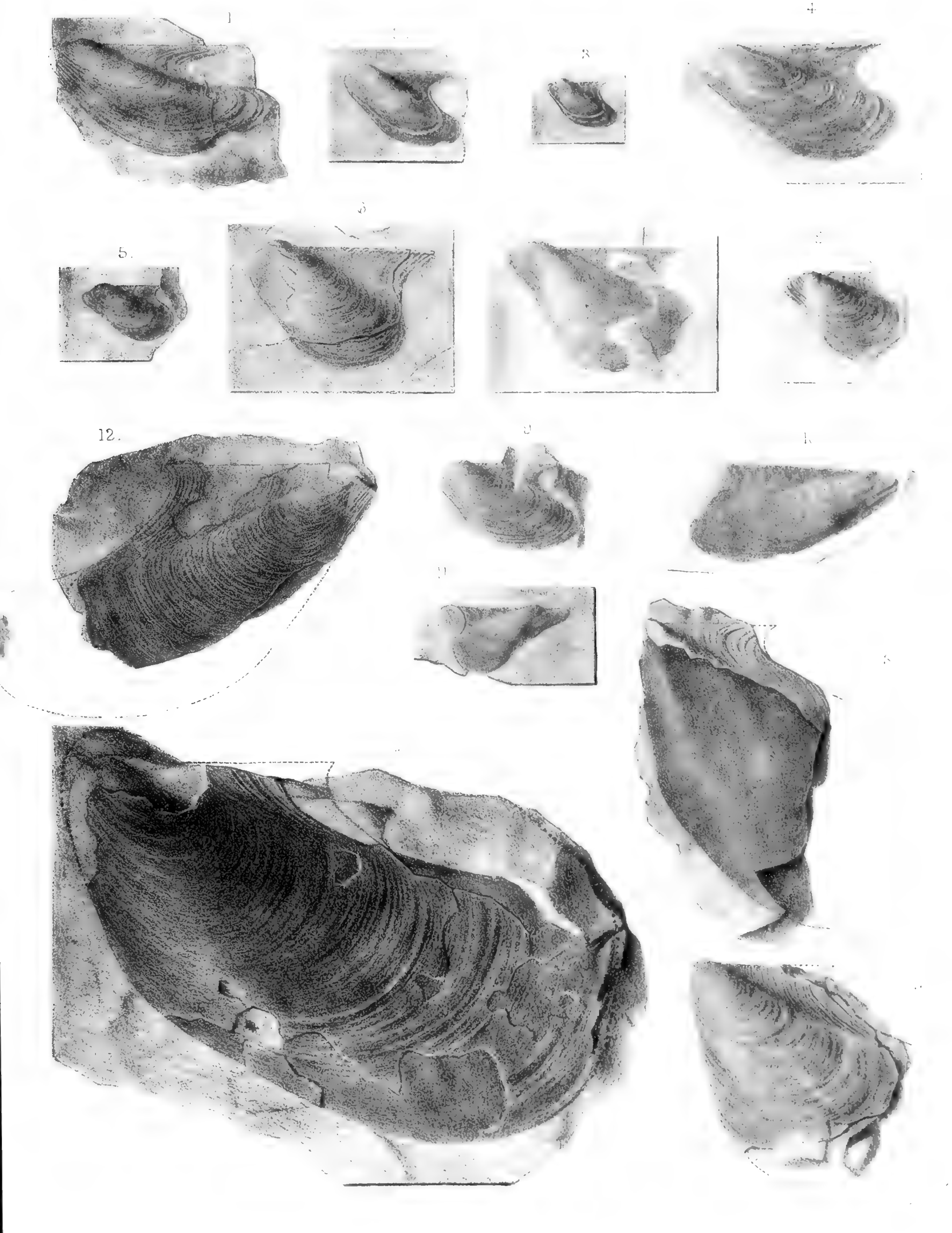

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PLATE IV.

Fig. 1.—*Pinna flabelliformis.* The specimen described as *P. flabelliformis*, var. *inæquicostata*, by Portlock. From Carnteel, Tyrone. (Page 1.)

Fig. 2.—*Leiopteria Thompsoni.* The cast of a left valve. From Potmetal Plantation, Fife. In the Collection of the Geological Survey, Jermyn Street. (Page 17.)

Fig. 3.—*Leiopteria Thompsoni.* A more perfect specimen of the cast of a left valve, showing the anterior hinge-teeth. Same locality and Collection. (Page 17.)

Fig. 4.—*Leiopteria lunulata.* The type of *Avicula angusta*, M'Coy. From Rohan Bay, Dunkineely, co. Donegal, Ireland. In the Griffith Collection, Museum of Science and Art, Dublin. (Page 11.)

Fig. 5.—*Leiopteria lunulata.* Portion of the cast of a left valve, the type of M'Coy's *Avicula informis.* From Killogunra, Killalu, co. Mayo. Same Collection. (Page 11.)

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Fig. 7.—*Leiopteria Thompsoni.* A young example of the right valve, with the test. Same locality and Collection. (Page 17.)

Fig. 8.—*Leiopteria lunulata.* A young example of the left valve. Same locality and Collection. (Page 11.)

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Fig. 10.—*Actinopteria persulcata.* A fine bivalve example. From the Limestone of Eskerhouse, near Grassington. In the Collection of the Geological Survey, Jermyn Street. (Page 23.)

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Fig. 11.—*Actinopteria persulcata.* From the Lower Limestone series at Lesmahagow, near Glasgow. Same Collection. (Page 23.)

Fig. 12.—*Leiopteria Thompsoni.*—The type of *Pterinea Thompsoni*, Portlock. From co. Fermanagh. Same Collection. (Page 17.)

Fig. 13.—*Leiopteria Thompsoni.* A second specimen. Same locality and Collection. (Page 17.)

Fig. 14.—*Leiopteria longirostris.* A left valve. From Black Limestone above the massif of White Limestone, below Mam Tor, Castleton. My Collection. (Page 20.)

Fig. 15.—*Leiopteria longirostris.* Another specimen. Same locality and Collection. (Page 20.)

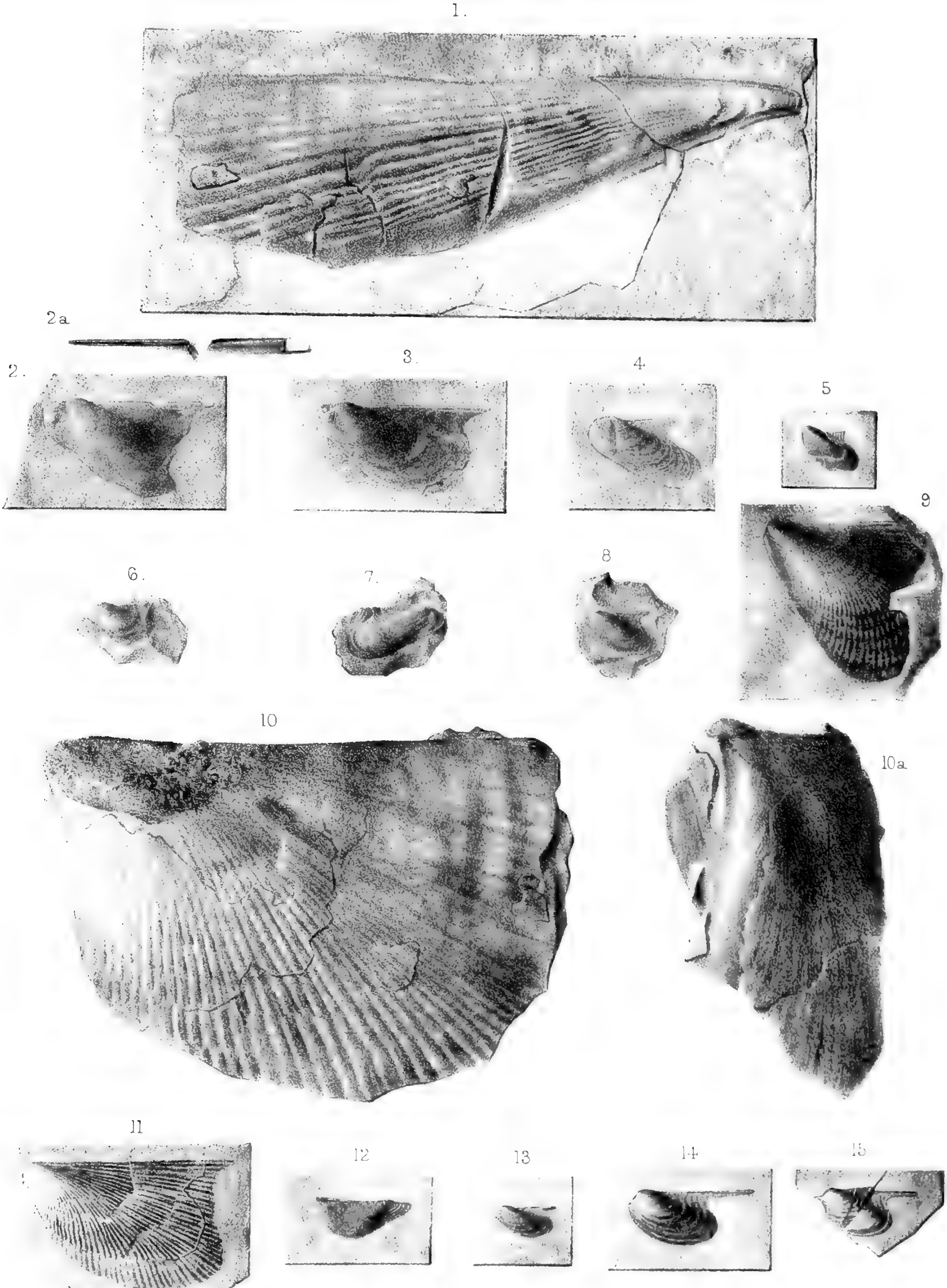
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PLATE V.

Fig. 1.—*Pteronites angustatus*. A right valve. From the Lower Carboniferous series of Lawston Linns, Liddlewater, Roxburghshire. In the Collection of the Geological Survey of Scotland. (Page 7.)

Figs. 2 and 3.—*Pteronites angustatus*. A right and left valve. From the Lower Carboniferous Beds of Lewisburn, Northumberland. My Collection. (Page 7.)

Fig. 4.—*Pteronites angustatus*. A left valve. From the Calciferous Sandstone series of Glencartholm, Dumfriesshire. In the Collection of the Geological Survey of Scotland. (Page 7.)

Fig. 5.—*Pteronites angustatus*. The specimen in the Griffith Collection at the Museum of Science and Art, Dublin. Probably not the type. From Bruckless, Dunkineely, co. Donegal. (Page 7.)

Fig. 6.—*Pteronites latus*. The specimen figured by M'Coy. From Millicent, Clane, co. Kildare. Same Collection. (Page 8.)

Fig. 7.—*Pteronites latus*. A left valve. From the Carboniferous Limestone of Grassington, Yorkshire. In the Museum of the Geological Survey, Jermyn Street. (Page 8.)

Fig. 8.—*Actinopteria fluctuosa*. Probably the type specimen. From Clecklimon, Kilbride. With an enlarged view, Fig. 8 *a*. In the Collection of the Geological Survey of Scotland. (Page 25.)

Fig. 9.—*Actinopteria fluctuosa*. A left valve. From the Lower Limestone series of Beith. In the Collection of Mr. J. Smith, of Kilwinning. (Page 25.)

Fig. 10.—*Actinopteria fluctuosa*. A left valve. From Waterland, Ayrshire. Same Collection. (Page 25.)

Fig. 11.—*Actinopteria fluctuosa*. From the First Limestone on the shore east of Kinghorn, Fife. In the Collection of the Geological Survey of Scotland. (Page 25.)

Fig. 12.—*Actinopteria fluctuosa*. From the West Quarry at Salton. Same Collection. (Page 25.)

Fig. 13.—*Actinopteria sulcata*. The type from Manor Hamilton, co. Leitrim. In the Griffith Collection, Museum of Science and Art, Dublin. (Page 26.)

Fig. 14.—*Actinopteria persulcata*. A specimen broken, so as to assume a triangular form; from near the Chemical Works, West Calder. In the Museum of the Geological Survey, Jermyn Street. (Page 23.)

Fig. 15.—*Leiopteria obtusa*. A beautifully preserved right valve. From Cunningham, Baidland, Dalry. In the Collection of Mr. J. Smith. (Page 21.) 15 *a*. An enlarged view.

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Fig. 18.—*Posidonomya membranacea*. M'Coy's type specimen. From Skerries, co. Dublin. In the Griffith Collection, Museum of Science and Art, Dublin. (Page 33.)

Figs. 19—21.—*Posidonomya membranacea*. A specimen from bank of river Wharf, below Linton. My Collection. (Page 33.)

Fig. 22.—*Posidonomya membranacea*. A large specimen. From Garristown, co. Dublin. In the Museum of the Geological Survey of Ireland. (Page 33.)

Fig. 23.—*Posidonomya membranacea*. A specimen from Newtown, co. Dublin. Same Collection. (Page 33.)

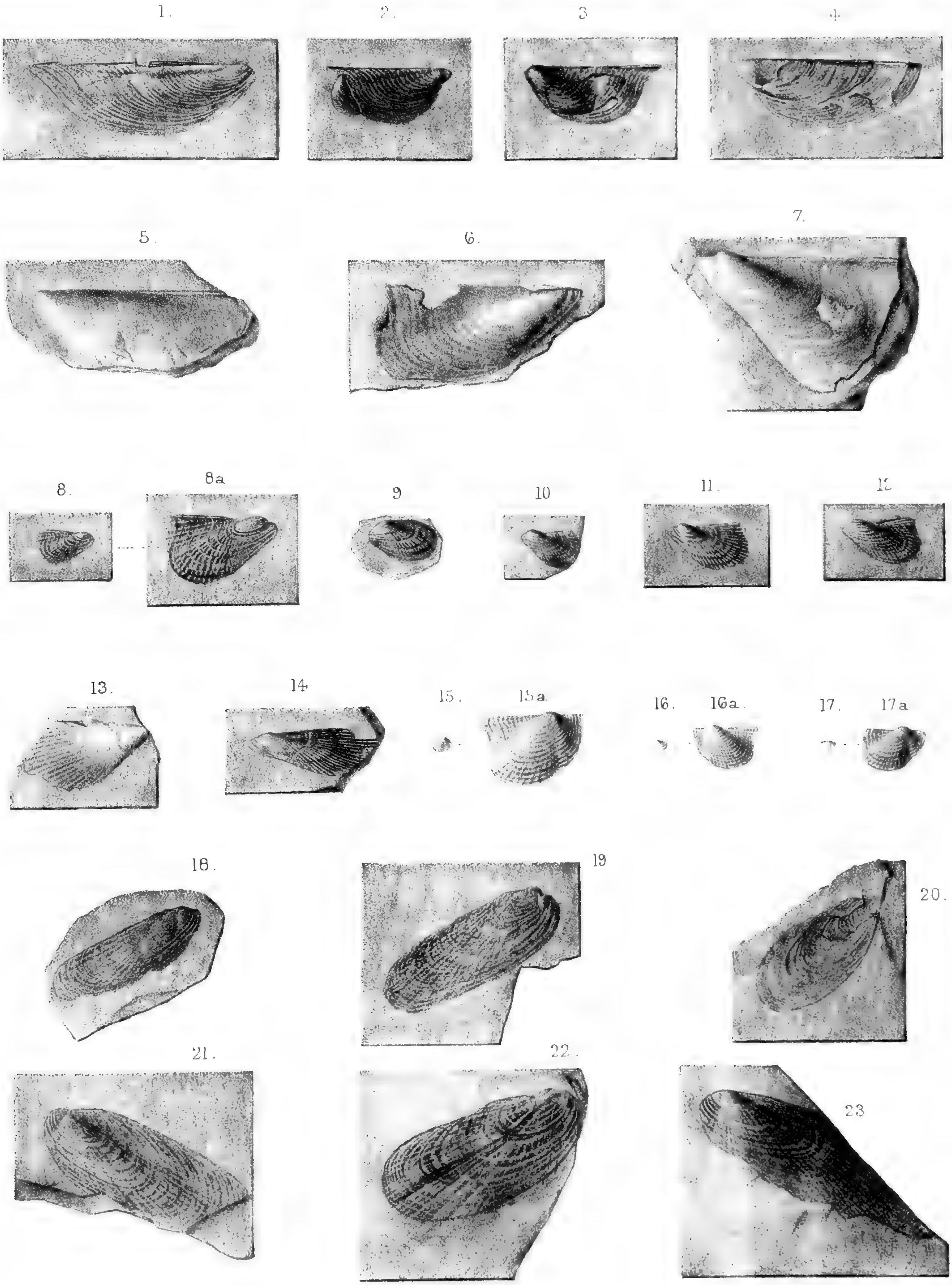

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PLATE VI.

Figs. 1, 2.—*Posidonomya corrugata.* A right and left valve. From Jameston Burn, Dalry. In the Collection of Mr. J. Smith. (Page 30.)

Fig. 3.—*Posidonomya corrugata.* From near Paisley. In the Collection of the Geological Survey of Scotland. (Page 30.)

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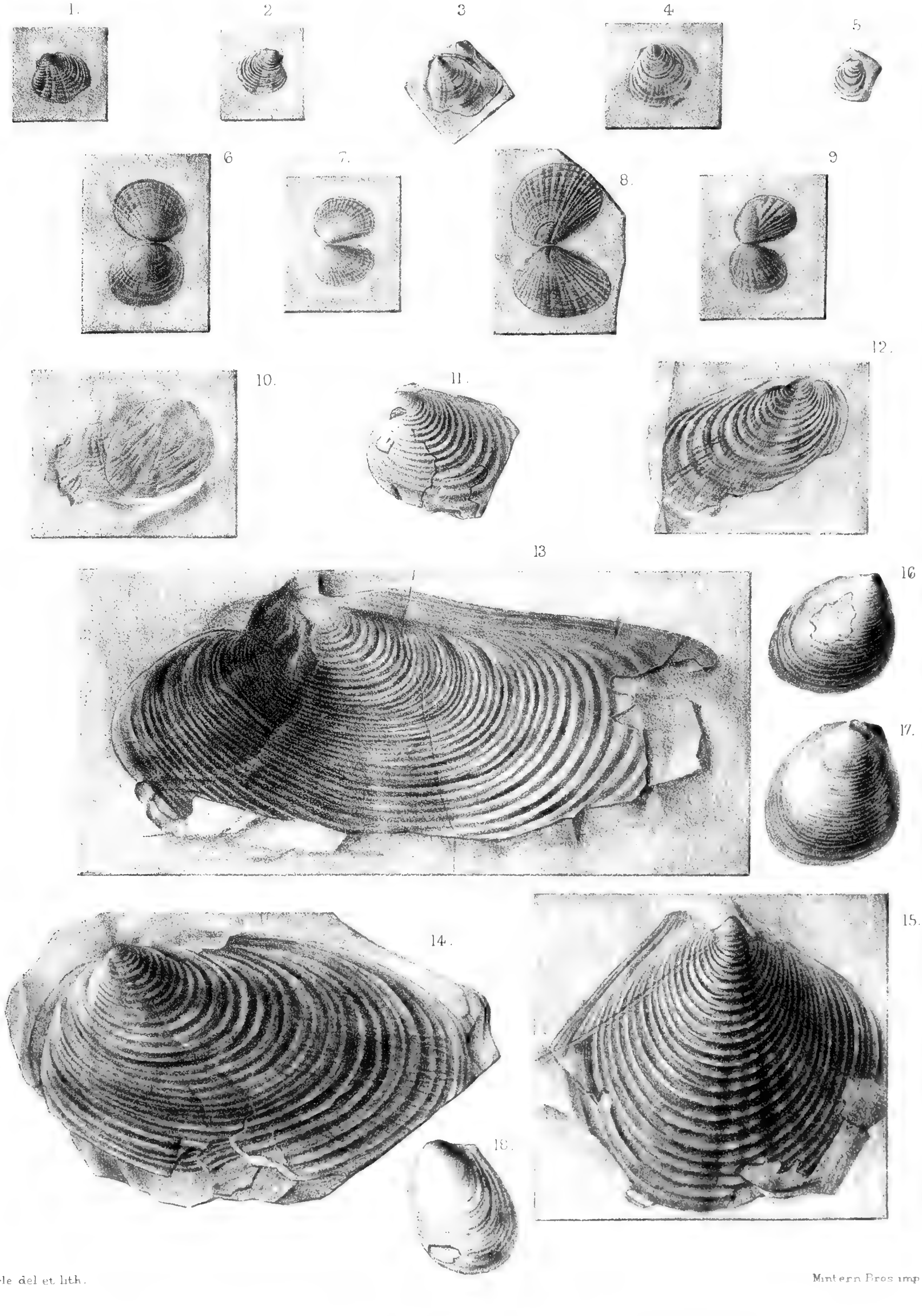
Fig. 12.—*Posidonomya Becheri.* A right valve. From Budle, Northumberland. To show the wrinkled periostracum. My Collection. (Page 27.)

Fig. 13.—*Posidonomya Becheri.* A large example from the Culm of Swanbridge, Devon. In the Museum of the Geological Survey, Jermyn Street. (Page 27.)

Fig. 14.—*Posidonomya Becheri.* A left valve. From Budle, Northumberland. Same Collection. (Page 27.)

Fig. 15.—*Posidonomya Becheri.* A right valve, with the normal convexity preserved. From the Culm of Swanbridge, Devon. Same Collection. (Page 27.)

Figs. 16—18.—*Posidonomya lamellosa.* From the Carboniferous Limestone of Castleton, Derbyshire. My Collection. (Page 34.)



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A MONOGRAPH

OF THE

BRITISH CARBONIFEROUS LAMELLIBRANCHIATA.

BY

WHEELTON HIND, M.D., B.S.Lond., F.R.C.S., F.G.S.,

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ERRATA.

Page 11. At line 20 insert as part of the Carboniferous Limestone series—

"Upper:—Consisting of Sandstone shales, the Castle Cary, Linn Spout, Calmy or Arden, and Index limestones."

Middle:—Sandstones and shales with coals and ironstones.

Lower:—

Page 23, line 19, *insert* "collected" *after* species.
,, 26, ,, 23, *for* sec. *read* ser.
,, 26, ,, 24, *for* vii *read* xii.
,, 27, ,, 12, *for* Wilkestarre *read* Wilkesbarre.
,, 27, ,, 15, for *Wyomengensis* read *Wyomingensis.*
,, 27, ,, 15, for *Naidites* read *Naiadites.*
,, 27, ,, 17, for *Posidinia? Cluthiata* read *Posidonia clathrata.*
,, 27, ,, 18, for *perstuat* read *perstriata.*
,, 28, ,, 38, for *sulcifii* read *sulciferi.*
,, 28, ,, 40, for *jallax* read *fallax.*
,, 30, ,, 2, *for* Bailey *read* Baily.
,, 31, ,, 15 *for* Bailey *read* Baily.
,, 32, *delete* lines 26—29.
,, 34, line 22, *for* York *read* Cork.
,, 38, ,, 19, *for* p. 71 *read* 170, 171.
,, 42, ,, 10, for *Swalleri* read *Swallovi.*
,, 85, ,, 33, *delete* Flasby and Todmorden.
,, 179, ,, 28, *for* Barnes *read* Barns.
,, 181, ,, 8, *for* Robringston *read* Robroyston.
,, 181. It is probably more correct to refer to this species as *Ctenodonta undulata.*
,, 183. ,, ,, ,, *Ctenodonta lævirostra.*
,, 207, line 3 from bottom, the specimen, Fig. 39, is in Mr. J. Smith's Collection.
,, 227, line 21, *for* Freech *read* Frech.
,, 238, ,, 11, *for* 9 *read* 2.
,, 280, ,, 6, *for* Dunkinealy *read* Dunkineely.
,, 336, ,, 10, *for* Upper *read* Lower.
,, 358, ,, 2 from bottom, *for* sources *read* courses.
,, 474, after line 8, *insert* Cardiidæ.
Plate II, line 5, *for* Kelbride *read* Kilbride.
,, ,, 9, *delete* the Coombes.
,, ,, 29, for *lithonomus* read *lithodomus.*
Plate XV, *for* Fig. 18 *read* 17 *a.*
,, *for* Fig. 19 *read* 18.
,, Fig. 31, for *Nucula* read *Nuculana.*
,, Fig. 32, for *Nucula* read *Ctenodonta.*
,, Figs. 34—38, for *Nucula* read *Ctenodonta.*
Plate XXV, Fig. 3, line 3, *for* "of Ireland" *read* Jermyn Street.
Plate XXVI, Fig. 5, *for* Bath *read* Beith.
Plate XXXVI, Fig. 26, line 2, *for* Currow *read* Burrow.

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MONOGRAPH

ON THE

CARBONIFEROUS CEPHALOPODA

OF

IRELAND.

BY

ARTHUR H. FOORD, Ph.D. (Münch.), F.G.S.

PART IV.

CONTAINING THE FAMILIES

SOLENOCHEILIDÆ (CONCLUDED) AND GLYPHIOCERATIDÆ.

Pages 127—147; Plates XXXIII—XXXIX.

LONDON:

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last. At the edge of the umbilicus, where the lower margin of the aperture meets the lateral margins, there is a distinct swelling, a characteristic feature seen in all individuals of the species in which the aperture is preserved at this point (Pl. XXXIII). With the complete form of the aperture and its hyponomic sinus I am unacquainted, as I have not met with any specimens in which it is preserved; nor are the lines of growth sufficiently distinct to indicate its nature in the specimens known to me.

The septa, as indicated by their sutures, are wide apart. In a large specimen from Rathkeale, near Limerick (Pl. XXXV,[1] fig. 1), the diameter of which is approximately 230 mm., the distances between the sutures in the last six chambers, measured along the median line of the periphery (reading them towards the body-chamber), are as follows:—28 mm., 28·5 mm., 29 mm., 34 mm., 32 mm., 35 mm.[2]

The siphuncle has a diameter near the body-chamber of about 4 mm.; it lies immediately under the test, so that the removal of the latter exposes it. The test is marked only by very faint lines of growth.

Affinities.—The most nearly related species is *Solenocheilus evolutus*, Hyatt[3] (= *Nautilus dorsalis*, de Kon.,[4] *not* Phillips), but the whorls in this species are only just in contact instead of overlapping considerably as is the case with *S. dorsalis*, Phill. Hence the renaming of de Koninck's species by Hyatt.

From *S. latiseptatus*, de Kon.,[5] the present species differs in its much narrower periphery, more rapid rate of tapering, and overlapping whorls, as well as in its relatively closer septation.

Remarks.—The Irish specimens of this species agree well with Phillips's type (form *a*, from Bolland, Yorkshire), which I had the opportunity, through the kindness of Dr. Henry Woodward, F.R.S., of re-examining at the British Museum in the summer of 1900. They have the characteristic narrowly rounded periphery possessed by the type specimen. The sutures are not seen in the latter, which has, however, part of the body-chamber intact. The test is badly preserved, its surface having been entirely destroyed by a crystalline deposit.

S. dorsalis is widely distributed in Ireland, where it attains a very considerable size. The largest I have met with is now in the British Museum; it was found in the quarries at Clane. I give its dimensions, kindly supplied to me

[1] This plate, having been added after the publication of Part III of the present Monograph, is not enumerated at the head of the description of this species on page 126.

[2] These measurements will not be found to agree precisely with the drawing, owing to the position of the lines in the latter being naturally affected by the curved surface of the shell.

[3] "Carboniferous Cephalopods." Second paper. 'Geological Survey of Texas, Fourth Annual Report,' 1892, p. 460.

[4] "Faune Calc. Carb. Belg.," 1878 ('Ann. Mus. Roy. d'Hist. Nat. Belg.,' tom. ii), pt. 1, p. 111, pl. xviii, figs. 1—3.

[5] Ibid., p. 110, pl. xxii, figs. 1—3. Also 'Cat. Foss. Ceph. Brit. Mus.,' 1891, pt. 2, p. 171, fig. 29.

by my friend Mr. G. C. Crick; adding to it the measurements of the large specimen I have figured in this Monograph (Pls. XXXIII, XXXIV). It will be seen that there is very little difference in size between these two specimens.

In the synonymy of this species given in Part III, p. 126, of this Monograph, I have suggested that *Nautilus* [*Solenocheilus*] *dorsalis* of de Koninck (not of Phillips) may be the var. γ of Phillips ('Geol. York.,' 2, pl. xviii, figs. 1, 2), overlooking the fact stated above, that Hyatt ('Geological Survey of Texas,' 1892, p. 460) had renamed de Koninck's species, calling it *Solenocheilus evolutus*, in allusion to its evolute whorls.

Dimensions.

	Large specimen from Clane, in the British Museum (No. C. 4626).	Large (figured) specimen from Clane, in Dublin Museum of Science and Art.
Diameter of shell . .	240 mm.	. 230 mm.
„ umbilicus (suture to suture)	—	. 40 „
Height of whorl (dorso-ventral) .	—	. 133 „
Thickness at umbilical margin of aperture (about) . . .	160 mm.	. 150 „

Localities.—St. Doulagh's, county of Dublin; Clane, county of Kildare; Rathkeale, near Limerick; Blackrock and Little Island, near Cork; and Kilcommoch, county of Longford. (The last three localities are cited in Sir Richard Griffith's 'Localities of Irish Carboniferous Fossils,' forming an appendix to M'Coy's 'Synopsis,' issue of 1862.)

SOLENOCHEILUS ? HIBERNICUS, *A. H. Foord.* Plate XXXVI, figs. 1 *a*, *b*, 2.

1836. NAUTILUS DORSALIS (var. β), *J. Phillips.* Geology of Yorkshire, pt. 2, p. 231.

1891. SOLENOCHEILUS HIBERNICUS, *A. H. Foord.* Cat. Foss. Ceph. British Museum, pt. 2, p. 171, fig. 28.

1893. — — *A. Hyatt.* Carboniferous Cephalopods. Second paper. Geological Survey of Texas, Fourth Annual Report, 1892, p. 461.

Description.—Shell of medium size, so far as the species is known, nautilus-like, subglobose, consisting of about one and a half rapidly expanding involute whorls, the last overlapping the preceding one to the extent of about three-fourths. Umbilicus proportionately small, exposing the inner volution, with a central vacuity of moderate size; the sides steep, with a distinctly angular margin.

The section is broadly sagittate, the periphery constituting the apex of the triangle.

The body-chamber is large, extending to about three-fourths of the circumference of the last whorl. The periphery is rather narrowly rounded, and merges in the sides as they gradually expand towards the edge of the umbilicus. The aperture is not preserved in any of the specimens that have come under my notice. The apex, so far as it can be observed, is obtusely pointed as in other shells belonging to this genus.

The septa, as indicated by the sutures, are somewhat widely separated. In a specimen contained in the "Gilbertson Collection" at the British Museum (No. C. 212), from Bolland, Yorkshire (Pl. XXXVI, fig. 2), the sutures increase from a distance of 10 mm. to one of 20 mm. apart where the diameter of the shell is 76 mm. The siphuncle is not known, but it is assumed to be peripheral, hence the reference of the species to *Solenocheilus*. The surface of the shell is perfectly smooth.

Dimensions.

	Type specimen in the British Museum (No. C. 4505).	Specimen in British Museum ("Gilbertson Collection," No. C. 212).
Diameter of shell (about)	117 mm.	91·5 mm.
,, umbilicus (edge to edge)	24 ,,	17 ,,
,, ,, (suture to suture)	18 ,,	— ,,
Height of whorl (dorso-ventral) about	67 ,,	— ,,
Thickness at umbilical margin	82·5 ,,	85 ,,

Affinities.—The angularity of the umbilical margin distinguishes this species from *Solenocheilus dorsalis*, which it resembles in its general form and septation; and this seems to justify its reference to *Solenocheilus*, though the siphuncle is unknown. *S. atlantoideus*, de Koninck,[1] though possessing a similarly angulated umbilical margin, has a very different form in cross-section, caused by its more broadly rounded periphery, while it has also at least one whorl more than *S. hibernicus*, giving the umbilicus a much greater width.

Remarks.—This species is represented in the Dublin Museum of Science and Art by a recently acquired specimen from Little Island, near Cork. Like many of the Carboniferous Limestone fossils from this part of the south of Ireland, it is greatly distorted, the peripheral area being completely flattened in the region of the body-chamber in the dorso-ventral direction, causing the sides of the shell to be much narrowed and the periphery proportionately widened. The flattening and distortion has also affected the septate part of the shell, which is squeezed into an elliptical form. The angular edge of the umbilicus is marked by a narrow rim,

[1] "Faune Calc. Carb. Belg.," 1878 ('Ann. Mus. Roy. d'Hist. Nat. Belg.,' tom. ii), pt i, p. 97, pl. xi, figs. 1, 2.

which expands in the vicinity of the aperture in such a manner as to show that its margin had the spout-like projection which is one of the characteristics o *Solenocheilus.*

I have described this individual somewhat in detail in order to point out how completely rock-pressure may transform a fossil so that it may, as in the present case, put on a shape which is quite foreign to its normal one.

Localities.—Little Island, near Cork; Ireland (precise locality unknown; this is the type specimen in the British Museum).

SOLENOCHEILUS ? CLAUSUS, sp. nov. Plate XXXVI, fig. 3.

Description.—Shell (known only in the adult stage) nautilus-like, inflated, with rapidly expanding whorls, the inner ones concealed by the last one. The sides broad, somewhat compressed, and merging in the widely rounded periphery. The outline of the aperture, which is only partially preserved, forms a broad curve at the sides, and where it meets the umbilical margin is reflected inwards, forming a flattened, slightly concave, thickened band (callus), which enters and closes the umbilicus.

The sutures, of which only five are seen owing to the presence of the test, are rather widely separated from each other. Measured from the last they are respectively 15 mm., 15 mm., 14 mm., and 12 mm. apart. The siphuncle is not seen. The test is represented apparently only by the thin inner layer, which is perfectly smooth.

Dimensions.

	Specimen in British Museum (No. C. 7967).
Diameter of shell	140 mm.
Height of whorl at aperture about . .	60 ,,
Thickness at umbilical margin close to the aperture (perhaps somewhat affected by distortion) .	120 ,,

Affinities.—I am not acquainted with any species with which *S. clausus* may be compared.

Remarks.—The completely closed umbilicus is the distinguishing mark of the present species, and, so far as my observation carries me, this is uncommon among the Nautiloids, the tendency in this group being to leave the inner whorls more or less exposed even in those species which approximate most closely to the recent *Nautilus* in their general form, which on the whole is the case with the Solenocheilidæ.

Unacquaintance with the siphuncle throws some doubt on the generic position of this species, as was the case with *Solenocheilus? hibernicus*, and its reference to that genus may possibly prove to be erroneous.

It is interesting to note among these very ancient Cephalopods of the Irish Carboniferous seas the varying plans of whorl structure exemplified in their shells. The present species adds another to this category, and demonstrates once more the richness of the marine fauna in this extreme western extension of the European Carboniferous rocks.

Besides the specimen here figured, there is one, less perfect, in the Museum of Science and Art, Dublin, from the same locality. Both have been recently collected.

Locality.—Little Island, near Cork.

Genus AIPOCERAS (see *ante*, p. 116).

AIPOCERAS? HAINESIANUM, sp. nov. Plate XXXV, figs. 2 *a*, *b*.

Description.—Shell composed of about one and a half to two very rapidly enlarging incontiguous volutions. Both the dorsal and ventral areas are considerably flattened through rock pressure, the crushing having come in a direction oblique to the longitudinal axis of the shell. The cross-section is transversely oval, the ratio of the two diameters being as 10 : 14 in the younger part of the shell, where it has been less affected by distortion. The periphery is broadly expanded; normally it probably presented a broad, low arch when seen in profile. The sides are narrowly rounded, and merge into the broad dorsal area, which is slightly convex in the median zone, a faint ridge bounding this central area on either side. The outline of the aperture is imperfect, only interrupted portions of it remaining. No trace of a sinus is seen in the peripheral area, but dorsally it appears to have had a broad and shallow sinus (fig. 2 *b*).

The whole of the septate region of the shell is filled with crystalline calcite, which has destroyed every trace of the septa and siphuncle. The surface of the shell is perfectly smooth.

Remarks.—My attention was originally drawn to this species by my friend Mr. Joseph Wright, F.G.S., of Belfast, to whose collection it now belongs, and who kindly lent it to me for examination. It was formerly in the collection of Dr. Haines, of Cork, whose gatherings in the neighbourhood of that city supplied some of the material used by M'Coy in his 'Synopsis.' The specimen described is unique.

Affinities.—The evolute condition of the whorls in this species has suggested the view of its affinities expressed in the doubtful reference to *Aipoceras*.

This uncertainty is caused by the fact that the whorls in the individual here described are wider than high, while in *Aipoceras* (see p. 116) the reverse of this is the case. Its relationship, therefore, taking this feature into account, would lean rather towards *Solenocheilus* than *Aipoceras*, and the non-contiguity of the whorls may, when all is considered, be of less importance than their general conformation. The question must rest in uncertainty for the present.

Locality.—Near Cork.

Incertæ sedis.

A specimen belonging to the family Solenocheilidæ, but too imperfect for specific identification, is interesting from its exhibiting what *appears to be* a portion of the outer test, which is ornamented with very prominent, transverse, rugose lines. The general form of the shell is very similar to that of *Asymptoceras crassilabrum*, and this resemblance is particularly observable in the broad, slightly depressed periphery; the septa also, so far as they can be made out, agree with that species. The margin of the aperture is not preserved, a considerable part of the body-chamber having been broken off, thus destroying the evidence which might have established its identity with *A. crassilabrum*.

This is the specimen referred to by M'Coy [1] under the name of "*Nautilus dorsalis* (var. γ), Phill.," as being, at the time he wrote, in the collection of the Royal Dublin Society. It now forms part of the general collection of fossils in the Dublin Museum of Science and Art, and is labelled "Kildare." It seems to have been more nearly perfect when M'Coy described it, as he says "mouth nearly circular, receiving the preceding whorl at its ventral [= dorsal] margin." The rugose surface is referred to in his description, and this feature has been the means of identifying the specimen.

Sub-order—AMMONOIDEA.

Family—GLYPHIOCERATIDÆ.

Genus Brancoceras, *Hyatt* (not *Steinmann*), 1883 (emend. Holzapfel, 1889).

Brancoceras ornatissimum, *L. G. de Koninck*, sp. Plate XXXVII, figs. 1 *a—c*.

1881. Goniatites ornatissimus, *L. G. de Koninck*. Sur quelques céphalopodes nouveaux du calcaire carbonifère de l'Irlande. Ann. Soc. géol. de Belg., tom. ix, Mémoires, p. 53, pl. vi, figs. 4, 5.

1899. Brancoceras ornatissimum, *G. C. Crick*. Ann. and Mag. Nat. Hist., ser. 7, vol. iii, p. 453.

[1] 'Synops. Carb. Foss. Ireland,' 1844, p. 23.

Description.—Shell discoidal, compressed, with closed umbilicus; greatest thickness at about one-fourth of the height of the whorl from the umbilicus, about seven-tenths of the diameter of the shell; height of outer whorl about three-fifths of the diameter of the shell. Number of whorls unknown; inclusion complete. Sides very slightly convex, merging in the narrowly rounded and somewhat truncated periphery. Umbilicus closed with a callus, which extends to the centre of a shallow funnel-shaped depression. Whorls subcordate in cross-section. Body-chamber unknown, the septate portion alone being present in the sole individual found.

The septation is clearly exhibited, not only by the removal of the test, but also, owing to a fortunate transverse fracture, the greater part of a septum is exposed, thus giving an interior view, which shows the digitate form of the lobes and the cavities left between them (Pl. XXXVII, fig. 1 *b*).

The ornamentation is well marked and very elegant; it consists of distinct raised lines or fine ribs, separated by spaces which are a little wider than the latter. The ribs are from about ·75 to 1 mm. apart. Proceeding from the umbilicus they describe a wide-spread, forwardly directed curve, which merges in a greatly narrowed and backwardly directed sinus upon the periphery, indicating a deeply indented hyponomic sinus. The siphuncle is seen in section in the centre of the peripheral lobe, where it has a diameter of 2 mm.

Dimensions.

	Type specimen in Museum of Science and Art, Dublin.
Diameter of shell	68 mm.
Height of outer whorl (dorso-ventral) . .	41·5 ,,
,, above preceding whorl . . .	23 ,,
Thickness at umbilical margin . . .	46 ,,

Affinities.—Among the species belonging to this genus hitherto described there is none that can be strictly compared with the present one.

The Belgian Carboniferous species, *Brancoceras rotatorium*, de Kon.,[1] sp., resembles the latter in its rather depressed form and closed umbilicus, but the sutures differ in a marked degree. As de Koninck's species is only represented by an internal cast, no comparison can be made of the ornaments of the two species.

Remarks.—This beautiful form, the only one known to occur in the British Isles, is represented by the specimen which is the subject of the above description. Its true affinities had not been recognised until Mr. Crick, in looking over the small collection of Goniatites in the Geological Survey Collection (Dublin Museum of

[1] "Faune Calc. Carb. Belg.," 1880 ('Ann. Mus. Roy. d'Hist. Nat. Belg.,' tom. ii), pt. ii, p. 94, pl. xlvii, fig. 12.

Science and Art), found that not only was it the type of de Koninck's *Goniatites ornatissimus*, but that it belonged to the well-marked group of *Brancoceras* of Hyatt. The specimen had up to that time borne the name of "*Goniatites sphæricus*, var. *crenistria*," but with this species, it need scarcely be said, it has no features in common. It should be stated that the locality given by de Koninck (who must have got his information from an Irish source) for the present species—Tomdeelys, county of Limerick—does not agree with the one registered by the Geological Survey of Ireland, here accepted as authoritative.

Locality.—Glenbane East, county of Limerick.

Genus PERICYCLUS, *von Mojsisovics*, 1882 (emend. Hyatt, 1883; Holzapfel, 1889).

PERICYCLUS FUNATUS, *J. Sowerby*, sp. Plate XXXVIII, fig. 5; Plate XXXIX, figs. 1 *a*, *b*.

1813. ELLIPSOLITHES FUNATUS, *J. Sowerby*. Min. Conch., vol. i, p. 81, pl. xxxii.
1822. AMMONELLIPSITES FUNATUS, *J. Parkinson*. Introd. Foss. Org. Rem., pp. 164 and 233.
1828. NAUTILUS FUNATUS, *J. Fleming*. British Animals, p. 32.
1843. GONIATITES FUNATUS, *L. G. de Koninck*, in J. J. d'Omalius, Précis élém. géol., p. 515.
— NAUTILUS FUNATUS, *J. Morris*. Cat. Brit. Foss., p. 182.
1844. AMMONITES PRINCEPS (pars), *L. G. de Koninck*. Descrip. Anim. Foss. Terr. Carb. Belg., p. 579 (excl. figs.).
1848. GONIATITES PRINCEPS (pars), *H. G. Bronn*. Gesch. d. Natur., vol. iii, p. 543.
1888. — FUNATUS, *R. Etheridge*. Brit. Foss., vol. i, Palæozoic, p. 311.
1897. PERICYCLUS FUNATUS, *A. H. Foord and G. C. Crick*. Cat. Foss. Ceph. British Museum, pt. 3, p. 147.

Description.—Shell of moderate size, subdiscoidal, widely umbilicated; greatest thickness at the umbilical margin; height of outer whorl probably about one-third of the diameter of the shell. Whorls four or five; inclusion about one-half; umbilicus not very deep, nearly one-half of the diameter of the shell in width, with subangular margin. Whorl reniform in section, much wider than high; considerably indented by the preceding whorl; periphery broadly convex and continuous with the sides; inner margin narrow, well defined, steep.

Body-chamber, chambers, and suture-line not seen. Ornamentation consisting of strong, rounded, transverse ribs, as in *P. fasciculatus*, which bifurcate frequently in the young shell, apparently more rarely in the adult. The spaces between the ribs are a little wider than the ribs themselves. Constrictions occur apparently irregularly and at long intervals apart; these are bounded anteriorly by a somewhat stronger rib, upon which a conspicuous node is developed at the umbilical margin. There is no trace of the sharp raised lines which form such a marked feature in the ornamentation of *P. fasciculatus.* The ribs are almost direct upon the sides of the shell, and form a broad and shallow sinus upon the periphery.

Dimensions.

	Specimen in Museum, Trinity College, Dublin.
Diameter of shell (elliptical by rock pressure) .	78 mm.
„ umbilicus (suture to suture of the longer diameter)	36 „
Diameter of umbilicus (of the shorter diameter) .	30 „
Thickness at umbilical margin . . .	36 „

Affinities.—A comparison between this species and *P. fasciculatus* is made under the description of the latter (see below). From *P. plicatilis*, de Kon., it is easily distinguished by its more compressed shape, its wider and much shallower umbilicus, and its much coarser ribbing.

Remarks.—Only three specimens of this species are known to me, one of which is the type specimen in the British Museum ("Sowerby Collection"), unfortunately very imperfect (Pl. XXXVIII, fig. 5); another and much better specimen of about the same size contained in the museum of Trinity College, Dublin; and the third a young shell (cast) belonging to Mr. Joseph Wright, F.G.S., of Belfast. All three were obtained in the neighbourhood of Cork, and all are distorted in a similar manner. The pressure causing the distortion has operated from above in a direction oblique to the plane of the umbilicus such that the peripheral area, instead of being at right angles to that plane, as it would be normally, presents an angle of nearly 45° to it, as the result of this severe crushing.

The Trinity College specimen, mentioned above, was kindly lent to me by Professor J. Joly, F.R.S.

Localities.—"Blackrock range, south-east of Cork" (Sowerby's type in the British Museum); "Cork" (Trinity College specimen); "near Cork" (Mr. Wright's specimen, formerly in the collection of Dr. Haines, of Cork).

PERICYCLUS FASCICULATUS, *F. M'Coy*, sp. Plate XXXVII, figs. 2—6.

1844. NAUTILUS (TEMNOCHEILUS) FURCATUS, *F. M'Coy.* Synops. Carb. Foss. Ireland, p. 21, pl. iv, fig. 13.

— GONIATITES FASCICULATUS, *F. M'Coy.* Synops. Carb. Foss. Ireland, p. 13, pl. ii, fig. 8.

1850. AGANIDES SUBFURCATUS, *A. d'Orbigny.* Prod. de Paléont. stratigr., vol. i, p. 115.

1850. Aganides fasciculatus, *A. d'Orbigny.* Prod. de Paléont. stratigr., vol. i, p. 116.

1852. Ammonites Listeri (pars), *C. G. Giebel.* Fauna der Vorwelt, vol. iii, p. 476.

1854. Goniatites furcatus, *J. Morris.* Cat. Brit. Foss., 2nd ed., p. 303.

— — fasciculatus, *J. Morris.* Cat. Brit. Foss., 2nd ed., p. 303.

1855–57. Temnocheilus furcatus, *J. Kelly.* Journ. Geol. Soc. Dublin, vol. vii, p. 8.

— Goniatites fasciculatus, *J. Kelly.* Journ. Geol. Soc. Dublin, vol. vii, p. 7.

1888. Gastrioceras fasciculatum, *M. Tzwetaev.* Mém. Com. géol. St. Pétersbourg, vol. v, No. 3, p. 1.

1897. Pericyclus furcatus, *A. H. Foord and G. C. Crick.* Cat. Foss. Ceph. British Museum, pt. 3, p. 149, fig. 71.

— — fasciculatus, *A. H. Foord and G. C. Crick.* Cat. Foss. Ceph. British Museum, pt. 3, p. 148.

[Not 1841. *Goniatites furcatus,* G. Münster, Beitr. zur Petrefactenkunde, iv, p. 128, pl. xiv, fig. 11.]

Description.—Shell discoidal, somewhat inflated, umbilicated; greatest thickness at the umbilical margin, where it is two-thirds of the diameter of the shell; height of outer whorl two-fifths of the diameter of the shell. Whorls not fewer than five (exact number not ascertainable); inclusion about one-half; umbilicus somewhat less than one-half of the diameter in width, with subangular margin, deep, partly exposing the inner whorls. Whorl reniform in section, about twice as wide as high, not much indented by the preceding whorl; periphery broadly convex, continuous with the convex sides; inner margin rather wide, well defined, very steep.

Body-chamber occupying at least one whorl; aperture not seen. Chambers of moderate depth; suture-line as in Pl. XXXVII, fig. 6. Test ornamented with strong, rounded, transverse ribs, which generally begin to bifurcate at or near the umbilical margin, the bifurcation in some specimens not taking place till the middle of the sides is reached. The ribs form a broad, shallow sinus in crossing the periphery, the sinus sometimes becoming sharply concave in the median line; the intervening concave spaces wider than the ribs. Covering the ribbing and interspaces there are a series of very distinct, sharp, raised lines, disposed irregularly as regards their distance apart; on the ribs about two of the lines occupy the space of 1 mm., but between them the lines are a little more spread out. The tendency of these fine ribs to form bundles is well marked, and made the name "fasciculatus," given by M'Coy to the specimen bearing the test, singularly appropriate.

Affinities.—Though at first sight there is much resemblance between *P. fasciculatus* and *P. funatus*, yet on a closer inspection it is seen that the differences far outweigh the resemblances. *P. funatus* is the more slowly tapering shell of the two, and has more numerous whorls, giving a considerably larger umbilical area. Again, though the ribs (at least in casts) are similar in character in the two species, the bundles of finer ribbing in *P. fasciculatus*, only seen when the test is preserved, are entirely absent in *P. funatus*. The two species agree perfectly in the bifurcation of the ribbing, and M'Coy, who seems to have relied upon Sowerby's description, is not accurate when he states that the ribs in *P. funatus* (he calls them "ridges") are "simple, equal, and proceed directly across the shell." Periodic constrictions are present in both species.

From *P. multicostatus*, sp. nov. (p. 139), the present species can be easily distinguished by its less numerous and much coarser ribs and larger umbilicus, and the same features distinguish it still more manifestly from *P. Doohylensis*, which is remarkable for the extreme fineness of its ribbing.

Remarks.—While looking over the choice collection of Carboniferous Limestone fossils in the possession of Mr. Joseph Wright, of Belfast, found chiefly in Cork and places in its vicinity, he drew my attention to a specimen of the so-called *Nautilus* [*Pericyclus*] *furcatus* from Blackrock, in which a portion of the test was preserved, pointing out that the ornamentation was precisely that of the specimen to which M'Coy gave the name "*Goniatites*" *fasciculatus*, in allusion to the bundles of sharp raised lines or fine ribs covering the test.[1] Fortunately M'Coy's type is still extant (Pl. XXXVII, fig. 5), and a comparison of it with Mr. Wright's specimen soon convinced me that that observer was quite correct in his view of the identity of the two so-called species. In most specimens of *P. fasciculatus* collected the test is stripped off and remains in the parent rock, nothing but the cast being left in the collector's hands. This explains M'Coy's omission to notice the finer ribbing, since his specimen was doubtless a cast. It is unfortunately missing from the "Griffith Collection" of the Dublin Museum, in which many of M'Coy's type specimens are contained, but the excellent figure of it in the 'Synopsis' renders it easy of identification.

Though all the specimens of the present species known to me from Cork and its vicinity are more or less distorted, some excessively so, those from other parts of Ireland are of the normal shape. One of these, collected by myself in the Clane quarries, was figured in the 'Catalogue of Fossil Cephalopoda, British Museum,' Part 3, and shows the natural form. It is refigured in the present work (Pl. XXXVII, fig. 2), and may be compared with the larger individual represented on the same plate (fig. 3). Owing to the crushing the latter has been subjected to, its true shape is altered, and the lateral view (fig. 3 *a*) shows some of the peripheral

[1] This name must be retained to the exclusion of *furcatus* (1) because it was the first to be described in the 'Synopsis,' and (2) because it shows the ornaments on the test, whereas the name *furcatus* was applied merely to the cast of the shell.

area (especially on the left-hand side of the figure), none of which would have come into view but for the distortion (cf. fig. 2 *b*). On comparing fig. 3 *a* with M'Coy's figure ('Synopsis,' pl. iv, fig. 13) it will be seen that the latter is pressed into an elliptical form, the crushing in this case having been exerted in a direction vertical to the plane of the umbilicus and sides of the shell, instead of, as in my shell, oblique to that plane. There is a specimen in Mr. Wright's collection exactly similar to the one represented in M'Coy's figure, both in its size and in the manner of its distortion.

Localities.—Cork, Midleton, Blackrock, in the county of Cork; Glenbane, county of Limerick; Clane, county of Kildare.

PERICYCLUS DOOHYLENSIS, *A. H. Foord and G. C. Crick.* Plate XXXVII, figs. 8 *a*—*c*.

1897. PERICYCLUS DOOHYLENSIS, *A. H. Foord and G. C. Crick.* Cat. Foss. Ceph. British Museum, pt. 3, p. 151, fig. 72.

Description.—The following is the diagnosis of this species given in the 'Catalogue of Fossil Cephalopoda in the British Museum,' from which it will be seen that two forms of the species, one being more compressed than the other, were recognised. No new material has been since acquired.

Shell discoidal, somewhat inflated, umbilicated; greatest thickness near the umbilical margin, from about five-eighths (in the inflated form) to about five-ninths (in the compressed form) of the diameter of the shell; height of outer whorl from about two-fifths (in the inflated form) to about four-ninths (in the compressed form) of the diameter of the shell. Whorls few, but exact number unknown; inclusion about three-fourths; umbilicus deep, exposing the edges of the inner whorls, about one-fourth of the diameter of the shell in width. Whorl semilunate (in the inflated form) or semi-elliptical (in the compressed form) in section, wider than high, indented to about one-quarter of its height by the preceding whorl; periphery broadly convex, sides convex, a little more flattened in the compressed than in the inflated form; inner margin well defined, convex, nearly at right angles to the plane of symmetry.

Body-chamber occupying the whole of the last whorl; aperture with a broad and very shallow peripheral sinus. Suture-line as in Pl. XXXVII, fig. 8 *c*. Test ornamented with numerous very fine, rounded, transverse ribs, separated by rather wider interspaces; the ribs are nearly direct on the lateral area, and form on the periphery a broad, very shallow, forwardly concave sinus; they bifurcate near the umbilical margin at rare intervals. The outer whorl with about four constrictions, the rib immediately posterior to each of the latter being somewhat stronger than the rest; bifurcation takes place here.

Dimensions.

	British Museum (C. 5934). Inflated form.	Compressed form.
Diameter of shell . .	40 mm. .	45 mm.
" umbilicus . .	10 " .	11·5 "
Height of outer whorl . .	16 " .	20 "
" " above preceding whorl . . .	12 " .	15 "
Thickness at umbilical margin .	24·5 " .	25 "

Affinities.—The affinities between this species and *P. multicostatus* are pointed out under the description of the latter. It is also nearly related to *P. Kochi*, Holzapfel,[1] but is more widely umbilicated and more compressed. The fineness of its ribbing, added to the periodic constrictions, brings it also into relationship with "*Goniatites*" (*Pericyclus ?*) *impressus*, de Kon., sp.[2] This comparison applies especially to the compressed form of *P. Doohylensis;* another species related to the last named is "*Goniatites*" (*P. ?*) *virgatus*, de Kon., sp.,[3] which is, however, still more compressed, and has a smaller umbilicus.

Remarks.—This species is apparently greatly restricted in its stratigraphical range in the horizontal sense, being confined, so far as is known, to the two localities cited below. It was collected at Doohyle by the writer in a small slab of decomposing limestone, in a railway cutting on the line of the Limerick and Foynes Railway, not far from Rathkeale. The type specimen is in the British Museum, but others are to be found in the Dublin Museum of Science and Art.

Locality.—Doohyle, near Rathkeale, and Glenbane (compressed form), county of Limerick.

PERICYCLUS MULTICOSTATUS, sp. nov. Plate XXXVII, figs. 7 *a*—*c*.

Description.—Shell discoidal (rendered elliptical by rock pressure), inflated, rather narrowly umbilicated, greatest thickness at the umbilical margin, where the shell expands slightly near the aperture; height of outer whorl, compared with this dimension, as 5 : 7. Whorls few, inclusion fully three-fourths. Umbilicus

1 'Paläont. Abhandl.,' Dames und Kayser, vol. v, i, 1889, p. 35, pl. iii, figs. 2—7.

2 "Faune Calc. Carb. Belg.," 1880 ('Ann. Mus. Roy. d'Hist. Nat. Belg.,' tom. ii), pt. ii, p. 118, pl. xlix, fig. 3.

3 Loc. cit., p. 118, pl. xlix, fig. 4.

moderately deep, with subangular margin, about two-ninths the diameter of the shell in width, partly exposing the inner whorls. Whorl semilunate in section, considerably wider than high, indented to about one-third of its height by the preceding whorl. Periphery broadly convex, merging into the rather flattened sides; inner (umbilical) margin rather steep, not very well defined.

Body-chamber unknown. Suture-line as in Pl. XXXVII, fig. 7 *c*.

Shell (as indicated on the cast) ornamented with numerous rounded ribs, numbering about five in the space of 1 cm., therefore more numerous than in *P. fasciculatus*, in which there are only four in that space. Interspaces between the ribs somewhat wider than the latter. The ribs bend backwards in passing over the periphery, and form there a shallow median sinus. The fragments of the test that remain are too imperfect to admit of the surface markings being determined. So far as can be discovered in the somewhat unfavourable condition of the cast, bifurcation of the ribs in the adult shell appears to be quite exceptional, but in the young it occurs more frequently, though not as a characteristic feature, as in *P. fasciculatus*. Constrictions separated by wide intervals are seen upon the cast, which would probably be covered by the test when present.

Dimensions.

	Specimen in Mr. Joseph Wright's Collection.
Diameter (longer) of shell (elliptical by rock pressure)	65 mm.
„ „ umbilicus . . .	15 „
Height of outer whorl	32 „
„ „ above preceding whorl .	21 „
Thickness at umbilical margin . . .	35 „

Affinities.—The resemblance between this species and *P. fasciculatus* has already been adverted to; the type of ornamentation is the same; the points in which they differ are sufficiently plain, and they are these: (1) the character of the ribbing, which is much finer in the present species than in *P. fasciculatus*, bifurcation being the exception in the former, and not the rule, as in the latter; (2) the size of the umbilicus, which is smaller in the present species than in *P. fasciculatus*.

From *P. Doohylensis* the present species is distinguished chiefly by its coarser ribbing; it is thus seen that in this feature *P. multicostatus* comes between *P. fasciculatus* and *P. Doohylensis*.

The difference in the septation between *P. multicostatus* and *P. Doohylensis* may be appreciated on comparing the figures of these species on Pl. XXXVII (figs. 7 and 8).

Remarks.—The specimen from which the above description has been drawn up was kindly lent to me by Mr. Joseph Wright.

Locality.—Midleton, county of Cork; Glenbane East, county of Limerick.

PERICYCLUS FOORDI, *G. C. Crick.* Plate XXXVIII, figs. 3 *a*, *b*, 4.

1899. PERICYCLUS FOORDI, *G. C. Crick.* Ann. Mag. Nat. Hist., ser. 7, vol. iii, p. 430, fig. 1.

Description.—The following is Mr. Crick's description of this species, drawn up from the original specimen:—" Shell discoidal, somewhat compressed, and rather widely umbilicated; greatest thickness at the margin of the umbilicus, rather more than two-fifths of the diameter of the shell; height of outer whorl a little more than three-sevenths of the diameter of the shell. Whorls eight or nine; inclusion fully three-fourths; umbilicus rather deep, displaying the umbilical margins of all the inner whorls, about three-tenths of the diameter of the shell in width. Whorl semi-elliptical in cross-section, a little higher than wide, indented to about two-fifths of its height by the preceding whorl; periphery convex, imperfectly defined, sides feebly convex; umbilical zone well defined, sloping towards the umbilicus, and making an obtuse angle with the sides, rather narrow.

" Body-chamber not fully seen, but occupying at least one-half of the outer whorl; aperture not seen, but the peristome (judging by the ornaments and the lines of growth) probably with a feeble lateral crest at about the middle of the lateral area and a deep and wide hyponomic sinus. Depth of chambers not seen; suture-line only imperfectly known.

" Test ornamented with fine, backwardly directed, and somewhat irregularly spaced riblets, which form rather a low crest at about the middle of the lateral area, and a deep and wide hyponomic sinus on the periphery, where some of them are thicker than the rest and somewhat regularly placed. Up to a diameter of about 56 mm. the test is ornamented with rather coarse, regularly placed ribs, which are separated by interspaces a little wider than themselves, and have the same direction as the ornaments of the adult."

Dimensions.

	Cast of type specimen in Museum of Science and Art, Dublin.	Specimen from Cloghran, in British Museum (No. C. 7972).
Diameter of shell	106·5 mm.	122 mm.
,, umbilicus (edge to edge)	42 ,,	48 ,,
,, ,, (suture to suture)	32 ,,	40 ,,
Height of outer whorl	47 ,,	53 ,,
Thickness of shell at umbilical margin	46 ,,	52 ,,

Supplementary Description.—By the acquisition of more nearly complete specimens I am enabled to amplify Mr. Crick's diagnosis as follows:—(1) The suture-line has been artificially worked out in a young shell, with a diameter of 68 mm., from Cloghran,[1] in which it is very clearly shown (Pl. XXXVIII, fig. 4). (2) Another feature worthy of note is a flattening of the peripheral area in the young shell, scarcely observable in the (older) type specimen. This flattening amounts almost to truncation at this stage of growth, but becomes obsolete at a diameter of about 100 mm. In the young shell above referred to it defines the area of the periphery, upon which the ribs are disposed in a remarkably regular manner, as observed by Mr. Crick. (3) Judging by the new material placed at my disposal, I think Mr. Crick's estimate of the number of whorls in this species is somewhat excessive. The original specimen, of which I have a plaster cast before me, is broken across the umbilicus, making it difficult to compute the number of the younger whorls. I should put down the total number of whorls at about five, or six at the utmost.

Affinities.—The subject of the relationship of the present species to *Pericyclus subplicatilis*, Crick, is discussed under the description of the latter (below); it will, therefore, only be necessary here to refer to some other species which it resembles. *P. rotuliformis*, Crick,[2] may be taken first; this species bears at least a general resemblance to *P. Foordi* in form and ornamentation, but as respects the first it is a flatter shell, and as to the second feature the ribbing is stronger, and it possesses, in addition, very strong periodic constrictions which give it the wheel-like aspect that suggested its name. In *P. Bailyi*, Crick,[3] we have a species which, while it has a decided resemblance to the present one in its ornamentation, differs from it in its much more inflated form and relatively larger umbilicus.

Localities.—St. Doulagh's (type specimen) and Cloghran, county of Dublin.

PERICYCLUS SUBPLICATILIS, *G. C. Crick.* Plate XXXVIII, figs. 1 *a*, *b*, 2.

1899. PERICYCLUS SUBPLICATILIS, *G. C. Crick.* Ann. and Mag. Nat. Hist., ser. 7, vol. iii, p. 442, figs. 8, 9.

Description.—Mr. Crick gives the following description of this species:—"Shell discoidal, somewhat compressed, moderately widely umbilicated; greatest thickness almost close to the margin of the umbilicus, about two-fifths of the diameter of the shell; height of outer whorl about two-fifths of the diameter of the shell. Whorls six or seven, inclusion four-fifths; umbilicus rather deep, with subangular margin, exposing the edges of the inner whorls, about three-tenths of the diameter of the shell in width. Whorl semi-elliptical in cross-section, about as high as wide, indented to about one-fifth of its height by the preceding whorl; periphery

[1] Now in the British Museum (No. C. 7973).

[2] 'Ann. Mag. Nat. Hist.,' ser. 7, vol. iii, 1899, p. 434, fig. 3.

[3] Ibid., p. 438, figs. 6, 7.

broadly convex, imperfectly defined; sides feebly convex, somewhat flattened near the umbilical margin; umbilical zone narrow, well defined, nearly perpendicular to the plane of symmetry of the shell.

"Body-chamber occupying the whole of the last whorl; aperture not seen, but, judging by the growth-lines and ornaments, the peristome probably nearly straight on the lateral area, and with a deep and broad hyponomic sinus. Chambers [shallow]; suture-line as in [Pl. XXXVIII, fig. 2].

"Test ornamented with feeble, somewhat inequidistant ribs, which, arising at the umbilical margin, pass thence obliquely backward as far as the margin of the periphery, where they bend somewhat abruptly backward, and form on the periphery a deep and wide hyponomic sinus; on the periphery the ribs become nearly equidistant, fairly coarse, and separated by interspaces of about their own width; the ornaments gradually disappear on the outer whorl, those on the lateral area disappearing first, and the ribs on the periphery at about the middle of the last whorl. The whole surface of the test with very fine growth-lines."

Dimensions.

	Cast of type specimen, in Museum of Science and Art, Dublin.	Specimen from St. Doulagh's, in the Woodwardian Museum, Cambridge.
Diameter of shell	113·5 mm.[1]	120 mm.
,, umbilicus (edge to edge)	40 ,,	45 ,,
,, ,, (suture to suture)	33 ,,	37 ,,
Height of outer whorl	43·5 ,,	50 ,,
,, above preceding whorl about	35 ,,	— ,,
Thickness of shell at umbilical margin	44 ,,	43 ,,

Affinities.—Mr. Crick recognised the close resemblance in the ornamentation of the present species to that of *Goniatites plicatilis*, de Kon.,[2] which undoubtedly exists, but the two species differ widely in form. *P. plicatilis*[3] has a much more inflated and thicker shell than *P. subplicatilis*, and the umbilicus is more cavernous in form and has steeper sides than the latter. More complete material has convinced me that in the aggregate of characters *P. Foordi* is the most nearly

[1] This specimen has been broken across and the fissure filled with calcite, so that the diameter of the shell and the height of the last whorl appear to be greater than they really are; the diameter appears to be 122 mm., and the height of the outer whorl 55·5 mm. (Foot-note in Mr. Crick's description of this species, *loc. cit.*, p. 444,—to which may be added that the interposed vein of calcite referred to, by adding to its length, gives the shell an elliptical shape.)

[2] "Sur quelques Céphalopodes nouveaux du calcaire carbonifère de l'Irlande," 'Ann. Soc. géol. de Belgique,' vol. ix, Mémoires, 1881, p. 55, pl. v, figs. 3, 4.

[3] This species will be described and figured later on in this Monograph.

related species to *P. subplicatilis.* I have found, in fact, no inconsiderable difficulty in distinguishing the two, in spite of Mr. Crick's careful diagnosis of them; this difficulty arises partly from the imperfection of the specimens available for description when he wrote, and partly from the fact that there are no specimens of the young shell of *P. subplicatilis* to compare with that of *P. Foordi*, which shows it exposed by the breaking away of the outer whorl. There is good reason for supposing, however, that the young shell in *P. subplicatilis* was much more compressed in form than that of *P. Foordi*, which is remarkable at this stage of growth for the breadth of its whorls compared with their height—a feature which is not maintained in the adult shell. On a comparison of the ornamentation of the two species it is seen that in *P. Foordi* the ribbing when crossing the periphery makes a broader median sinus than that of *P. subplicatilis*, and this is found to be due to the considerably greater breadth of the periphery in the former species, perhaps the most easily distinguishable feature when an appeal has to be made solely to external characters.

When the sutures are compared it will be observed that there are not wanting distinctive marks whereby the differences between the two species are further accentuated. These consist (1) in the greater proximity of the sutures, indicating shallower chambers in *P. Foordi;* (2) in the disposition of the lateral in relation to the peripheral lobe in that species when contrasted with *P. subplicatilis.*

Remarks.—This species is rather plentiful at St. Doulagh's, though the specimens hitherto collected there are all more or less imperfectly preserved, and some are in a crushed condition.

I must express my great indebtedness to the authorities of the Woodwardian Museum, Cambridge, represented by Mr. F. R. Cowper Reid, M.A., F.G.S., who most kindly sent me several interesting specimens obtained at St. Doulagh's, one of which is figured on Pl. XXXVIII. By the loan of these specimens I have been much assisted in completing the description of the present species.

Locality.—St. Doulagh's, county of Dublin.

PERICYCLUS TRAPEZOIDALIS, *G. C. Crick.* Plate XXXIX, figs. 2 *a—d.*

1899. PERICYCLUS TRAPEZOIDALIS, *G. C. Crick.* Ann. Mag. Nat. Hist., ser. 7, vol. iii, p. 432, fig. 2.

Description.—The original diagnosis runs as follows:—" Discoidal, flattened, rather widely umbilicated; greatest thickness at the margin of the umbilicus, nearly four-elevenths of the diameter of the shell; height of outer whorl about four-elevenths of the diameter of the shell. Whorls fairly numerous (exact number not known); inclusion rather more than one-half; umbilicus shallow, displaying the edges of all the inner whorls, about three-eighths of the diameter of the shell in width, with subangular margin and nearly vertical sides. Whorl subtrapezoidal in cross-section, about as high as wide; indented to about one-fourth of its height by the preceding whorl; periphery narrowly convex, imperfectly defined; sides feebly convex, a little flattened near the umbilicus, and becoming more flattened and convergent on the body-chamber; umbilical zone well defined, narrow, almost perpendicular to the plane of symmetry of the shell. Body-chamber occupying nearly a complete whorl; aperture not seen, but the peristome (judging by the lines of growth) probably with a broad, feeble lateral crest and a fairly deep hyponomic sinus. Depth of chambers not seen; suture-line only imperfectly seen. Test ornamented with narrow, prominent ribs, which pass obliquely backward from the umbilical margin, cross the lateral area in a feeble anteriorly convex curve, and form on the periphery a fairly deep and wide hyponomic sinus; interspaces flat, nearly twice as wide as the ribs; the whole surface of the ribs and interspaces (when well preserved) with fine, close-set lines of growth, especially on the body-chamber. The outer whorl with numerous (nine or ten) constrictions, following the course of the ornaments of the test. 'Wrinkle-layer' composed of fine, regular, close-set longitudinal lines."

Dimensions.

	Unique specimen in Museum of Science and Art, Dublin.
Diameter of shell	141 mm.
,, umbilicus (suture to suture) . .	49 ,,
,, ,, (edge to edge) . . .	53 ,,
Height of outer whorl	51 ,,
,, above preceding whorl (about) . . .	30 ,,
Thickness of outer whorl	50 ,,

Supplementary Description.—Crossing the ribs and interspaces nearly at a right angle, and thus running in accordance with the curvature of the whorls, are a series of fine raised lines which may easily be seen in a favourable light by the naked eye. On examining the surface of the test with a low magnifying power there is a decided appearance of these lines having formed nodes in crossing the ribs, but the condition of preservation makes this point a doubtful one (Pl. XXXIX, fig. 2 *c*).

The highly ornate character of the test in this species will make it easily recognisable should other specimens fall into the hands of collectors.

Owing partly to distortion, partly perhaps to the grinding of the surface in the effort to develop the sutures having been carried too deep, the latter are not satisfactorily shown, but their general plan can very well be seen (Pl. XXXIX, fig. 2 *d*).

It will be noticed in the drawing that the wall of the siphuncular neck has been cut through, exposing it as a short open tube.

I think it would be a great advantage if authors were to display, whenever this is possible, more than one suture-line, and thus show the distance separating the chambers, as well as the relation of the sutural lines to each other. A suture-line is hardly ever developed without exposing the neighbouring one, either wholly or in part, and the illustrations will be more instructive when they include the latter, even if imperfect.

Affinities.—As one of the distinguishing marks of this species, Mr. Crick points out the " flattened trapezoidal form of the cross-section of its whorls." The ornamentation also is so distinct and characteristic as to be in itself a sufficient means of identification. The only species having any obvious resemblance to the present one is *Pericyclus rotuliformis*, G. C. Crick,[1] but this has much less conspicuous ribbing, while, on the other hand, the constrictions are much stronger than those of *P. trapezoidalis*.

Locality.—Clane, county of Kildare. (Mr. Crick has erroneously given St. Doulagh's as the locality.)

[1] 'Ann. Mag. Nat. Hist.,' ser. 7, vol. iii, p. 435, fig. 3.

PLATE XXXIII.[1]

SOLENOCHEILUS DORSALIS, *J. Phillips*, sp.

Lateral view of a large and nearly perfect specimen. Clane. Dublin Museum of Science and Art. (Page 126.)

[1] The figures in this and the following plates represent the specimens of the natural size unless the contrary is stated.

W H Crowther lith.

PLATE XXXIV.

SOLENOCHEILUS DORSALIS, *J. Phillips*, sp.

Front view of the individual drawn on Pl. XXXIII. Clane. Dublin Museum of Science and Art. (Page 126.)

A H F del.
W H Crowther lt

West, Newman imp

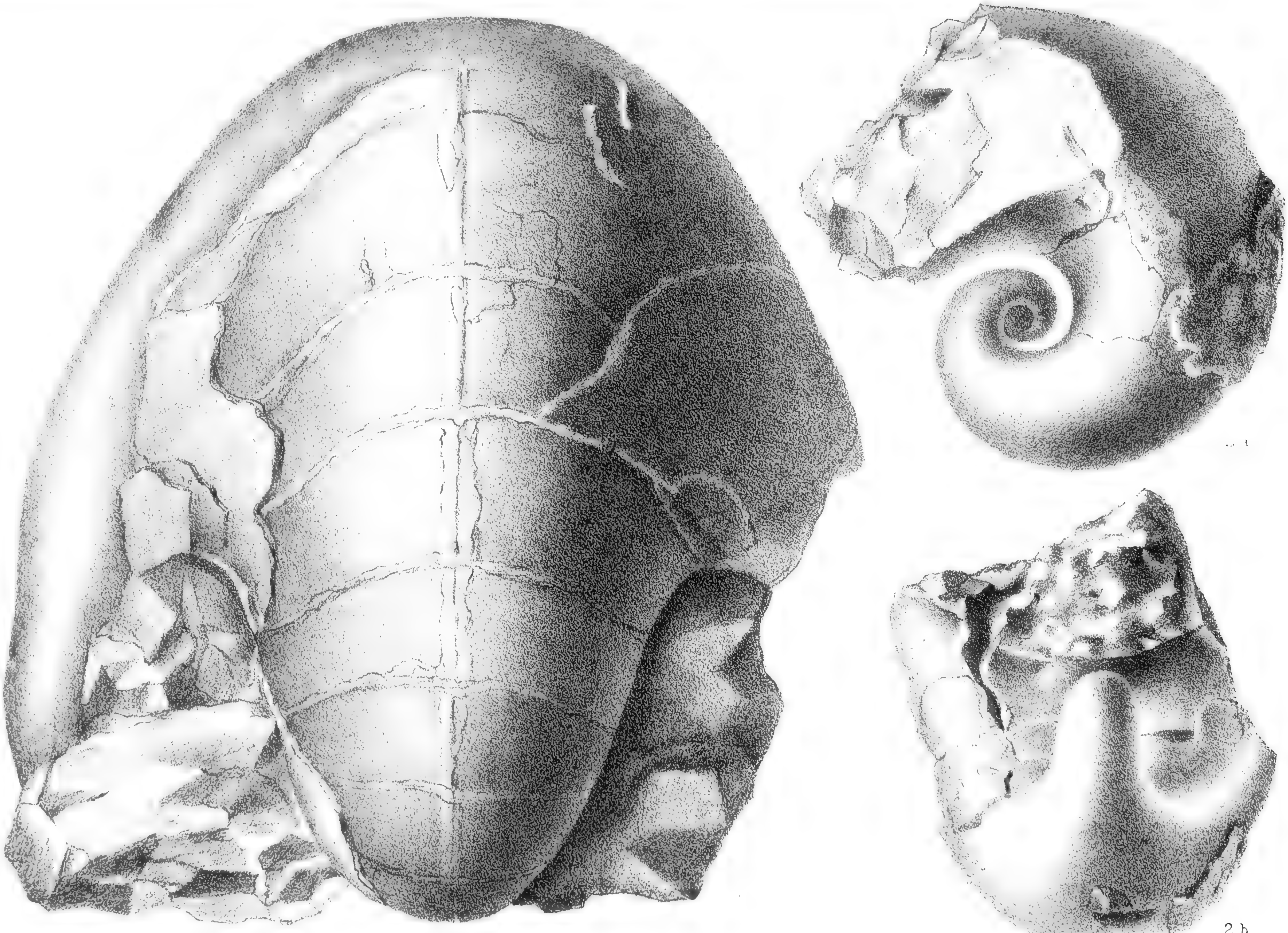
PLATE XXXV.

SOLENOCHEILUS DORSALIS, *J. Phillips*, sp.

Fig. 1. Peripheral view of a large specimen, showing the sutures and the remains of the siphuncle upon the cast. Rathkeale. Dublin Museum of Science and Art (Geological Survey Collection). (Page 127.)

AIPOCERAS ? HAINESIANUM, sp. nov.

Fig. 2 *a*. Lateral view of an imperfect and distorted individual. (Since this figure was drawn the matrix has been cleared away from the apical part of the shell, disclosing the fact that the whorls are free—that is, non-contiguous—from the initial point.) 2 *b*. Front view of the same individual. Near Cork. Mr. Joseph Wright's Collection. (Page 131.)



2 b

A.H.F. del
W.H. Crowther lith

West, Newman imp

PLATE XXXVI.

SOLENOCHEILUS ? HIBERNICUS, *A. H. Foord.*

Fig. 1 *a*. Lateral view of a nearly perfect individual. 1 *b*. Front view of the same, reduced in size. Ireland (exact locality unknown). British Museum, type specimen (No. C. 4505). (Page 128.)

Fig. 2. Lateral view of a specimen from Bolland, Yorkshire, showing the septation more completely than fig. 1 *a*. British Museum, "Gilbertson Collection" (No. C. 212). (Page 129.)

SOLENOCHEILUS ? CLAUSUS, sp. nov.

Fig. 3. Lateral, somewhat foreshortened view, showing the callus closing the umbilicus. Little Island. British Museum. (Page 130.)

PLATE XXXVI

W H Crowther del
A H F dir

West Newman imp

PLATE XXXVII.

Brancoceras ornatissimum, *L. G. de Koninck*, sp.

Fig. 1 *a*. Lateral view of the type specimen, showing the closed umbilicus. 1 *b*. Front view of the same, showing the surface of a septum with the cavities between the lobes. 1 *c*. Suture-line. Glenbane East. Dublin Museum of Science and Art (Geological Survey Collection). (Page 132.)

Pericyclus fasciculatus, *F. M'Coy*, sp.

Fig. 2 *a*. Front view of an undistorted specimen. 2 *b*. Lateral view of the same. Clane. British Museum. (Page 135.)

Fig. 3 *a*. Lateral view of a somewhat distorted specimen. 3 *b*. Peripheral view of the same. Midleton. Mr. Joseph Wright's Collection. (Page 137.)

Fig. 4 *a*. Lateral view of a young individual. 4 *b*. Peripheral view of the same. Glenbane East. Dublin Museum of Science and Art (Geological Survey Collection). (Page 135.)

Fig. 5 *a*. Lateral view of the type specimen of "*Goniatites*" *fasciculatus*, M'Coy. 5 *b*. Peripheral view of the same. 5 *c*. Enlargement of a portion of the ornamentation to show more clearly the fasciculate character of the ribbing. Millicent, Clane. Dublin Museum of Science and Art ("Griffith Collection"). (Page 137.)

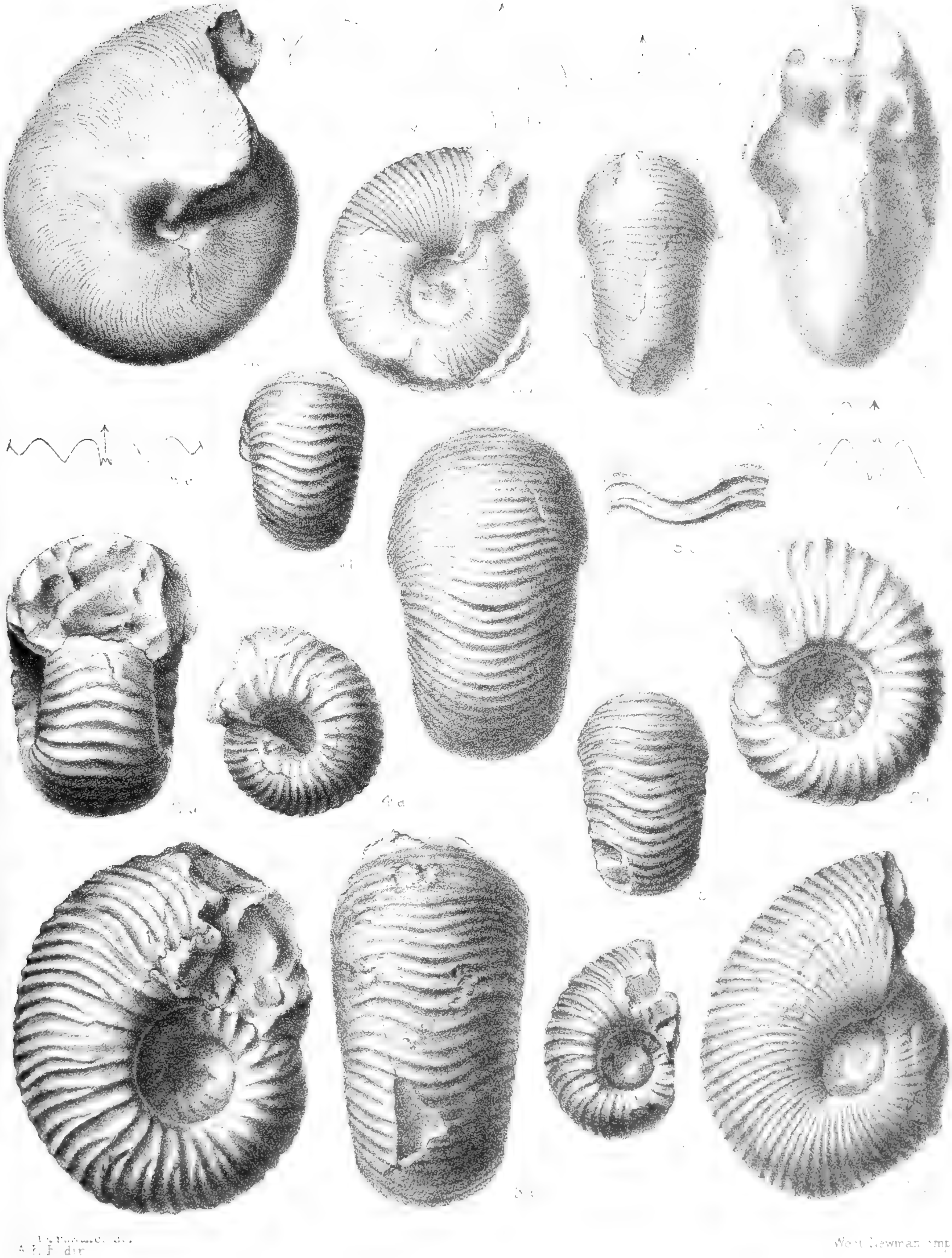
Fig. 6. Suture-lines of a small specimen where the diameter of the shell is about 30 mm. (A figure of the suture-line of a specimen nearly the same size as the above will be found in the 'Cat. Foss. Ceph., Brit. Mus.,' pt. iii, 1897, p. 150, fig. 71 *c*.) Glenbane. Dublin Museum of Science and Art. (Page 136.)

Pericyclus multicostatus, sp. nov.

Fig. 7 *a*. Lateral view of a somewhat distorted specimen, the umbilical cavity of which is filled with the matrix. 7 *b*. Peripheral view of the same. 7 *c*. Suture-lines of the same. Midleton. Mr. Joseph Wright's Collection. (Page 139.)

Pericyclus Doohylensis, *A. H. Foord and G. C. Crick*.

Fig. 8 *a*. Lateral view of a specimen of the compressed form of the species. 8 *b*. Peripheral view of the same. 8 *c*. Suture-line, taken from fig. 72 *c* of 'Cat. Foss. Ceph., Brit. Mus.,' pt. iii, 1897, p. 151. Doohyle. British Museum. (Page 138.)



A.H.F. dir

West Newman imp

PLATE XXXVIII.

Pericyclus subplicatilis, *G. C. Crick.*

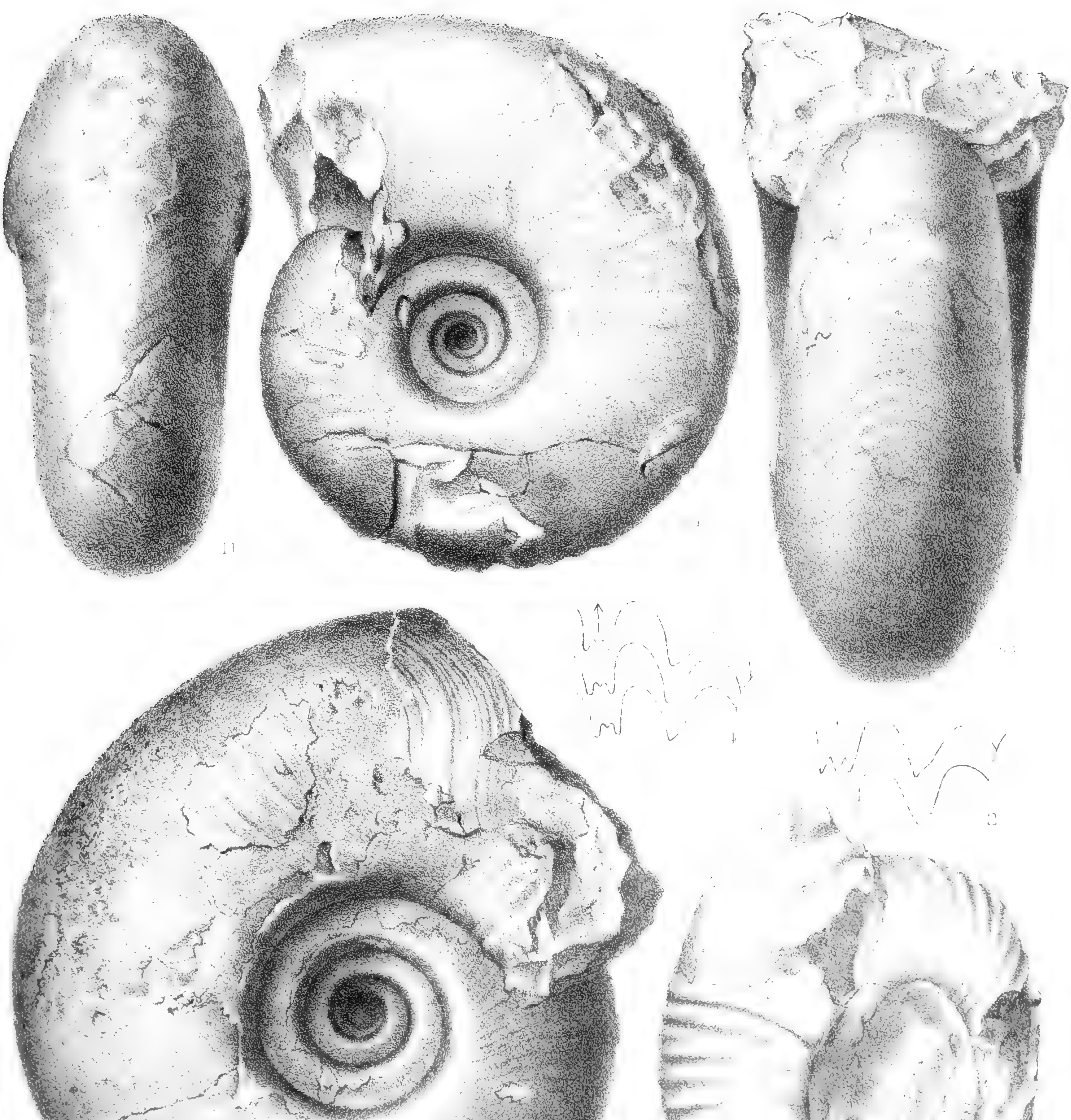
Fig. 1 *a.* Lateral view of an imperfect individual which is not quite so large as others that have been obtained at the same locality. 1 *b.* Peripheral view of the same. 2. Suture-lines from another individual. St. Doulagh's. Woodwardian Museum, Cambridge. (Page 142.)

Pericyclus Foordi, *G. C. Crick.*

Fig. 3 *a.* Lateral view of a remarkably fine specimen with some of the test preserved. 3 *b.* Front view of the same. 4. Suture-lines from a smaller individual. Cloghran. British Museum. (Page 141.)

Pericyclus funatus, *J. Sowerby*, sp.

Fig. 5. Lateral view of the distorted and imperfect type specimen. Blackrock. British Museum ("Sowerby Collection"). (Page 134.)



del. West, Newman imp.

PLATE XXXIX.

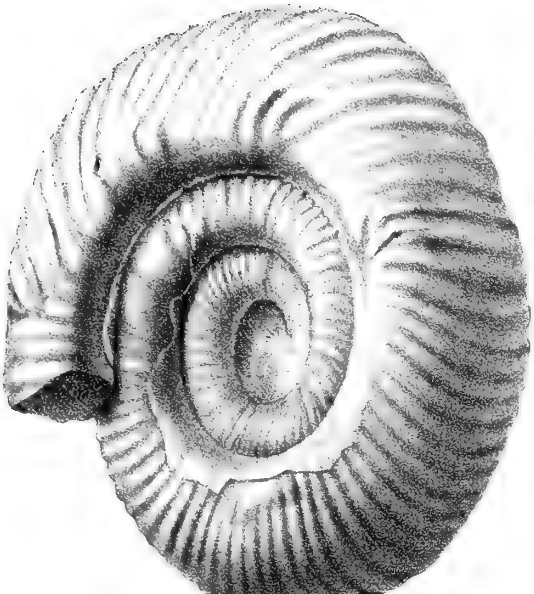
PERICYCLUS FUNATUS, *J. Sowerby*, sp.

Fig. 1 *a*. Lateral view of a distorted but otherwise fine specimen, showing the inner whorls which are only imperfectly preserved in the type specimen figured on Pl. XXXVIII. 1 *b*. Peripheral view of the same. Cork. Trinity College, Dublin. (Page 135.)

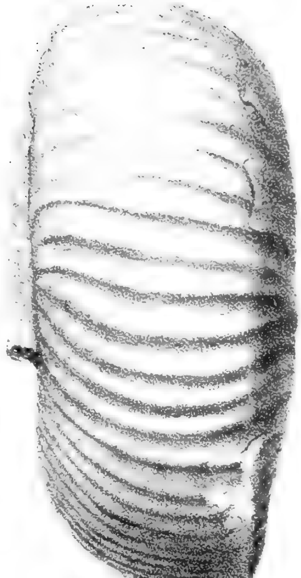
PERICYCLUS TRAPEZOIDALIS, *G. C. Crick*.

Fig. 2 *a*. Lateral view of the only individual known, showing the strong ribbing with the numerous constrictions. 2 *b*. Peripheral view of the same. 2 *c*. Enlargement of a portion of the ornamentation, showing more clearly the longitudinal lines crossing the ribs. 2 *d*. Suture-lines. Clane. Dublin Museum of Science and Art. (Page 144.)

PLATE XXXIX

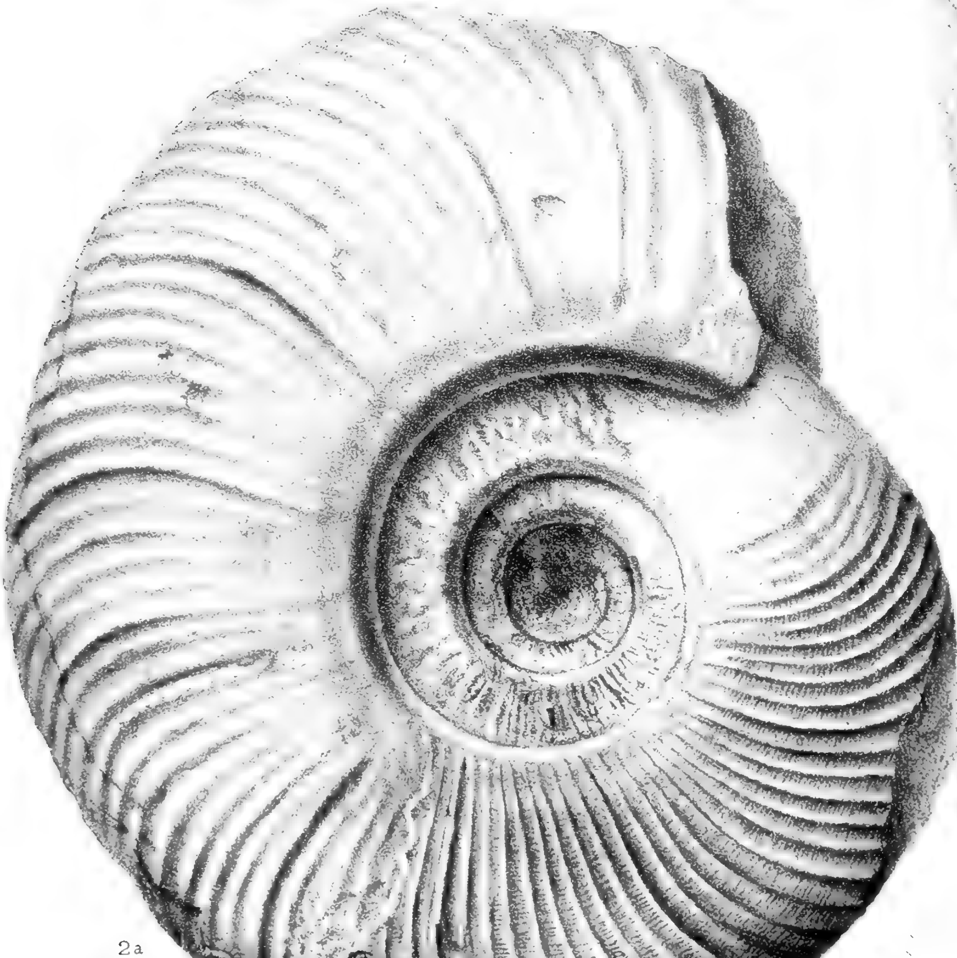


1a



1b

2b



2a

2c

2d

A.T. Hollick del et lith.
AHF dir.

West, Newman imp.

THE

PALÆONTOGRAPHICAL SOCIETY.

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MDCCCCI.

A MONOGRAPH

OF

BRITISH GRAPTOLITES.

BY

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AND

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PART I.

DICHOGRAPTIDÆ.

PAGES 1—54; PLATES I—IV.

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A MONOGRAPH OF BRITISH GRAPTOLITES.

INTRODUCTION.

By the EDITOR.

A Monograph upon the British Graptolites has long been a promised publication of the Palæontographical Society. It was originally undertaken by the late Professor (Sir) Wyville Thomson about the year 1870. After his death the late Professor H. Alleyne Nicholson and myself engaged to prepare a joint Monograph, and for the last ten years or so I have been alone responsible.

I have felt hitherto, however, that the time had not yet arrived for the publication of such a Monograph. The wide interest in Graptolites aroused in Britain and abroad within the last twenty years has been mainly due to the demonstration of their extreme importance as "zone fossils" in the stratigraphy of the Lower Palæozoic formations. The close attention thus called to these fossils in the field, and their consequent collection in great abundance, has had the effect of adding so largely to the number of new species and varieties, and of so modifying our earlier views of the limits of the species previously accepted, that the descriptive parts of a Monograph written during this interval would have been practically obsolete before the work itself was completed.

Again, notwithstanding the great amount of material collected and described, our knowledge of the intimate structure of the Graptolites still remained far behind our knowledge of the structure of other groups of fossils of like systematic importance. Nor, until the recent results of the detailed methods of investigation developed by Holm, Törnquist, Wiman, and others, began to be published, was this department of the subject in a state sufficiently definite to admit of its being treated in a manner worthy of a Monograph of the Palæontographical Society.

Further—and this was in reality the main drawback to the preparation of a Monograph upon Graptolites having any pretension to accuracy and permanence,—no method of illustration, except at great cost, had yet been arrived at by which fac-similes of these fossils could be reproduced in the printing-press. Many of the best figures yet published are more or less unconsciously idealised or inadequate. How impossible it has been to feel confident that the figures and descriptions give an adequate transcript of the facts, even when both author and artist are of the best and most trustworthy, needs only one illustration. Several of the forms described and figured in the epoch-making work of Barrande on the 'Graptolites de la Bohème' have been differently interpreted by almost every field geologist and palæontologist who has used the book.

To meet this difficulty it was obviously necessary to give such figures of the fossils themselves—by mechanical means if possible—as should agree with the originals in all respects, showing their imperfections as well as their perfections, that the reader might be in a position to judge of the fidelity of the descriptions by the figures themselves, and might also be able, should the need arise, to identify the actual fossil or type specimen represented on the plates.

The vast majority of our British Graptolites are preserved as thin, shining films or markings upon the surface of black shales. They can be seen, in most cases, only by reflected light, so that illustration by direct photography is out of the question. Again, the specific characters of these fossils depend upon markings, features, and measurements of almost microscopic minuteness, and no figure can be regarded as satisfactory unless these details can be identified upon it by means of an ordinary hand-lens. And, as the illustrations are required for constant comparison with ordinary specimens obtained in the field, it is necessary that they shall be figured of the natural size.

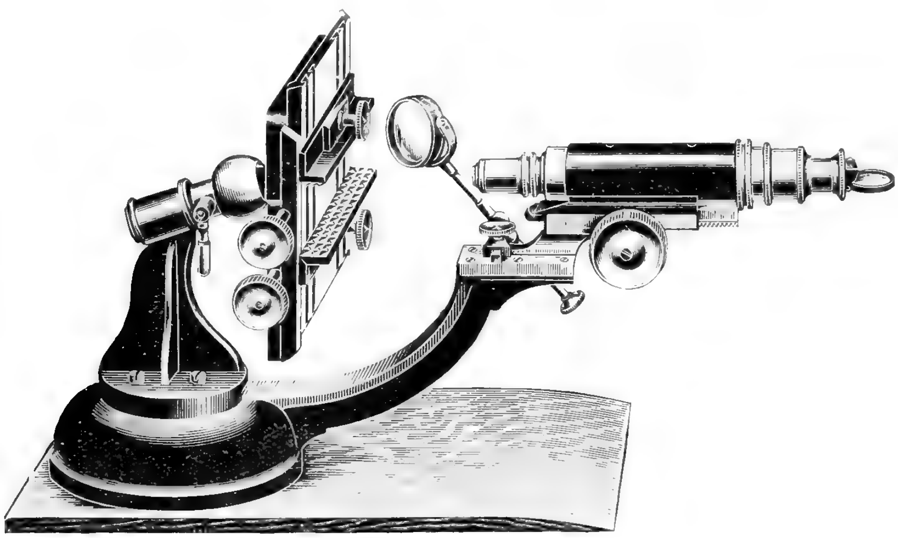
After some years of experimenting it was found that the best plan of obtaining satisfactory fac-similes of these fossils was to draw them by means of the camera lucida attached to a special microscope constructed for the purpose. On this microscope the slate carrying the fossil is attached to a large stage, having a universal joint and a travel of several inches. The light can be so adjusted that the amount of distortion due to the obliquity of the stage is small, and may generally be neglected.

The usual method of procedure is to draw each fossil in black crayon to a scale of five times the natural size, so that all visible details can be inserted. When finished, the drawing, which has been tinted with a grey tone, is reduced by means of photography to the natural size.

When such drawings are photographed as silver prints, the details come out with exquisite sharpness. Unfortunately, however, no mechanical process suitable for the printing-press has yet been invented in which the grain of the background carrying the printer's ink is sufficiently fine to allow of the sharp reproduction of all this detail. By far the best process among those which I have tested is collotype, which is consequently the one adopted in the present work. The collotype plates which illustrate this Monograph are by Messrs. Bemrose, of Derby, and I have most gratefully to acknowledge the skill and patience with which they have seconded our efforts to give accurate reproductions of the specimens figured.

All the figures given upon the plates are of the natural size. The figures in the text, which are inserted for the purpose of illustrating structural details, were originally drawn upon a scale of ten times linear, and afterwards reduced to a uniform scale of five times the natural size, the same scale being retained throughout for the purpose of easy comparison.

Now that the subject is in a state to admit of the satisfactory production of a Monograph of the British Graptolites, being myself too busy with other matters to do the necessary detailed labour, I have, with the consent of the Council of the Palæontographical Society, handed over the work of the preparation and illustra-



Parkes-Lapworth Microscope.[1]

tion of the Monograph to the two English palæontologists best qualified for the task—Miss G. L. Elles, of Newnham College and the Woodwardian Museum, Cambridge, and Miss E. M. R. Wood, of Newnham College and the Birmingham University. The present part is the first instalment of their labour. For all matters connected with the description and illustration of the various species, etc., they alone must be credited; for the general plan and the editing of the work throughout I am responsible.

On their behalf as well as my own I must here gratefully acknowledge how freely all type specimens of Graptolites already described have been placed at our service, and how all those who have collections of Graptolites, either public or private, have permitted us to study such specimens as we considered necessary for the purpose of this work. In connection with this first part we may mention, among others, the Woodwardian Museum, Cambridge; the British Museum of Natural History, South Kensington; the Geological Survey Museums of London,

[1] J. Parkes and Son, Vesey Street, Birmingham.

Edinburgh, and Dublin; the Museum of Local Natural History, Keswick; Mr. Postlethwaite and Mr. Christopherson, Keswick; Dr. H. Oliphant Nicholson, Edinburgh; Mr. J. E. Marr, Cambridge; and Mr. Matley, Birmingham.

Bearing in mind the fact that the primary need for a work of this kind is the natural demand of the field geologist and the palæontologist for figures and descriptions of the British species, we propose that the bulk of the letterpress and plates and figures of the earlier parts of the Monograph shall be devoted to this purpose. Such technicalities as are necessary for the diagnoses in each group will be prefixed to the section to which they refer. The working classification adopted by us is that in use among the majority of graptolithologists, and in the descriptive parts of the work all questions of theory respecting classification, nomenclature, and the like will be as far as possible avoided. In the parts to be published in future years there will be included, first, a general account of the historical development of our knowledge of the Graptolites; next, a comparative account of the structure of the various families, etc.; and afterwards sections dealing with the classification, zoological relationships, and geological range. As the descriptive and the general sections will be paged separately, the two may in future years be published concurrently.

CHAS. LAPWORTH.

Birmingham University;
November, 1901.

BRITISH GRAPTOLITES.

DESCRIPTION OF GENERA AND SPECIES.

Family **DICHOGRAPTIDÆ**, *Lapworth.*

1873. *Dichograptidæ,* Lapw., "Notes on the British Graptolites and their Allies," Geol. Mag., vol. x, p. 555.

Uniserial Graptoloidea with bilateral polyparies, bearing simple subcylindrical thecæ. Branching usually dichotomous, but occasionally irregular. Primary angle of divergence generally 180° or less.

Genus **DIDYMOGRAPTUS**, *M'Coy.*

1851. *Didymograpsus,* M'Coy (*pars*), "British Palæozoic Fossils," p. 9.

Polypary bilaterally symmetrical, consisting of two uniserial stipes which diverge from the sicula at angles usually less than 180° (rarely more).

Thecæ simple subcylindrical tubes expanding slightly towards their apertures, the plane of which is normal; they are inclined at various angles to the axis of the stipe, and are in contact for a considerable portion of their length.

The initial cone-like body (*sicula*) in *Didymograptus* is composed of the usual two portions—the *apertural* (or *oral*) and the *apical* (or *aboral*). The apical portion is often seen to be prolonged into the fine *initial thread* (*nema*) which is believed to be identical with the *virgula* of *Diplograptus.*

The sicula occupies the middle of the *proximal* (*initial* or *central*) part of the compound *polypary* (or *rhabdosoma*), and gives origin to the two *stipes* (or branches), which usually increase in diameter towards their distal extremities. The stipes are generally straight, but occasionally curved. For purposes of description the form of the curvature is always referred to the general line of the ventral margin. The ventral angle (the angle subtended by the ventral sides of the dorsal walls of the stipes) is selected as the conventional *angle of divergence.*

The *thecæ* (*cells, cups,* or *calycles*) are arranged upon one side of the stipe only (*uniserial*). They are not parallel to the axis of the stipe, but are *inclined* to it at various angles. In form they are simple conical or subcylindrical tubes. They communicate with each other at their bases, and open to the exterior at their distal ends (*apertures*). These subcylindrical thecæ are usually somewhat compressed

FIG. 1.

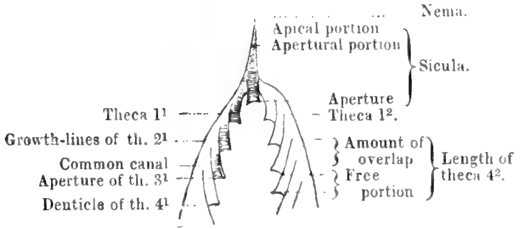


FIG. 2.

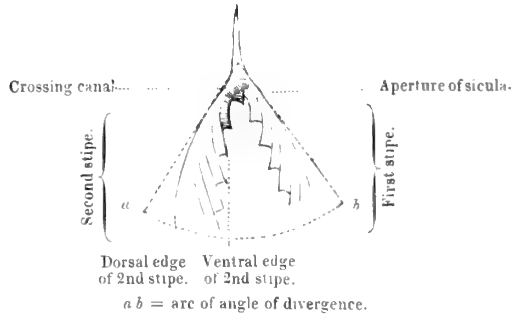


FIG. 1.—*Didymograptus bifidus* (Hall). Diagrammatic figure of proximal portion, obverse view. × 5.
FIG. 2.—*Didymograptus bifidus* (Hall). Diagrammatic figure of proximal portion, reverse view. × 5.

into the form of more or less quadrangular tubes, each of which may be conventionally regarded as bounded by four walls, viz. one *dorsal* (inner), one *ventral* (outer), and two *lateral* walls. The distal free margins of these walls constitute collectively the *apertural margin*, the plane of which is almost invariably at right angles (*normal*) to the axis of the theca itself. The corner (or *coign*) made by the common edge of the lateral and ventral walls and the apertural margin occasionally forms a well-marked *denticle*, and is sometimes prolonged into an *apertural spine*. The ventral wall of each theca—which is conventionally regarded as defining the *length* of the theca itself—is in *contact* with (*overlapped* by) the dorsal wall of the theca immediately preceding for a variable portion of its length, but is *free* towards its distal extremity. In well-preserved specimens the walls of the thecæ are marked by closely set *lines of growth*, which run parallel with the apertural margins.

The vast majority of examples of Graptolites occur in a compressed state, forming a thin flattened film upon the surface of the rock. In this condition the most characteristic appearance of the polypary in *Didymograptus* is that presented by the *profile* view, in which the *dorsal edge* is seen to be smooth and continuous, and the *ventral edge* denticulated by the outer margins of the thecæ and the apertural margins.

In one aspect (*obverse*) of the profile view of the polypary the sicula is visible for the whole of its length; in the opposite aspect (*reverse*) the sicula is more or less concealed by the crossing canal. The stipes originate from the sicula by means of a bud developed from its left side (when the polypary is regarded in the typical or obverse aspect), and from this bud two sets of structures are developed, namely—

(1) The first theca (th. 1[1]) and the first so-called common canal, which give origin to the first stipe by a process of budding; and

(2) A tubular body (the *crossing canal*) which grows across the sicula from left to right, forming the first part of the second theca (th. 1^2) and the second common canal, from which similarly the second stipe is developed.

The succeeding thecæ (th. 2^1, 3^1, etc., and 2^2, 3^2, etc.) in both stipes are developed in a continuous linear series, each individual apparently budding from the theca immediately preceding it in order, the budding orifices remaining permanently open as the *common canal*.

The various species of the genus *Didymograptus* arrange themselves very naturally in morphological *groups* around certain special forms, each of which may conveniently be regarded as normal or typical for a single group. Some of these groups, again, agree in the possession of common characteristics of general habit, which allow of their being united in a connected *series*. How far these groups and series are significant of the phylogenetic relationships of the individual species comprised within them, must be left for future discovery to determine.

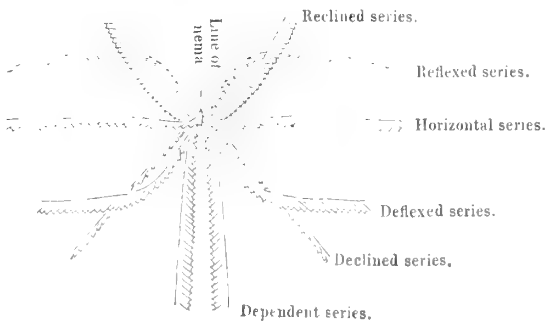


Fig. 3.—Diagrammatic figure, showing the relative angles of divergence of the stipes characteristic of the several series of Didymograpti.

Horizontal series.

Group I.—Type *D. extensus*.
- *D. extensus*,
- *D. nitidus*,
- *D. uniformis*,
- *D. patulus*,
- *D. hirundo*,
- *D. sparsus*,
- *D. pennatulus*.

Group II.—Type *D. superstes*.
- *D. superstes*,
- *D. euodus*.

Declined series.

Group III.—Type *D. affinis*.
- *D. affinis*,
- *D. gracilis*,
- *D. acutidens*,
- *D. Nicholsoni*,
- ,, var. *planus*.
- *D. serratulus*,
- *D. simulans*,
- *D.* cfr. *filiformis*.

Deflexed series.

Group IV.—Type *D. v-fractus*.
- *D. v-fractus*,
- ,, var. *volucer*,
- *D. deflexus*.

Dependent series.

Group V.—Type *D. Murchisoni*.

(*a*) Sub-group of *D. bifidus*.
- *D. Murchisoni*,
- ,, var. *geminus*.
- *D. bifidus*,
- *D. amplus*.

(*b*) Sub-group of *D. indentus*.
- *D. indentus*,
- *D. nanus*,
- *D. artus*,
- *D. stabilis*.

Reflexed series.

Group VI.—Type *D. fasciculatus*.
- *D. fasciculatus*.

Reclined series.

Group VII.—Type *D. gibberulus*.
- *D. gibberulus*.

Horizontal Series.

Didymograpti with approximately straight and horizontal stipes in which the ultimate angle of divergence is 180°.

Group I.—Type *D. extensus*.

Didymograpti in which the stipes originate near the apex of the sicula and grow horizontally. Their thecæ are inclined at large angles, and overlap considerably.

Didymograptus extensus (Hall). Plate I, figs. 1 *a*, *b*.

1858. *Graptolithus extensus*, Hall, Rep. Geol. Survey Canada, 1857, p. 132.
1865. *Graptolithus extensus*, Hall, "Grapt. of Quebec Group," Geol. Surv. Canada, Canadian Organic Remains, dec. 2, p. 80, pl. ii, figs. 11—16.
1870. *Didymograptus extensus*, Nicholson, Ann. Mag. Nat. Hist. [4], vol. v, p. 341, pl. vii, figs. 2, 2 *a*.
1875. *Didymograptus extensus*, Hopkinson, Quart. Journ. Geol. Soc., vol. xxxi, p. 642, pl. xxx, figs. 1 *a*—*d*.
1898. *Didymograptus extensus*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 504.
1901. *Didymograptus extensus*, Törnquist, Lunds Univ. Årrsk., Bd. xxxvii, Af. 2, Nr. 5, p. 14, pl. i, figs. 25—30.

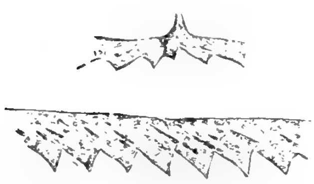
Stipes diverging at 180°, 20—30 cm. in length, narrow, widening slightly and gradually from their origin throughout their length to a maximum of 1·6 mm. Thecæ nine to ten in 10 mm., inclined at a fairly large angle, three times as long as wide, and free one third their length. Apertural margins normal, concave.

Description.—The stipes are characteristically slender and flexuous. They widen very gradually for the first 12 mm. of their length, and still more gradually afterwards. The width at origin is generally about ·5 mm.; this may increase to a maximum of 1·6 mm., but more commonly the stipes do not exceed 1 mm. in breadth. They seem occasionally to have attained a great length, one specimen known to us measuring fully 30·5 cm. from end to end. In such long forms there is always a distinct tendency to upward curvature of the stipe in the distal region. There is also a further curvature of the celluliferous margins accompanied by a diminution in width; this is due, as in other cases, to the incomplete development of the latest formed thecæ.

The sicula is small and inconspicuous; it never exceeds 1·3 mm. in length. The earliest theca (th. 1^1) originates in the apical region of the sicula, and grows in such a manner that the sicula is free on the left side for a short distance near its aperture. It is possible that th. 1^2 also originates near the apex of the sicula, since the appearance of the polypary in the reverse aspect suggests the almost horizontal growth of the crossing canal. Consequently the whole appearance of the proximal end is very symmetrical. In addition to this there is a characteristic "widely open" appearance due to the direction of growth of the earliest formed thecæ. These seem to be appressed to the sicula for a short distance from their origin, but in the region of its aperture they begin to curve steadily away. The walls of these earliest thecæ always exhibit slight curvature, but those developed later have their walls approximately straight.

FIGS. 4 *a* and *b*.—*Didymograptus extensus* (Hall).

a



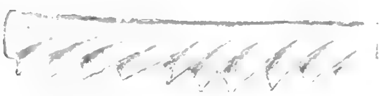
b

a. Proximal end, obverse view. Outerside, Keswick. Coll. British Museum (Nat. Hist.).
b. Distal thecæ of same, compressed.

The thecæ are narrow tubes of uniform width, which are three times as long as wide in the adult part of the stipes, but only twice as long as wide near the sicula. The maximum thecal length is 2·1 mm. The thecæ are free for one third of their length in the distal parts of the stipes, but for nearly as much as a half in the proximal parts; they have an inclination of about 40°, but this may vary considerably even in the same stipe. In some specimens the thecæ resemble in form the peculiar thecæ of *D. constrictus*, but the "*constrictiform*" appearance would seem to be the result of the mode of preservation.

FIGS. 4 *c* and *d*.—*Didymograptus extensus* (Hall).

c. Distal thecæ in relief, showing "constrictiform" appearance. Below Raven Crag, Skiddaw. Coll. Woodwardian Museum.



d. Part of same stipe preserved as a cast, showing apparent variation in the inclination of the thecæ; constrictiform appearance no longer observable.

Affinities.—*D. extensus* can readily be distinguished from most other forms by its slender flexuous character and "widely open" proximal end. From *D. nitidus*, which it resembles more closely than any other form, it can be easily separated by the smaller number of thecæ in a given unit of length.

Horizon and Localities.—Arenig (Lower Arenig of Hicks), St. David's district; Mytton beds, Shropshire; Middle Skiddaw slates.

St. David's District: Road Isaf, Road Uchaf, Ramsey Island; north of Talfan, Whitland. *Lleyn Peninsula:* Nant-y-gadwen. *Lake District:* Randal Crag, Skiddaw; below Raven Crag, west of Skiddaw; Outerside; Knockmurton; Barf; Eggbeck. *Shropshire:* Tankerville Mine; East Gravels Mine. *Scotland:* Bennane Head, Ballantrae.

Associates.—In the St. David's district *D. extensus* occurs in association with *D. sparsus*, *D. pennatulus*, *D. nitidus*, etc. Specimens from the English areas are in the Woodwardian Museum, Cambridge. There are examples from the Skiddaw slates in the British Museum (Nat. Hist.); and in Lapworth's collection examples from Skiddaw and Shropshire.

Didymograptus nitidus (Hall). Plate I, figs. 2 *a—c*.

1858. *Graptolithus nitidus,* Hall, Rep. Geol. Survey Canada, 1857, p. 129.

1865. *Graptolithus nitidus,* Hall, "Grapt. of Quebec Group," Geol. Surv. Canada, Canadian Organic Remains, dec. 2, p. 69, pl. i, figs. 1—9.

1868. *Didymograpsus nitidus,* Nicholson (*pars*), Quart. Journ. Geol. Soc., vol. xxiv, p. 135.

1870. Non *Didymograpsus nitidus,* Nicholson, Ann. Mag. Nat. Hist. [4], vol. v, p. 341, figs. 3 *a—c.*

1874. *? Didymograptus nitidus,* Etheridge, jun., Ann. Mag. Nat. Hist. [4], vol. xiv, p. 6, pl. iii, fig. 20.

1898. *Didymograptus nitidus,* Elles (*pars*), Quart. Journ. Geol. Soc., vol. liv, p. 499, fig. 20.

Stipes 2—5 cm. in length, narrow at origin, but increasing in width throughout up to 1·6 mm., diverging from a small sicula at wide but varying angles, and growing subsequently in an approximately horizontal direction. Thecæ twelve to thirteen in 10 mm., inclined at a large angle, three times as long as wide, free one third their length. Apertural margins normal, slightly concave.

Description.—The stipes measure at their origin about ·87 mm. in width, but widen gradually up to a maximum of 2·1 mm.; this width is only attained in the largest specimens, those more commonly met with do not exceed 1·6 mm.; there is always diminution at the distal extremities, owing to the incomplete development of the thecæ. The greatest length observed in any one stipe is 5·7 cm. In some specimens the stipes diverge from each other at a primary angle of 175°, and their dorsal walls are straight; but in others there seems to be a tendency to grow at first downward, the angle of divergence being about 130°. In exceptional cases this downward growth may be continued, but more frequently it is arrested after the development of six to ten thecæ on each stipe, and then the horizontal direction is gradually assumed: in this case the dorsal walls are at first curved, but subsequently straight. In other cases again, where the downward growth is arrested, the stipes are directed slightly but persistently upward, and the dorsal walls are slightly but persistently curved.

Fig. 5 *a.*—*Didymograptus nitidus* (Hall).

Proximal end preserved as a cast, obverse view. Randal Crag, Skiddaw. Coll. Woodwardian Museum.

The sicula is small, it measures commonly about 1·3 mm. in length; it is decidedly broad in proportion to its length, and tapers abruptly towards the apex. It is often placed somewhat obliquely with regard to the stipes. Th. 1^1 arises from the sicula at a short distance below its apex, and grows down some little way before originating the crossing canal, which traverses the sicula approximately horizontally. It should be noticed that th. 1^2 is closely appressed to the sicula till the aperture is reached, at which point it curves gradually away.

The thecæ are 1·6—2 mm. in length; they are narrow at their bases, but wider towards their apertures, being often twice as broad there as at their origin. Their outer walls show a slight sigmoid curvature; near the base they are somewhat convex, near the aperture concave. They are inclined at an average angle of about 40°, but, owing to the curvature of the cells, the initial angle may be as small as 35°, while the angle near the aperture may be as large as 50°. They are in contact for one half their length in the proximal part of the stipe, but this amount of overlap increases usually to two thirds, and may even be as much as three fourths, near the distal extremities. The apertural angle is normal. The thecæ frequently present a "constrictiform" appearance.

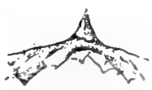
FIG. 5 *b*.—*Didymograptus nitidus* (Hall).

Distal thecæ of same in relief.

Remarks.—*D. nitidus*, as here described, does not include those forms from the Skiddaw Slates originally identified and described by Nicholson as Hall's *D. nitidus* (see above), but even without these the British forms appear to exhibit a greater degree of variation than those of America. Particularly is this the case with regard to the angle of divergence. In Britain there are, however, a number of forms which agree in all essential particulars with the description given by Hall, but these graduate so insensibly into other varieties that it is not advisable to separate them.

FIGS. 5 *c* and *d*.—*Didymograptus nitidus* (Hall).

c. Proximal end, obverse view. From Hall's original locality, beach below Pt. Levis. Coll. Lapworth.



d. Reverse view of same.

Affinities.—*D. nitidus* in its typical form is most closely allied to Hall's *D. patulus;* in fact, it differs from that species mainly in the greater number of thecæ in a given unit of length. Some forms also resemble *D. uniformis*, sp. nov., in general appearance, but differ in having a smaller sicula, and in the gradual increase in width of the stipes.

D. nitidus also approaches *D. simulans* in general form, but differs in the proximal end and the characters of the thecæ.

Horizon and Localities.—Arenig, Middle Skiddaw Slates (Lake district); Middle Arenig Hicks (St. David's); Mytton beds (S. Shropshire).

Lake District: Randal Crag, Skiddaw; Ullock Pike, below Raven Crag, W. Skiddaw; east of Longside; Bassenthwaite; Connor; Knott Head; Whinlatter Pass; Brundelhow Lead Mine; Gatesgill. *St. David's District:* North of Talfan, Whitland. *Lleyn Peninsula:* Aberdaron. *S. Shropshire:* Ladywell; Shelve.

Associates, etc.—This species occurs in the Skiddaw Slates associated with *Tetragraptus quadribrachiatus* (Hall), in the St. David's district associated with *T. serra* and *D. extensus*, and with similar associates in S. Shropshire. Specimens from all these areas are in the collection of the Woodwardian Museum, and some from the Skiddaw Slates in the collection of the Keswick Museum and the private collection of Mr. Postlethwaite, Keswick.

Didymograptus uniformis, sp. nov. Plate I, figs. 3 (?) and 4.

Stipes 5 cm. or more in length; bent at their origin into a small inverted **V**, but running later in an approximately horizontal direction, having a uniform width (1·6 mm.) for the greater part of their length. Sicula conspicuous. Thecæ eleven in 10 mm., inclined at 30°, three times as long as wide, in contact one half to two thirds their length. Apertural margins normal, straight.

Description.—The stipes are ·9 mm. wide at their origin; they increase in the **V** part up to 1·3 mm., and this width is maintained for the remainder of their length, which may be as much as 5 cm. This uniform width is especially characteristic of the horizontal portions of the stipes; the **V** part is about 6 mm. in extent.

The sicula measures 1·8 mm. in length, and the first theca appears to develop from the apical region, and growing straight downward beyond the aperture of the sicula has its ventral wall closely appressed to the sicula. This direction of growth parallel to the sicula is also followed by all the earliest developed thecæ, and their ventral margins are straight.

FIGS. 6 *a* and *b*.—*Didymograptus uniformis*, sp. nov.

a. Proximal end preserved mainly as a cast, obverse view. Enlargement of part of Pl. I, fig. 4.

b. Distal thecæ of same, in full relief, enlarged.

The later thecæ are equal in length to the sicula; they are inclined at a constant angle of 30°. They are in contact for half their length in the proximal regions of the stipes, but this amount increases to nearly two thirds in the more distal parts. There is a slight sigmoid curvature of the outer wall, each thecal wall showing slight concavity in its initial region, which changes to slight convexity near the aperture.

Affinities.—*D. uniformis* approaches most nearly in shape to *D. nitidus* and *D. simulans*; from *D. nitidus* it may be distinguished by its larger sicula, the character of the proximal end, and the uniform width; from *D. simulans* it differs in the characters of the proximal end and those of the thecæ.

Numerous examples of a form of *Didymograptus* on a slab in the possession of Mr. Christopherson from the Skiddaw Slates at Raulnay may be provisionally referred to this species. They agree with *D. uniformis* as regards—

(1) the uniform width of the polypary,

(2) the proximal end,

(3) the number and form of the thecæ.

They differ, however, in the general form of the polypary. This closely resembles that of *D. nitidus*, the inverted V portion characteristic of *D. uniformis* being much less conspicuous; but this difference does not justify us in separating off these specimens as a distinct variety.

FIG. 7.—*Didymograptus* cf. *uniformis*, sp. nov.

Proximal end preserved as a cast, obverse view. Enlargement of part of Pl. I, fig. 3.

Up to the present time *D. uniformis* has only been recorded from the Skiddaw Slates. The best example yet known is in Postlethwaite's collection, and is regarded as the type specimen (Pl. I, fig. 4).

Horizon and Localities.—Arenig, Middle Skiddaw Slates (?).

Lake District: Bassenthwaite Sand-beds; Randal Crag.

Didymograptus patulus (Hall). Plate I, figs. 8 *a*—*c*.

1858. *Graptolithus patulus*, Hall, Rep. Geol. Survey Canada, 1857, p. 131.

1865. *Graptolithus patulus*, Hall, "Grapt. of Quebec Group," Geol. Surv. Canada, Canadian Organic Remains, dec. 2, p. 71, pl. i, figs. 10—15.

1868. Non *Didymograpsus patulus*, Nicholson, Quart. Journ. Geol. Soc., vol. xxiv, p. 135.

1870. Non *Didymograpsus patulus*, Nicholson (*pars*), Ann. Mag. Nat. Hist. [4], vol. v, p. 340, pl. vii, fig. 1 *a*.

1875. *Didymograptus patulus*, Hopkinson, Quart. Journ. Geol. Soc., vol. xxxi, p. 644, pl. xxxiii, figs. 4 *a*—*e*.

1898. Non *Didymograptus patulus*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 504, figs. 22, 23.

1901. Non *Didymograptus patulus*, Törnquist, Lunds Univ. Årssk., Bd. xxxvii, Af. 2, Nr. 5, p. 15, pl. ii, figs. 1—6.

Stipes several centimetres in length, widening fairly rapidly from their origin to a maximum width of 2·1 mm., and diverging from a small sicula at about 180°. Thecæ nine to ten in 10 mm., inclined at a large angle, three to four times as long as wide, free one quarter their length. Apertural margins concave, mucronate, and normal.

Description.—The stipes are narrow at their origin, the earliest few thecæ being short; but they lengthen fairly rapidly, and the maximum width of 2·1 mm. is usually attained within the first 12 mm. of the stipe. This width is maintained throughout the length of the stipe, which may attain 5 cm. Near the distal extremities there is again slight diminution in width, owing to the partial development of the latest thecæ.

The sicula is small; it is generally rather less than 2 mm. in length. British specimens of this species showing details of the structure of the proximal end are rare, but it would seem that the earliest theca originated close to the apex of the sicula, and that the crossing canal was short and approximately horizontal, so that the growth of the two earliest thecæ, th. 1^1 and th. 1^2, conceals the greater part of the sicula in the reverse aspect, leaving it free on one side only for a short distance near its aperture.

Figs. 8 *a* and *b*.—*Didymograptus patulus* (Hall).

a

b

a. Proximal end. Enlargement of part of Pl. I, fig. 8 *a*.
b. Distal thecæ. Enlargement of part of Pl. I, fig. 8 *c*.

The thecæ number nine to ten in 10 mm., but that number may be slightly exceeded in the initial region of the stipes. Near the apertures the thecæ are inclined at 60°. In Hall's figures the initial angle of inclination is rather less, but our specimens do not admit of satisfactory determination in this respect; the angle is, however, always rather lower near the sicula; the outer walls show slight convex curvature, and the apertures are deeply concave, with mucronate outer edges. Each mature theca has a length of about 2·5 mm.

Affinities.—*D. patulus* exhibits points of resemblance with several other species. Distal fragments of the stipes often closely resemble those of *D. hirundo*, but are usually somewhat narrower; when complete it can readily be distinguished from that form by the character of the proximal end, for the sicula is smaller and the initial region more "open" than is the case with *D. hirundo.*

D. patulus also bears certain superficial resemblances to *D. extensus*, but may be distinguished from it by the greater width of the mature stipe and the higher inclination of the thecæ.

In general form *D. patulus* reminds us greatly of *D. nitidus*, which it resembles especially in the character of the proximal region; but it differs in having fewer thecæ in the same unit of length, and in the general absence of curvature in the stipes.

Horizon and Localities.—This species occurs in the Lower Llanvirn beds of Hicks (= Upper Arenig). The form has also been recorded by Salter from Hicks' Middle Arenig rocks of Whitesand Bay (see 'Catalogue Woodwardian Museum,' fossils, p. 20), but the only specimen from that locality in the museum at present is a fragment from the Upper Arenig beds. Hopkinson records the species from the Middle Arenig beds of the Shelve district, and it also occurs in Upper Arenig beds of the same area.

St. David's District: Llanvirn Quarry. Porth-hayog, Ramsey Island; north of Talfan, Whitland.

Shropshire: Shelve Church; Disgwylfa.

Ireland: Kiltrea, near Ennisworthy.

Associates, etc.—*D. patulus* occurs associated with *D. Nicholsoni*, *D. bifidus*, *D. artus*, and *D. nanus* in the St. David's district. Perfect examples are rare, but numerous fragmental specimens are in the collections of the Woodwardian Museum, the Geological Survey of Ireland, and the Authors.

Didymograptus hirundo, Salter. Plate I, figs. 5 *a—c*.

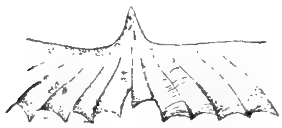
1863. *Didymograpsus hirundo*, Salter, Quart. Journ. Geol. Soc., vol. xix, p. 137, fig. 13 *f*.
1866. *Didymograpsus hirundo*, Salter, Mem. Geol. Survey, vol. iii, p. 331, pl. ii, figs. 6 and 7.
1868. *Didymograpsus patulus*, Nicholson, Quart. Journ. Geol. Soc., vol. xxiv, p. 135.
1870. *Didymograpsus patulus*, Nicholson (*pars*), Ann. Mag. Nat. Hist. [4], vol. v, p. 340, pl. vii, fig. 1 *a*.
1898. *Didymograptus patulus*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 504, figs. 22, 23.
1901. *Didymograptus patulus*, Törnquist, Lunds Univ. Årssk., Bd. xxxvii, Af. 2, Nr. 5, p. 15, pl. ii, figs. 1—6.

Stipes several centimetres in length, broad even at origin, and attaining a maximum width of 4 mm., diverging from a conspicuous sicula at an angle of 180°, and continuing to grow in a horizontal direction. Thecæ nine to ten in 10 mm., inclined at various large angles in different parts of the stipes, three times as long as wide, free about one fourth their length. Apertural margins normal, concave, and submucronate.

Description.—In this species, though the stipes grow throughout their length in an approximately straight line, there is a tendency to upward curvature at the distal extremities in some of the larger specimens. At times the stipes seem to have attained an enormous length; a slab in the Keswick Museum of Local Natural History shows a large specimen, one stipe of which is complete and measures 30·5 cm. in length; the total length of this specimen must therefore have been 61 cm. Another specimen in the Woodwardian Museum, Cambridge, must have measured 53 cm. when complete. So far as we are aware these are the longest Didymograpti on record. The stipes are also characteristically wide, the average breadth being 2·5 to 2·1 mm.; but in the larger specimens referred to above the width may be as much as 4 mm. The variation in the width of the stipe is due no doubt in part to the variation in the length of the thecæ and their inclination: in some young specimens, therefore, the maximum width is never attained. As a general rule the stipes are wide at their origin, and continue to broaden slightly toward their distal ends, but a slight diminution in width takes place immediately before the distal extremity is reached.

The sicula is unusually long (3·2 mm.), but owing to the size of the polypary it does not appear remarkable. It is narrow, especially in the apical part; at its aperture it is about ·5 mm. in width. The first theca (th. 1^1) seems to originate very near the apex of the sicula; it grows at first closely appressed to the sicula in a straight downward direction, but then curves away, leaving the sicula free near its aperture for about one third of its length on the left side. The crossing canal originates near the apex of the sicula, to which the second theca (th. 1^2) is closely appressed. Theca 1^2 does not grow much farther down than theca 1^1, consequently the proximal part of the polypary in this species has an unusually symmetrical appearance. In the obverse view the sicula is seen to be somewhat obliquely placed, but this is not so apparent in the reverse view, where the right side and part of the aperture are concealed by the growth of theca 1^2.

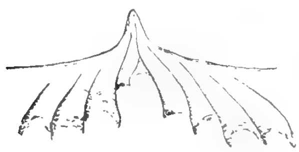
Fig. 9 *a*.—*Didymograptus hirundo*, Salter.



Proximal end, obverse view. Enlargement of Pl. I, fig. 5*a*.

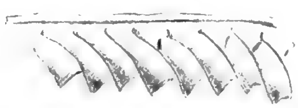
The thecæ number generally about nine to ten in 10 mm.; but ten to eleven in 10 mm. may be counted near the proximal end. In none of the specimens that have come under our notice have we found the number greater than eleven, and that number is only attained when the thecæ are imperfectly developed, and never in the distal portions of the stipe. Nicholson, however, has given twelve to fourteen in 10 mm. for some forms from the Skiddaw Slates, which he refers to *D. patulus.* Most of the specimens in his collection referred by him to Hall's species should, we think, be referred to Salter's *D. hirundo*, except those figured by him with closely set thecæ or with concavely curved dorsal walls. These in our opinion are more closely related to *D. nitidus.* Each mature theca measures fully 3·2 mm. The inclination of the thecæ to the axis of the stipe varies in different parts: near the proximal end they are inclined at about 45°; a little further away from the sicula they curve in such a manner that, while the inclination at their bases is only 25°, the inclination in the apertural region makes an angle of 60° with the general direction of the stipe. In certain specimens it appears that communication between the different thecæ was not so perfectly free as in some forms, but was effected through a more constricted aperture at the base of each cell. It is characteristic of the species that a vertical line drawn through the aperture cuts the base of the second theca in advance. The thecæ are sometimes so well preserved that they show lines of growth parallel to their apertures.

Fig. 9 *b*.—*Didymograptus hirundo*, Salter.



Proximal end, reverse view. Enlargement of Pl. I, fig. 5 *b*.

Fig. 9 *c*.—*Didymograptus hirundo*, Salter.



Distal thecæ, preserved as a cast, showing apparent constriction of the common canal. Randal Crag, Skiddaw. Coll. Woodwardian Museum.

Affinities.—This species presents many points in common with *D. patulus* and *D. sparsus*,—in fact, some distal fragments can hardly be distinguished from Hall's species; and for this reason it was formerly included under the head of *D. patulus*, and Salter's specific name fell into abeyance. But since the characters of the proximal end of Hall's species are now more fully known, it is clearly recognisable as a distinct species, and Salter's name must therefore be revived. *D. hirundo* differs from *D. patulus* in its proximal end, which is "closed," in contrast with the "open" character of the initial region of *D. patulus.* The distal fragments of the stipes of *D. hirundo* and *D. patulus* often bear a very close resemblance to each other, but those of *D. hirundo* may attain a greater width.

In the character of its proximal end *D. hirundo* is closely connected with *D. sparsus*. It resembles this form in the unusually large size of the sicula and the general proximity of the earliest developed thecæ; it differs, however, in the characters of the thecæ in the distal parts of the stipes.

Horizon and Localities.—Arenig, highest beds of Middle Skiddaw Slates (upper Tetragraptus beds) and base of Upper Skiddaw Slates. Upper Mytton beds.

Lake District: Randal Crag, Skiddaw; Carlside Edge; Aik Beck; Outerside. *S. Shropshire:* Tankerville Road; W. of Stiper Stones. *Lleyn Peninsula:* Nant-y-gadwen.

Associates, etc.—*D. hirundo* occurs in abundance in the Lake district associated with *D. gibberulus* and *Azygograptus suecicus*, in the Lleyn Peninsula, and also in S. Shropshire, where it occurs to the exclusion of other species, forming a well-defined zone in the upper Mytton beds. Numerous good specimens have been found and are now in the collections of the Keswick Museum of Local Natural History, British Museum, Geological Survey, and Woodwardian Museum, Cambridge, and in Lapworth's collection.

Salter's type specimen (Pl. I, fig. 5 *c*) is in the Museum of Practical Geology, Jermyn Street.

Didymograptus sparsus, Hopkinson. Plate I, figs. 6 *a*, *b*.

1875. *Didymograptus sparsus*, Hopkinson, Quart. Journ. Geol. Soc., vol. xxxi, p. 643, pl. xxxiii, figs. 2 *a*, 2 *d*.

Stipes 5—7 cm. in length; fairly wide at origin, and increasing gradually to a maximum of 3 mm.; diverging from a large sicula at a primary angle of 120°, but straightening at once and running horizontally. Thecæ seven in 10 mm., inclined at about 45°, twice as long as wide, free one half their length. Apertural margins concave, approximately perpendicular.

Description.—The stipes measure 1·6 mm. in width at their origin, and gradually widen up to a maximum of 3 mm. They are straight except in the region of the sicula, and have been known to extend for 7·5 cm. on either side of it.

FIG. 10.—*Didymograptus sparsus*, Hopkinson.

Proximal end, obverse view, somewhat distorted. Road Uchaf, Ramsey Island. Coll. Woodwardian Museum.

The sicula is large and conspicuous, it measures 3·2 mm. in length; the first theca originates near the apex, and grows down closely appressed to the sicula throughout its length, reaching about 1 mm. beyond it; the crossing canal appears to be small and approximately horizontal in direction, so that theca 1^2 arises at about the same level as theca 1^1, and grows down closely appressed to the sicula. This mode of growth has the effect of almost completely concealing the greater part of the sicula in the reverse aspect, leaving it visible only near its aperture.

The thecæ are always in contact for half their length, and have a uniform inclination of about 45°; their outer walls are straight, and their apertures concave; in the fully developed parts of the stipe the apertures appear to be perpendicular to the general direction of the stipe. The thecæ average seven in 10 mm.; they are markedly more remote than those of any other form with which this species is associated. Each individual theca measures 3·2 mm.

Affinities.—The proximal end of this species is similar to that of *D. hirundo*, but the remote thecæ in the distal parts of the stipe serve to distinguish it. It may easily be separated from the other forms with which it occurs associated, namely, *D. pennatulus* and *D. extensus*, by its large sicula and remote thecæ.

Horizon and Locality.—Lower Arenig (of Hicks).

St. David's District: Road Uchaf, Ramsey Island.

Associates, etc.—The species occurs associated with *D. pennatulus* and *D. extensus* in the cleaved slates of the St. David's district, and several specimens originally collected by Hopkinson are now in the Woodwardian Museum, Cambridge, as are also the type specimens (Pl. I, figs. 6 *a*, *b*).

Didymograptus pennatulus (Hall). Plate I, fig. 7.

1865. *Graptolithus pennatulus*, Hall, "Grapt. of Quebec Group," p. 82, pl. iii, figs. 1—8; pl. v, fig. 9 (?).
1875. *Didymograptus pennatulus*, Hopkinson, Quart. Journ. Geol. Soc., vol. xxxi, p. 643, pl. xxxiii, figs. 3 *a*—*e*.

Stipes several cm. in length, very narrow at origin, but widening abruptly to a breadth of 3·2 mm., and then gradually to 6·4 mm.; diverging at 180° from the sicula. Thecæ nine to ten in 10 mm., inclined at a large angle, eight times as long as wide, free one fourth their length. Apertural margin concave.

Description.—The stipes widen very abruptly for the first 6 mm. from a width of 1 mm. to 3·2 mm.; thereafter the increase is very gradual up to a maximum of 7·6 mm. in the widest forms, but rather less in others; there is a slight diminution in breadth at the distal extremities, owing to the incomplete development of the latest formed thecæ, producing an apparent curvature of the thecal margin.

The sicula has not been observed in any British specimens,—in fact, only isolated stipes have as yet been recognised; but the form of the stipe and the general characters of the thecæ leave no doubt as to their identity with Hall's species.

The proximal thecæ are very small, measuring barely 2·1 mm., but those in the mature part of the stipe are very long and narrow, measuring 6·3 mm. The walls are concavely curved, so that while the initial inclination may be as low as 35°, near the aperture the theca is inclined at about 60°. The apertures are small and distinctly mucronate; the apertural angle, after compression, is about 100°—110°, which is not so oblique as indicated by Hall's figures. The apex of the denticle of each aperture is vertically above the fourth or fifth theca in advance.

Affinities.—The peculiar form of the stipe and the great length of the thecæ render this species easily recognisable, and by these same characters it can readily be distinguished from all other forms.

Horizon and Localities.—Lower Arenig (of Hicks).

St. David's District: Road Uchaf, Ramsey Island.

Associates, etc.—It occurs in association with *D. extensus* and *D. sparsus* in the Arenig rocks of the St. David's district. Specimens collected from that area by Hopkinson are now in the Woodwardian Museum.

Characters of the Group of *D. extensus.*

	D. extensus.	*D. nitidus.*	*D. uniformis.*	*D. patulus.*	*D. hirundo.*	*D. sparsus.*	*D. pennatulus.*
Form of stipe	Horizontal (or with slight curvature)	Horizontal (or with proximal curvature)	Horizontal (but with marked proximal curvature)	Horizontal	Horizontal	Horizontal	Horizontal
Width	1·6 mm., increase gradual	1·6 – 2·1 mm., increase gradual	1·6 mm., uniform	2·1 mm., increase gradual	2·1—4 mm., increase rapid	3 mm., increase gradual	7·6 mm., increase very rapid
Length of sicula	1·3 mm.	1·3 mm	1·8 mm.	2·1 mm.	3·2 mm.	3·2 mm.	—
Origin of stipes	Apical	Apical	Apical	Apical	Apical	Apical	Apical
No. of thecæ in 10 mm.	9—10	12—13	11	9—10	9—10	7	9—10
Inclination	40°	40°	30°	60°	60°	45°	35°—60°
Overlap	$\frac{1}{2}$—$\frac{2}{3}$	$\frac{1}{2}$—$\frac{2}{3}$	$\frac{1}{2}$—$\frac{2}{3}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{3}{4}$

Horizontal Series (*continued*).

Group II.—Type *D. superstes.*

Didymograpti in which the stipes are curved proximally but are distally horizontal; they originate a short distance above the aperture of the sicula. The thecæ are inclined at moderate angles, and the amount of overlap is never great.

Didymograptus superstes, Lapworth. Plate I, figs. 9 *a*, *b*.

1876. *Didymograptus superstes,* Lapworth, Cat. West. Scottish Fossils, pl. iii, figs. 74 *a*, *b*.

1877. *Didymograptus superstes,* Lapworth, "Graps. of Co. Down," Proc. Belfast Nat. Field Club, p. 142, pl. vii, figs. 15 *a*, *b*.

Stipes several cm. long and gracefully curved, narrow at origin, but increasing rapidly in width to a maximum of 3 mm., diverging from a small sicula at

120°. Thecæ nine to ten in 10 mm., inclined at a fairly large angle, four times as long as wide, and with increasing overlap towards the distal parts of the stipes. Apertural margins normal, concave, produced into a broad triangular denticle.

Description.—The stipes at their origin measure only 0·3 mm., but they widen regularly and quickly within the first 7 cm. to 3 mm. They always show curvature of some kind, the commonest form being that in which the stipes are slightly concave near the sicula, then convex. They become horizontal towards their distal extremities, and are known to attain a length of at least 25 cm.

The sicula is small and inconspicuous (1·1 mm.). It is slender near the apex, but widens very rapidly in the direction of its aperture. It is placed somewhat obliquely with reference to the stipes, and remains of the nema can occasionally be detected proceeding from its apical extremity. The first theca seems to originate midway between the apex and aperture of the sicula on the left side (obverse view). The theca 1^1 is unusually broad at its origin with the sicula; possibly this is the expression of an attempt to render the attachment of the stipe to the sicula more secure. This form therefore exhibits a change from the more usual method of securing permanent attachment to the sicula by appression of the earliest developed thecæ; in this case theca 1^1 grows away from the sicula *at once*, leaving the sicula free on the left side for a short distance above its aperture. In the reverse view of the polypary the crossing canal is seen to be oblique, and to grow in such a manner that part of theca 1^2 conceals a considerable amount of the apertural region of the sicula; subsequently the thecæ develop normally.

FIG. 11 *a.*—*Didymograptus superstes*, Lapworth.

Proximal end, obverse view. Enlargement of part of Pl. I, fig. 9 *a*.

FIG. 11 *b.*—*Didymograptus superstes*, Lapworth.

Specimen showing the nema, the proximal end being concealed by a film. Tottlehams Burn, Castle Douglas, Kircudbrightshire. Coll. H.M. Geological Survey, Edinburgh.

The thecæ themselves are simple tubes, expanding slightly in the direction of their apertures. When fully developed they are three times as long as wide, and have a length of 3·2 mm. They are inclined at a maximum angle of 40°, but near the sicula the angle is usually not more than 25°. The ventral wall is slightly concave, and the apertural angle being normal varies with the angles of inclination of the thecæ. The thecæ number nine to ten in 10 mm. at all points along the stipes. Near the sicula they are only just in contact with each other, but in the distal region of the stipes they may overlap for as much as one half to two thirds their length.

Affinities.—*D. superstes* appears to differ from all other forms in the characteristic curvature of the stipes, and the rapidity with which they increase in width.

Fig. 11 *c*.—*Didymograptus superstes*, Lapworth.

Distal thecæ. Enlargement of part of Pl. I, fig. 9 *b*.

Horizon and Localities.—Llandeilo, Upper (Glenkiln).

Moffat District: Birnock; Hawkwood Burn, Abington; Morrach Bay; Portpatrick; Tottlehams Burn; Castle Douglas. *Co. Down and Co. Armagh:* Ballygrot; Craigavad; Ballymony, Hollywood, Poyntzpass. *St. David's District:* Abereiddy Bay. *Shropshire:* Spy Burn.

Associates, etc.—*D. superstes* is best known from the Glenkiln Shales of S. Scotland, where it occurs associated with *D. serratulus*, *Cœnograptus gracilis*, *Leptograptus sp.*, *Dicellograptus Moffatensis*, *D. sextans*, *Dicranograptus ramosus*, *D. tardiusculus*, *Diplograptus bimucronatus*, *D. euglyphus*, *Cryptograptus tricornis*, *Glossograptus ciliatus*, and *Clathrograptus cuneiformis*. At Abereiddy Bay it occurs associated with *Didymograptus Murchisoni*, *D. euodus*, and various Diplograptidæ.

The best specimens are in Lapworth's collection, and in those of the Scotch and Irish Geological Surveys; there are also some in Swanston's collection. The type specimen (Pl. I, fig. 9 *a*) is in Lapworth's collection.

Didymograptus euodus, Lapworth. Plate I, figs. 10 *a*, *b*.

1875. *Didymograptus euodus*, Lapworth, Quart. Journ. Geol. Soc., vol. xxxi, p. 645, pl. xxxv, figs. 1 *a*—*c*.

Stipes several cm. in length, narrow at origin, but gradually increasing throughout their length to a maximum of about 2·4 mm., diverging from the sicula at a primary angle of 150°, but after a short distance curving back and running horizontally. Thecæ seven to eight in 10 mm., peculiar in form, having slight double curvature in their outer walls; inclined at about 30°, five times as long as wide, and free for half their length. Apertural margins normal, concave, broadly mucronate.

Description.—The stipes are narrow at their origin, and exhibit marked curvature; they measure only ·6 mm. in width at first, but increase steadily and almost imperceptibly up to a maximum of about 2·4 mm. This maximum width is not attained till a length of about 15 cm. has been reached, so that when completely developed the species must have been 30 cm. or more in length. Examples showing the proximal end in a fair state of preservation are rare, though fragments of stipes are fairly abundant at a certain horizon.

The sicula is wide in proportion to its length, which does not exceed 1·05 mm.;

but unfortunately all other details regarding the structure of the proximal end are obscure in the few specimens as yet known to us.

FIG. 12.—*Didymograptus euodus*, Lapworth.

Distal thecæ. Enlargement of part of Pl. I, fig. 10 *b*.

The thecæ show slight double curvature of their outer walls, and the concave aperture is frequently prolonged into a conspicuous denticle. The distal thecæ are inclined at an angle of 30° to the general direction of the stipe, but in the region of the sicula the inclination does not exceed 20°. They number seven to eight in 10 mm. The overlap increases from mere contact near the sicula to a maximum of one half the total length in the more distal portions of the stipes. The individual thecæ may measure as much as 3·2 mm. in the later parts of the stipe, but are much shorter near the proximal end.

Affinities.—The species may be distinguished from all other Didymograpti by the remote cells and the almost imperceptible increase in width of the stipes; in some respects it approaches in character the members of the *D. affinis* group, and in others to members of the *D. extensus* group; it may, in fact, be regarded as forming a link between these and the group in which it is included.

Associates, etc.—It occurs associated with *D. Murchisoni*, *D. superstes*, and certain Diplograptidæ. Lapworth originally cited S. Scotland as a region where it occurred in association with *D. superstes*, but this is an error; it appears to be as yet unknown from Scotch deposits.

Horizon and Localities.—Lower Llandeilo.

St. David's District: Abereiddy Bay (south end); Llanvirn Quarry?

A few specimens are in the Woodwardian Museum, Cambridge, including the type (Pl. I, figs. 10 *a*, *b*) originally described and figured by Lapworth.

Characters of the Group of *D. superstes*.

	D. superstes.	*D. euodus.*
Form of stipe . . .	Flexuous	Horizontal
Width	3 mm., increase rapid	2·4 mm., increase very gradual
Length of sicula . .	1·1 mm.	1·05 mm.
Origin of stipes . .	Suboral	Suboral
No. of thecæ in 10 mm.	9—10	8
Inclination . . .	40°	30°
Overlap	$\frac{1}{2}$—$\frac{2}{3}$	$\frac{1}{2}$

Declined Series.

Didymograpti with approximately straight stipes diverging downward, in which the ultimate angle of divergence is typically less than 180°.

Group III.—Type *D. affinis.*

Didymograpti in which the stipes are narrow, of approximately equal width, growing more or less rigidly outward and downward, and originating slightly above the aperture of the sicula. Thecæ are inclined at small angles, and the amount of overlap is never great.

Didymograptus affinis, Nicholson. Plate II, figs. 1 *a*, *b*.

1869. *Didymograpsus affinis*, Nicholson, Ann. Mag. Nat. Hist. [4], vol. iv, p. 240, pl. xi, fig. 20.
1870. *Didymograpsus affinis*, Nicholson, Ann. Mag. Nat. Hist. [4], vol. v, p. 343, fig. 4.
1875. Non *Didymograptus affinis*, Hopkinson, Quart. Journ. Geol. Soc., vol. xxxi, p. 645, pl. xxxiii, figs. 6 *a*—*c*.
1898. *Didymograptus affinis*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 503.

Stipes 12 to 18 mm. in length, very narrow throughout, never exceeding ·6 mm. in width, diverging from a small sicula at angles of 90° to 150°. Thecæ seven to ten in 10 mm., outer walls straight, three to four times as long as wide, free for the greater part of their length; inclination 15° to 20°. Apertural margins straight, perpendicular.

Fig. 13 *a*.—*Didymograptus affinis*, Nicholson.

Proximal end, reverse view; enlargement of part of Pl. II, fig. 1 *b*.

Description.—The stipes have a uniform width ·6 to ·5 mm., and are commonly 12 to 18 mm. in length.

The sicula is minute, being about ·8 mm. in length; the first theca (th. 1^1) originates at a very short distance above the aperture of the sicula and grows immediately outward, so that the sicula is free on one side of its aperture for a small fraction of its length. In the reverse aspect of the polypary the crossing canal is seen to be narrow, oblique, and short, and it conceals part of the aperture of the sicula.

Fig. 13 *b*.—*Didymograptus affinis*, Nicholson.

Distal thecæ; enlargement of part of Pl. II, fig. 1 *a*.

The general characters of the thecæ are simple; they are tubes which widen gradually in the direction of their apertures, and have a length of about 1·5 mm. Nicholson gives the number of thecæ as seven in 10 mm., but in some specimens this number would appear to be exceeded.

Affinities.—The species is closely allied in form to *D. Nicholsoni*, from which it may, however, be distinguished—

(1) by the greater tenuity of the stipe,

(2) the characters of the thecæ:

(*a*) low angle of inclination,

(*b*) short contact,

(*c*) number in a given unit of length,

(3) the character of the proximal end.

Horizon and Localities.—Arenig (Middle and Upper Skiddaw Slates); Upper Arenig (Shelve and St. David's).

Lake District: Aik Beck, Pooley; Barf; Carlside Edge, Skiddaw; Ellergill. *S. Shropshire:* Shelve; Hope Valley. *St. David's District:* Llanvirn Quarry; Porth-hayog, Ramsey Island.

Associates, etc.—The species occurs in association with *D. nanus*, and is fairly abundant at certain of the above localities. Good specimens are in the collections of the Geological Survey, the Woodwardian Museum, the British Museum (Natural History), and in that of Professor Lapworth.

The original specimen figured by Nicholson is unknown, but that illustrated on our Pl. II, fig. 1 *b*, now in the British Museum of Natural History, bears the label *D. affinis* in Nicholson's handwriting, and may be regarded as the type.

Didymograptus gracilis, Törnquist. Plate II, fig. 2.

1890. *Didymograptus gracilis*, Törnquist, "Undersök. ofver siljansområdets. Grapt., pt. 1," Lunds Univ. Årssk., vol. xxvi, p. 17, pl. i, figs. 9—12.

1898. *Didymograptus gracilis*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 506.

Stipes slightly curved, about 5 cm. in length, very slender, never exceeding ·5 mm. in width, diverging at 180° from a conspicuous sicula at markedly different levels. Thecæ widening towards these apertures, seven in 10 mm., free throughout their length, inclined at 15° or rather less, outer walls slightly curved. Apertural margin straight, perpendicular.

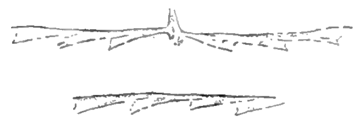
Description.—The narrow stipes are of approximately uniform width, and the greatest breadth, which never exceeds ·5 mm., is attained opposite the apertures of the thecæ. The stipes may attain a length of 5 cm.

The sicula is more than ordinarily conspicuous because of the slender character of the polypary. It measures about 1·2 mm. in length. The apparent origin of the stipes at different levels on the sicula must be due to the very oblique course taken by the crossing canal, though this has not been directly observed, the only specimen sufficiently well preserved to show such detail being presented in the obverse view. Theca 1^1 originates two thirds of the way down the sicula and grows out at once, so that the first stipe appears to originate at that point; but the second theca (th. 1^2) grows out close to the aperture.

The thecæ are in contact only; the width at their apertures is twice that at their origin, and they are three times as long as wide. The average length of each theca is 1·6 mm.

Figs. 14 *a* and *b*.—*Didymograptus gracilis*, Törnquist.

a



b

a. Proximal end, obverse view; enlargement of part of Pl. II, fig. 2.
b. More distal thecæ of same specimen.

Affinities.—*D. gracilis* is nearly related to *D. affinis*, but is distinguished by the horizontality of the stipes and the more remote thecæ.

Horizon and Localities.—Arenig, Middle Skiddaw Slates.

Lake District: Barf, near Keswick.

There are very few British specimens known; the best is in Postlethwaite's collection at Keswick, and all those recorded up to the present time have been found in the Lake district.

Didymograptus acutidens, Lapw. MS. Plate II, figs. 3 *a—d*.

1875. *Didymograptus affinis*, Hopkinson, Quart. Journ. Geol. Soc., vol. xxxi, pl. xxxiii, figs. 6 *b*, *c*.

Stipes 5—7 cm. or more in length, narrow at origin but widening steadily to a maximum of 1·5 mm., diverging from a conspicuous sicula at angles of 130°—150°. Thecæ eleven to thirteen in 10 mm., four times as long as wide, overlap and inclination varying in different parts of the stipe. Apertural margin slightly oblique, concave, and with distinct denticles.

Description.—The stipes are exceedingly narrow at their origin, being often not more than ·4 mm. in width; they widen steadily up to a maximum of 1·5 mm., but only measure ·6 mm. opposite the apertures of theca 10 or theca 11. The stipes are commonly straight, but may exhibit slight curvature in the region of the sicula.

Fig. 15 *a*.—*Didymograptus acutidens*, Lapworth MS.

a

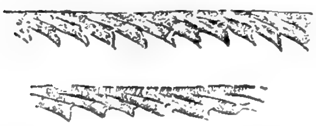
a. Proximal end, reverse view. Porthhayog, Ramsey Island. Coll. Woodwardian Museum.

The sicula is small and narrow though conspicuous; it is placed somewhat obliquely in the same manner as *D. Nicholsoni;* theca 1^1 appears to originate about halfway up the sicula on the left side (obverse aspect); it grows out at once and the crossing canal is very short, so that theca 1^2 arises almost at the same level as theca 1^1; it also curves away at once from the sicula, which thus has the whole of its apertural region free. The attachment of the stipes to the sicula is slender.

The general characters of the thecæ are peculiar; the form of the apertural margin is highly characteristic. It is deeply concave at its inner side, but near the outer truncate edge it becomes slightly convex; the apertures are nearly perpendicular in the initial region of the stipes, but are more oblique in the distal parts, and the apertural angle may be as low as 70°. In the distal portions of the stipes the thecæ number eleven to thirteen in 10 mm., but they are more remote near the sicula and each theca attains a length of 1·2 mm. The thecæ hardly overlap at all near the sicula, but this overlap increases toward the distal regions of the stipes to rather more than half their entire length, and a vertical line drawn through one thecal aperture cuts three different thecæ. The angle of inclination varies from 15° to 17°, but is rather smaller near the sicula.

FIGS. 15 *b* and *c*.—*Didymograptus acutidens*, Lapworth MS.

b



c

b. Distal thecæ showing obliquity of aperture. Enlargement of part of Pl. II, fig. 3 *d*.

c. Portion of stipe in low relief, showing large amount of overlap of the thecæ and growth-lines. Hope Stream, S. Shropshire. Coll. H.M. Geological Survey.

Affinities.—*D. acutidens* is allied to *D. affinis* in the uniformly low inclination of the thecæ, but differs from that species in the form of the aperture and the number of thecæ in a given unit of length. It was included by Hopkinson in *D. affinis* (Nich.) ('Quart. Journ. Geol. Soc.,' vol. xxxi, pl. xxxiii, figs. 6 *b*, *c*), though he recognised that it differed in certain particulars from the typical form. One of the specimens figured by him was found by us to be capable of further development, and the removal of a small piece of the rock matrix revealed the sicula and part of the second stipe, both exhibiting the characteristics of the present species. The number of thecæ in a given unit of length links this species with *D. Nicholsoni*, but the much lower inclination of the thecæ and the character of their apertures serve to distinguish it. In general form the polypary differs from that of either of its closest allies, and approaches that of *D. euodus*, from which, however, it is readily distinguished by the characters of the thecæ.

Horizon and Localities.—Upper Arenig (Llanvirn).

St. David's District: Porth-hayog, Ramsey Island. *S. Shropshire:* Hope Stream, a little west of Hope Quarry; Upper Grimmer Farm; Stream, quarter of a mile north-east of Knot Moor.

Associates, etc.—The species occurs fairly abundantly in the Lower Llanvirn beds of the St. David's district, associated with *D. bifidus*, *D. Nicholsoni*, and *D. nanus*. Several specimens are known in the collections of Lapworth, the Geological Survey, the Woodwardian Museum, and the Authors. We regard as type specimens those figured in Pl. II, figs. 3 *a* and 3 *b*. The former is in the Woodwardian Museum, and the latter in the collection of the Geological Survey.

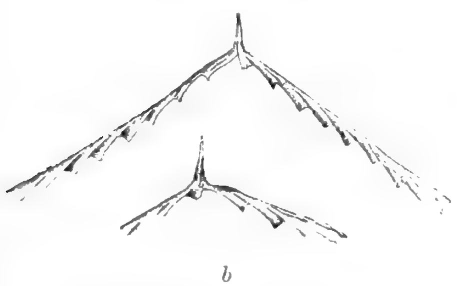
Didymograptus Nicholsoni, Lapworth. Plate II, figs. 4 *a—c*.

1868. *Didymograpsus serratulus,* Nicholson, Quart. Journ. Geol. Soc., vol. xxiv, p. 136.
1870. *Didymograpsus serratulus,* Nicholson, Ann. Mag. Nat. Hist. [4], vol. v, p. 343, pl. vii, figs. 3, 3 *d*.
1875. *Didymograptus Nicholsoni,* Lapworth, Quart. Journ. Geol. Soc., vol. xxxi, p. 644, pl. xxxiii, figs. 5 *a—d*.
1898. *Didymograptus Nicholsoni,* Elles, Quart. Journ. Geol. Soc., vol. liv, p. 502, fig. 21.

Stipes from 2·5 to 5 cm. in length, uniformly slender, never exceeding 1 mm. in width, diverging from the sicula at angles of 110°—130°. Thecæ ten in 10 mm., four to five times as long as wide, in contact for a small fraction of their length, inclined at 25°—30°. Apertural margin normal, straight.

Description.—The narrow stipes are usually rigid and their dorsal walls straight, but occasionally they may be slightly curved; in some individuals they attain a great length (11 cm.), but smaller specimens (4 cm.) are commoner. They widen very slightly from their point of origin, but are uniformly narrow for the greater part of their length, never exceeding 1 mm. in width, and measuring commonly rather less (·75 mm.).

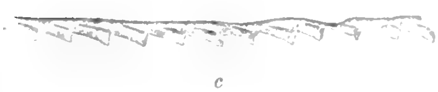
FIGS. 16 *a* and *b*.—*Didymograptus Nicholsoni,* Lapworth.



a. Proximal end, cast, reverse view. Barf. Coll. Woodwardian Museum.
b. Proximal end, obverse view. Enlargement of part of Pl. II, fig. 4 *a*.

The sicula is about 1·8 mm. in length; it is narrow, and does not widen much, even in the direction of its aperture, where it measures ·3 to ·4 mm. The earliest theca (th. 1^1) originates about halfway up the sicula on the left side (obverse view). The general structure of the polypary is, however, best seen in the reverse view. Theca 1^1 at once curves outward, leaving the sicula free on the left side near its aperture. The crossing canal is long and oblique, and theca 1^2 is closely appressed to the right side of the sicula. Of the thecæ developed subsequently, those nearest the sicula show a slight concave curvature of their outer walls, but the walls of the more distal thecæ are straighter.

FIG. 16 *c*.—*Didymograptus Nicholsoni,* Lapworth.



. Distal thecæ, cast. Enlargement of part of Pl. II, fig. 4 *a*.

The number of thecæ in a given unit of length is also somewhat variable; there are usually ten in 10 mm., but they are commonly more remote in the initial parts of the stipes. The average inclination to the axis is 25° to 30°, but varies from 20° to 30° in different parts of the stipes. In the distal parts the thecæ are in contact for half to one third their length, but near the sicula the overlap is less. The average thecal length is about 1·6 mm.

Affinities.—*D. Nicholsoni* may be said to be characterised—

(1) by the rigidity of the stipes,

(2) by the characters of the thecæ:

(*a*) their low angle of inclination,

(*b*) the number of a given unit of length.

From *D. affinis*, to which it is closely allied, it may be distinguished—

(1) by the greater width of the stipes,

(2) the characters of the thecæ:

(*a*) their greater overlap,

(*b*) higher inclination, and

(*c*) greater number in a given unit of length.

It has been already pointed out ('Quart. Journ. Geol. Soc.,' vol. liv, p. 502) that the Skiddaw Slate specimens were provisionally referred by Nicholson to *D. serratulus*, from which, however, he considered they varied in some particulars. Lapworth (see synonymy) showed that the thecæ differed in certain important features from those of Hall's species, and additional characteristics afforded by specimens subsequently discovered in the St. David's district convinced him that the present form was worthy of being separated as a distinct species, for which he proposed the name *D. Nicholsoni*.

Horizon and Localities.—Arenig (?), Upper part (Middle and Upper Skiddaw Slates); Llanvirn (St. David's); Upper Arenig of Shelve.

Lake District: Barf, near Keswick; Carlside Edge, Skiddaw; Outerside; Thornship Beck, Shap. *St. David's District:* Porth-hayog, Ramsey Island; Llanvirn Quarry; Whitland, Pwllacca. *Shropshire:* Ritton Castle, Shelve.

Associates, etc.—The species occurs low down in the Skiddaw Slates associated with *Tetragraptus quadribrachiatus*, and also in somewhat higher beds at Outerside and Barf; at St. David's it occurs exclusively—so far as we at present know—in beds corresponding with the higher beds of the Skiddaw series of the Lake district, namely, those of Llanvirn, where it occurs in association with *D. bifidus* and *D. nanus*.

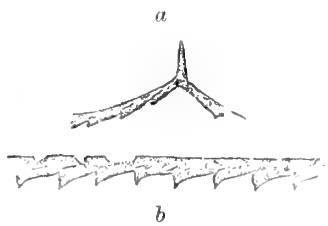
Several specimens are preserved in the collections of the British Museum (Nat. Hist.), the Woodwardian Museum, and in the private collections of Lapworth and the Authors.

Nicholson's original specimens are not known with certainty, but we regard that figured in Pl. II, fig. 4 *a*, as our type.

Didymograptus Nicholsoni, var. **planus,** Nov. Plate II, figs. 5 *a*, *b*.

In addition to the typical form of *D. Nicholsoni* there also occurs a variety differing from the type in general shape, and in the lower inclination of the thecæ, though agreeing with it in all other essential particulars. The stipes run horizontally, except in the neighbourhood of the sicula, where they exhibit marked convex curvature. The inclination of the thecæ seems never to be as high as 25°, but always exceeds 20°.

Figs. 17 *a* and *b*.—*Didymograptus Nicholsoni*, var. *planus*, nov.



a. Proximal end, obverse view. Enlargement of part of Pl. II, fig. 5 *a*.
b. Distal thecæ. Enlargement of part of Pl. II, fig. 5 *b*.

In the true *D. Nicholsoni* the angle of divergence never exceeds 150°, and the inclination of the thecæ in the distal parts of the stipes is almost invariably as high as 30°, and these characters are practically constant in the many specimens which we have examined from different parts of the country.

Horizon and Localities.—*D. Nicholsoni*, var. *planus*, occurs in the Upper Skiddaw Slates.

Lake District: Outerside.

Specimens of this variety, including our type specimen (Pl. II, fig. 5 *a*), are in the Woodwardian Museum.

Didymograptus serratulus (Hall). Plate II, figs. 7 *a*, *b*.

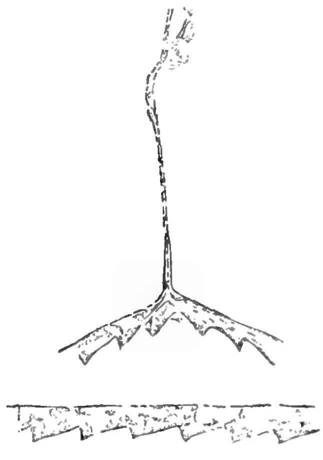
1847. *Graptolithus serratulus*, Hall, Pal. N. York, vol. i, p. 274, pl. lxxiv, fig. 5.
1868. Non *Didymograpsus serratulus*, Nicholson, Quart. Journ. Geol. Soc., vol. xxiv, p. 136.
1870. Non *Didymograpsus serratulus*, Nicholson, Ann. Mag. Nat. Hist. [4], vol. v, p. 343, pl. vii figs. 3, 3 *d*.

Stipes 5—7 cm. in length (or even more), uniformly narrow, not exceeding 1 mm. in width, straight or slightly curved, diverging from a conspicuous sicula at about 120°. Thecæ seven to eight in 10 mm., three to four times as long as wide, overlap increasing with age of stipe, inclined at an average angle of 25°. Apertural margin straight, practically normal.

Description.—The stipes vary from ·8 to 1 mm. in width, being practically uniform throughout. The only specimen known to us which exhibits any details of structure of the proximal end is seen in the reverse aspect. The sicula is 2 mm. or more in length, and its aperture almost entirely concealed by the second theca. The origin of the first theca is obscure, but it is almost certainly suboral. The apical end of sicula is prolonged into a fine thread (*nema*), some 6 mm. in length, which appears to branch at its extremity.

The number of thecæ varies in different parts of the stipes, being seven in 10 mm. near the sicula, but usually eight in 10 mm. in the more distal portions. The thecæ are free for half their length in the distal regions of the stipes, but for a greater fraction of their length near the sicula.

Figs. 18 *a* and *b*.—*Didymograptus serratulus*, Hall.



a. Proximal end showing long nema, reverse view. Enlargement of part of Pl. II, fig. 7 *a*.
b. Distal thecæ. Enlargement of part of Pl. II, fig. 7 *b*.

Remarks.—*D. serratulus* is found in the Glenkiln Shales of South Scotland and Ireland, but generally in a fragmentary condition. It occurs usually as isolated stipes, which agree, however, in all particulars with the American examples described by Hall, except that the general form is rather more curved than Hall's figures would seem to indicate is the case with the American forms.

Affinities.—*D. serratulus* is closely allied to *D. Nicholsoni* and *D. euodus*, from both of which it differs—

(1) in the number of thecæ in a given unit of length,

(2) in the greater inclination of the thecæ.

Horizon and Localities.—Llandeilo (Glenkiln Shales).

S. Scotland: Berrybush, Selkirkshire; Birnock, Lanarkshire; Minnoch Water, Glencaird Lodge. *N. Ireland:* Ballygrot, Craigavad (co. Down).

Associates, etc.—*D. serratulus* occurs in abundance in association with *D. superstes*, *Cœnograptus gracilis*, *Leptograptus*, sp., *Dicellograptus Moffatensis*, *Cryptograptus tricornis*, *Clathrograptus cuneiformis*, *Lasiograptus bimucronatus*, and *Diplograptus euglyphus* in the Glenkiln Shales of S. Scotland, where it has been collected by Lapworth, and by the officers of H.M. Geological Survey of Scotland. Lapworth also records the species from Ireland (co. Down).

Didymograptus simulans, sp. nov. Plate II, figs. 6 *a*, *b*.

1868. *Didymograpsus nitidus*, Nicholson (*pars*), Quart. Journ. Geol. Soc., vol. xxiv, p. 135.
1870. *Didymograpsus nitidus*, Nicholson, Ann. Mag. Nat. Hist. [4], vol. v, p. 342, fig. 3.
1898. *Didymograptus nitidus*, Elles (*pars*), Quart. Journ. Geol. Soc., vol. liv, p. 500, fig. 19.

Stipes 2—5 cm. in length, curved, narrow at origin, but widening steadily throughout their length to a maximum of 1·4 mm., diverging from a slender sicula at about 115°, and including ultimately an angle of about 160°. Thecæ thirteen to fourteen in 10 mm., inclined at 30°, three times as long as wide, free half their length. Apertural margins normal, straight, submucronate.

Description.—The dorsal wall of each stipe shows slight convex curvature in its initial region, but it becomes straighter distally. The increase in width is fairly rapid at first, but is more gradual in the distal parts of the stipe; the width at origin is about ·6 mm., and the maximum observed 1·4 mm.

FIGS. 19 *a* and *b*.—*Didymograptus simulans*, sp. nov.

a

b

a. Proximal end, obverse view. Enlargement of part of Pl. II, fig. 6 *b*.
b. Proximal end, in low relief, reverse view. Barf. Coll. Woodwardian Museum.

The sicula is slender and tapering, and measures 1·54 mm. in length. Theca 1^1 originates some little distance above the base, and appears at once to grow outward and downward with a graceful double curvature of its outer wall. The crossing canal is narrow. It crosses the sicula obliquely a little above the sicula aperture, to which theca 1^2 is closely appressed. This gives the sicula the appearance of being obliquely situated with respect to the two stipes.

The thecæ, which have an average length of 2 mm., are simple, and widen slightly in the direction of their apertures. The overlap is hardly appreciable in the initial part of the stipes, but the overlap increases to one half the length in the distal region. The apertural angle is commonly about 120°—125°, but occasionally the thecæ have a "*constrictiform*" appearance.

FIG. 19 *c*.—*Didymograptus simulans*, sp. nov.

c

c. Distal thecæ, preserved as a cast, showing growth-lines. Enlargement of part of Pl. II, fig. 6 *b*.

Affinities.—*D. simulans* is allied to *D. Nicholsoni* and *D. nitidus*. It resembles *D. Nicholsoni* in the character of its proximal end, which is almost identical with the proximal end of that species, but is distinguished by its more closely set thecæ. In the individual characters of the thecæ, on the other hand, this species approaches *D. nitidus*, but the sicula is different in form, and the whole character of the proximal end distinct.

D. simulans was originally referred by Nicholson to *D. nitidus* of Hall (loc. cit.), but is easily distinguished from that species by the characteristics above mentioned.

Horizon and Localities.—Arenig (Middle Skiddaw Slates).

Lake District: Barf; Randal Crag.

Associates, etc.—*D. simulans* appears to be confined to the Skiddaw Slates, in which it occurs in great numbers at certain horizons. It has not yet been found associated with any other species. Specimens collected from the Lake district, including the type specimen (Pl. II, fig. 6 *b*), are in the Woodwardian Museum.

Didymograptus, *cf.* **filiformis,** Tullberg. Text figs. 20 *a*, *b*.

1880. *Didymograptus filiformis,* Tullberg, Geol. Fören. i. Stockh. Förhandl., vol. v, p. 42, pl. ii, figs. 8—11.
1901. *Didymograptus filiformis,* Törnquist, Lunds Univ. Årssk., Bd. 37, Af. 2, Nr. 5, pl. iii, figs. 6—9.

Stipes very slender, not exceeding 12·7 mm. in length, and with a uniform width of about ·5 mm., diverging at about 90° from a long and narrow sicula. Thecæ seven in 10 mm., inclined at 20°, six times as long as wide, and in contact for only a small fraction of their length. Apertural margins normal, straight, occupying fully two thirds the width of the stipe.

Description.—The stipes have a slight concave curvature, and are of uniform width throughout their length.

The first theca (th. 1^1) originates close to the apex of the sicula, and grows downwards closely appressed to it throughout its length, curving away only when the aperture is reached. The second theca (th. 1^2) is continued from the crossing canal close to the aperture on the other side of the sicula, so that there is a marked want of symmetry as regards the origin of the branches. The sicula is 2·1 mm. in length, and the thecæ have a similar length.

FIGS. 20 *a* and *b*.—*Didymograptus,* cf. *filiformis,* Tullberg.

b a

a. Specimen in relief, natural size. Bennane Head, Ballantrae. Coll. Lapworth.
b. The same, obverse view. × 5.

Affinities.—The angle of inclination is rather lower than in Tullberg's type, but the form agrees closely with *D. filiformis* in other particulars. It does not seem to be closely allied to any other species, but is characterised by its general shape, uniformly slender width, want of symmetry at the proximal end, and the remoteness of the thecæ. It is provisionally placed in this group on account of its general form. In the characters of its proximal end, however, it is more closely allied to the group of *D. extensus.*

Horizon and Localities.—It has been found by Lapworth and the officers of H.M. Geological Survey in the Arenig rocks of Bennane Head, near Ballantrae.

Characters of Group of *D. affinis.*

	D. affinis.	*D. gracilis.*	*D. acutidens.*	*D. Nicholsoni.*	*D. serratulus.*	*D. simulans.*	*D. cf. filiformis*
Form of stipe	Narrow, rigid, straight	Narrow, rigid, horizontal	Narrow, rigid, nearly straight	Narrow, rigid, straight	Narrow, rigid, straight	Narrow, rigid, curved	Narrow, rigid, straight
Angle of divergence	90°—150°	180°	150°	110°—130°	120°—130°	115°—160°	90°
Maximum width	·6 mm.	·5 mm.	·63—1·5 mm.	1 mm.	1 mm.	1·4 mm.	·5 mm.
Length of sicula	·8 mm.	1·2 mm.	1·3 mm.	1·8 mm.	2 mm.	1·5 mm.	2·1 mm.
Origin of stipes	Suboral	Suboral (medial)	Suboral (medial)	Suboral	Suboral	Suboral	Apical
No. of thecæ in 10 mm.	8	7	11—13	10—11	7—8	13—14	7
Inclination	15°—20°	15°	15°—17°	25°—30°	25°	30°	20°
Overlap	Very small	Very small	Contact to ½	Contact to ½	Contact to ½	Contact to ½	Very small

Deflexed Series.

Didymograpti with flexed stipes diverging downward, in which the initial angle of divergence is less than 180°.

Group IV.—Type *D. v-fractus.*

Didymograpti in which the stipes grow outward and downward; they originate above the aperture of the sicula, and are at first concavely and then convexly curved. The thecæ are inclined at moderate angles, and the amount of overlap is considerable.

Didymograptus v-fractus, Salter. Plate II, figs. 10 *a*, *b*.

1863. *Didymograpsus v-fractus*, Salter, Quart. Journ. Geol. Soc., vol. xix, p. 137, fig. 13 *c*.
1868. *Didymograpsus v-fractus*, Nicholson, Quart. Journ. Geol. Soc., vol. xxiv, p. 134.
1895. *Didymograptus v-fractus*, Perner, Grap. de Bohême, pt. 2, p. 24, pl. v, figs. 15, 16; pl. vii, figs. 1, 2.
1898. *Didymograptus v-fractus*, Elles (*pars*), Quart. Journ. Geol. Soc., vol. liv, p. 508, *non* figs. 25—28.

Stipes about 5 cm. in length, widening steadily from their origin to a maximum of 2·5 mm., diverging from a conspicuous sicula to form an inverted **V**, but expanding somewhat abruptly afterwards to include a more open angle. Thecæ eight to ten in 10 mm., inclined to axis at angle increasing from 35° in the proximal part of the stipe to 55° in the distal, about four times as long as wide. Outer margins free one fifth their length. Apertural margin slightly concave, normal.

Description.—The stipes widen gradually from their origin; at first they are only ·8 mm. wide, but attain a maximum breadth of 2·5 mm. The curvature of the stipes is at first concave and then convex. The **V** shape is very open and prolonged, the initial angle of divergence being about 90°, subsequently 40°, and finally about 130°, though this ultimate angle is very variable, as is also the proportion of the whole occupied by the **V**.

FIGS. 21 *a* and *b*.—*Didymograptus v-fractus*, Salter.

a *b*

a. Proximal end as a cast, obverse view. Enlargement of part of Pl. II, fig. 10 *a*.
b. Proximal end, reverse view, showing crossing canal in relief. Enlargement of part of Pl. II, fig. 10 *b*.

The sicula is long and narrow, it is about 2·5 mm. in length; the first theca originates at a point nearly midway between the aperture and the apex, but rather nearer to the latter. It curves away from the sicula at once, leaving it isolated at its oral extremity for a considerable distance on the left side (obverse view); it is short, and its aperture is very slightly below the level of that of the sicula. The crossing canal is very conspicuous; it runs obliquely across the sicula from the point of origin of th. 1^1 to its aperture.

The walls of the thecæ are always curved, though a gradual change in the curvature takes place in passing from the initial to the distal regions of the stipes. The curvature of the earliest developed thecæ is concave, but this changes gradually to a convex curvature, causing an alteration in the direction of growth of the stipes, and with this change the angle of inclination of the thecæ rises. Near the sicula the thecæ are free for from two thirds to one half of their length, but only for one fifth of their length in the more distal parts of the stipes. The average length of each mature theca is about 3 mm., the average width ·8 mm.

Affinities.—This species may be readily distinguished from almost any other by its peculiar form. The only one it resembles in this respect is *D. deflexus*, which is a much more slender species, and smaller in every way.

Horizon and Locality.—Arenig, Middle Skiddaw Slates (Dichograptus beds).

Lake District: Buttermere.

Associates, etc.—It occurs in abundance in certain parts of the Skiddaw Slates associated with *Tetragraptus quadribrachiatus* and large specimens of *Temnograptus* *multiplex*, *Trochograptus diffusus*, and *Holograptus Deani*. The best specimens, which are excellently preserved, are in Lapworth's collection. We have not seen Salter's type specimen, but we regard the one figured in our Pl. II, fig. 10 *a*, as the typical example for this species.

Didymograptus v-fractus, var. **volucer,** H. O. Nicholson. Plate II, figs. 11 *a*, *b*.

1890. *Didymograptus v-fractus*, var. *volucer*, H. O. Nicholson, Geol. Mag. [3], vol. vii, p. 342, fig. 3.

Description.—In addition to the typical form of the species *v-fractus* there occurs in the same beds a form which exhibits certain differences from the type, and as these differences seem to be constant it has been separated by Dr. H. O. Nicholson as a distinct variety.

Fig. 22.—*Didymograptus v-fractus*, var. *volucer*, H. O. Nicholson.

Proximal end, reverse view. Enlargement of part of Pl. II, fig. 11 *b*.

In this variety the basal angle is narrower than in the typical form, and the stipes at the termination of the **V** are bent abruptly at right angles to their original direction of growth, and continue to grow thereafter in a horizontal direction. The maximum width, 2·1 mm., is attained at the bend. The angle of inclination of the thecæ in the **V** part is 25°—30°, at the bend 60°, and in the horizontal part 40°.

Horizon and Locality.—Arenig, Middle Skiddaw Slates.

Lake District: Outerside.

The type specimen is now in the collection of Professor Lapworth. Other specimens are in the Woodwardian Museum and in the Museum of the Geological Survey. Var. *volucer* has not been found associated with any other forms.

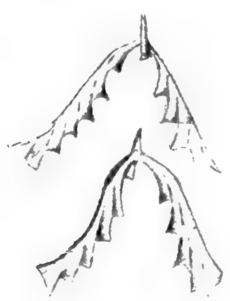
Didymograptus deflexus, sp. nov. Plate II, figs. 12 *a*, *c*.

1898. *Didymograptus v-fractus*, Elles (*pars*), Quart. Journ. Geol. Soc., vol. liv, p. 508, figs. 25—28.

Stipes 2·5—5 cm. in length at origin, narrow, widening fairly rapidly to a breadth 1 mm., diverging from a conspicuous sicula to form an inverted V, but expanding afterwards to include a more open angle. Thecæ fourteen in 10 mm., inclined to the axis at angles 25°—30°, about three times as long as wide, outer margins free one half to two thirds their length; apertural margin normal, slightly concave.

Description.—The stipes are narrowest at their origin, but they expand fairly rapidly to a width of 1 mm. near the bend; in the largest specimens the width may be as much as 1·5 mm., but the smaller breadth is the more usual. As in *D. v-fractus*, there is great variation as regards the length of the V part and the subsequent direction taken by the stipes. In some specimens the V part is narrow and rather long; in others it is small, and the stipes after the bend are exceedingly long in proportion; while in others again the initial angle of divergence is greater, and the change in direction less abrupt. Some forms indeed approach very nearly to Tullberg's *D. vacillans*, but the stipes in that species are of uniform width throughout, which is never the case in *D. deflexus*.

FIGS. 23 *a* and *b*.—*Didymograptus deflexus*, sp. nov.



a. Proximal end in relief, obverse view. Enlargement of part of Pl. II, fig. 12 *b*.
b. Proximal end, cast, reverse view. Enlargement of part of Pl. II, fig. 12 *a*.

The sicula is long and narrow; it attains a length of 1·6 mm. exclusive of the prolongation from its apex (nema). The sicula is not placed symmetrically with regard to the stipes; it is nearer the stipe bearing the second thecal series. The first theca (th. 1^1) appears to originate from the sicula some distance above its aperture; it grows at first away from the sicula in a horizontal direction, and thus in the obverse aspect the sicula is seen to be free on the left side near the aperture. After growing horizontally it curves downwards. Viewing the polypary in the reverse aspect, theca 1^2 is seen to be closely appressed to the apertural part of the sicula; the crossing canal is also visible, and is narrow and runs somewhat obliquely.

The thecæ in the initial part of the polypary are about 1·26 mm. long; they have their walls concavely curved, but after about two or three thecæ are formed this concave curvature begins to give place gradually to a slight convex curvature. The thecæ thus curve away from each other, and the general direction of the stipe is changed. The thecal walls in the distal portion of the stipes are nearly straight; the thecæ have a length of 1·6 mm., and are about three times as long as wide.

Affinities.—This species was originally included with Salter's *D. v-fractus* (Elles, 'Quart. Journ. Geol. Soc.,' vol. liv, p. 508), but an examination of additional specimens shows that the smaller form is not merely a young individual, but belongs to a distinct species.

The general shape of the polypary resembles that of *D. v-fractus*, but the V part is shorter in proportion to the size of the polypary, and the whole is more slender and graceful.

Horizon and Localities.—Arenig (Middle Skiddaw Slates).

Lake District: New Brow Quarry, Upper Lorton; Dodd, Brackenthwaite; Barf, near Keswick; Brunstock Scar.

Associates, etc.—*D. deflexus* has, up to the present time, been recorded from the Skiddaw Slates only, in which it is fairly abundant; good specimens are in the collection of the Woodwardian Museum and of the Geological Survey, and in that of Mr. John Postlethwaite, of Keswick. Its associates are unknown. The type specimen (Pl. II, fig. 12 *a*) is in the Woodwardian Museum.

Dependent Series.

Didymograpti with stipes diverging downward, and in which the stipes tend to become approximately parallel.

Group V.—Type *D. Murchisoni*.

Didymograpti in which the stipes grow downward; they originate slightly above the aperture of the sicula; the thecæ are inclined at large angles, and the amount of overlap is considerable.

Sub-group A.—Type *D. bifidus*.

Dependent Didymograpti in which the stipes widen throughout their length.

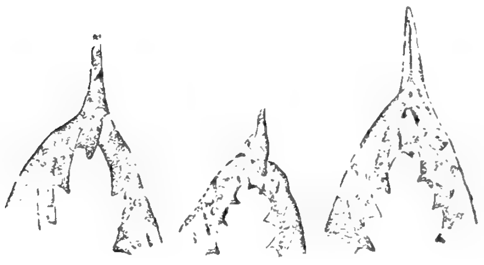
Didymograptus Murchisoni (Beck). Plate III, figs. 1 *a*—*k*.

1839. *Graptolithus Murchisoni*, Beck, Murchison's Sil. System, pl. xxvi, fig. 4.
1861. *Didymograpsus Murchisoni*, Baily, Journ. Geol. Soc., Dublin, vol. ix, pl. iv, figs. 1 *a*—*c*.
1869. *Didymograpsus Murchisoni*, Hopkinson, Journ. Quekett Micro. Club, vol. i, pl. viii, figs. 6 *a*, *b*.
1870. *Didymograpsus Murchisoni*, Nicholson, Ann. Mag. Nat. Hist. [4], vol. v, p. 349, pl. vii, figs. 7, 7 *a*, 7 *b*.
1875. *Didymograptus Murchisoni*, Lapworth, Quart. Journ. Geol. Soc., vol. xxxi, p. 648, pl. xxxv, figs. 2 *a*—*f*.

Stipes robust, from 5 to 7·5 cm. in length, somewhat narrow at their commencement, but expanding gradually in width to a maximum diameter of 3 to 4 mm., and then continuing without further widening; diverging from a large blunt sicula at a primary angle of about 40°, curved at their origin but almost immediately becoming straight and parallel. Thecæ twelve to fourteen in 10 mm., inclined to the axis at an angle of 45°, three to four times as long as wide, and free one half to one fifth their length. Apertural margin normal, concave, with an acute denticle.

Description.—The *gradual* widening of the stipes from their origin is eminently characteristic of the species; in the typical forms the stipes are parallel after the development of the first dozen thecæ, and widen but little. In some of the longer specimens the stipes, after running parallel for a short distance, gradually approximate, until the thecal margins are in contact, and in some extreme cases the stipes may actually cross each other near their distal ends. The maximum width is only attained in the largest individuals; specimens showing a width of 2·5—3·2 mm. are of commoner occurrence.

FIGS. 24 *a*, *b*, and *c*.—*Didymograptus Murchisoni*, Beck.



a *b* *c*

a. Proximal end, impression of obverse view. Abereiddy Bay. Coll. G. L. Elles.
b. Proximal end, obverse view, on same slab as type specimen of *D. Murchisoni*. Gelli, Llandrindod.
c. Proximal end, reverse view. Enlargement of part of Pl. III, fig. 1*j*.

The sicula is large; it attains a length of about 3 mm., and widens rapidly in the direction of its aperture, which has a breadth of about ·75 mm. The first theca (th. 1^1) originates about 1 mm. above the aperture of the sicula, and running outward and downward (at all events in the obverse aspect) leaves the aperture free on the left side for a small fraction of its length. The crossing canal is wide and but slightly oblique; owing to its width and the direction of its growth, a considerable part of the apertural region of the sicula is concealed in the reverse aspect of the polypary. The origin of the stipes is fairly symmetrical.

The number of thecæ in a given unit of length varies in different specimens, but is usually the same in the same individual at any point along the stipe. The number is normally fourteen in 10 mm., but it may be as low as twelve in 10 mm., or in very exceptional cases it may rise to sixteen in 10 mm. At the very commencement the ventral margin of each cell is in contact for about half its length, but near the distal extremities of the stipes the thecæ may overlap four fifths of their length. The angle of inclination of the thecæ varies in different parts of the stipes from about 25° near the sicula to 45° in the maturer parts of the stipes, while in very long forms the angle may become as much as 60°. The thecæ are at first about 1·3 mm. in length, but increase gradually until they reach 5 mm. as a maximum.

Remarks.—The above description has been mainly drawn up from the type specimens figured by Murchison in his 'Silurian System,' now in the museum of the Geological Society of London, supplemented by details drawn from similar forms in S. Shropshire.

This form, *D. Murchisoni*, is most intimately connected with the form *D. geminus* of Hisinger and other Swedish authors. Owing to the kindness of Dr. Törnquist, of Lund, who has furnished us with specimens of *D. geminus* from the typical Swedish locality, we are enabled to discuss the question of the resemblances and differences existing between these two forms in some detail.

The type specimens figured by Sowerby in illustration of Murchison's species

('Sil. System,' pl. xxvi, fig. 4) are on a solid block of limestone about 6·3 cm. thick, which bears numerous Graptolites on both sides. The specimens figured in the 'Silurian System' do not occur in juxtaposition as drawn upon his plate, but are scattered over both sides of the stone, and upon some of its fragments. It seems clear that in Sowerby's figures two fairly distinct forms are included :

1. A form in which the proximal end is thick, and in which the stipes are usually more or less parallel or convergent;

2. A form in which the proximal end is very slender, the increase in width rapid, and the stipes as a rule either continuously divergent or divergent distally.

Now while it seems certain that both forms were originally included in the *D. Murchisoni* as figured and described, it also appears evident that the second of the two forms is that which Swedish palæontologists recognise as the form which Hisinger afterwards described as *D. geminus.* The two forms occur in association on the same slabs in Britain, and it is possible that they may eventually be shown to be identical; at all events, we can only regard *D. geminus* as a variety or mutation of *D. Murchisoni.* This was the view taken by Tullberg in 1881 ('Kong. Sven. Vet. Akad. Handl.,' No. 13, p. 16), though the typical form of *D. Murchisoni* had not been recognised by him in Sweden. We hold that at present the balance of evidence is in favour of the varietal character of this second form, and we here restrict the name *D. Murchisoni* to those forms possessing a thick proximal end and more or less parallel stipes, and we employ the name var. *geminus*, His., for the second form only.

The well-known specimens of the *D. Murchisoni* group which occur in such abundance at Abereiddy Bay would seem at first sight to present certain differences from the typical form, the average number of thecæ to the cm. being fewer as a rule. It is, however, certain that the rocks at that locality have been much cleaved, and the fossils consequently much distorted. In correspondence with this we find, on one and the same slab, greatly elongated and narrow forms, with distant thecæ, lying more or less at right angles to forms much shortened and widened, and with close-set thecæ, which might naturally be taken for distinct species. But the two extremes are connected by transitional forms lying at intermediate angles. In spite, however, of this deformation we are still able to distinguish the type *D. Murchisoni* from its mutation *D. geminus*, to which latter we would refer Lapworth's *D. furcillatus.*

Affinities.—*D. Murchisoni* (as above restricted) is closely allied to var. *geminus* and *D. bifidus.*

From var. *geminus* it differs, as has been shown, in the characters of the proximal end; in addition it may be noted that the number of thecæ in a given unit of length is generally higher than in the variety, for while the number to the cm. may vary from twelve to sixteen in the typical form, and is most commonly fourteen, in the variety the number rarely exceeds twelve.

D. Murchisoni agrees with *D. bifidus* in the number of thecæ in a given unit of length, but differs in general shape: for, as a general rule, in *D. Murchisoni* the stipes are more or less parallel, and widen gradually up to their maximum, which is reached after about 2 cm.; while in *D. bifidus* the stipes are continuously divergent, and widen throughout their length.

Horizon and Localities.—Lower Llandeilo (Upper Llanvirn of Hicks).

Radnorshire: Gelli, Llandrindod. *Shropshire:* Holywell Burn, Betton Dingle, Stapeley. *Pembrokeshire:* Abereiddy Bay.

Associates, etc.—*D. Murchisoni* occurs in abundance in many localities at the base of the Lower Llandeilo beds, where it forms a well-defined zone. It has not yet been recognised in the Lake district. It is commonly associated with var. *geminus*, and with species usually referred to *Diplograptus foliaceus* and *Cryptograptus tricornis.*

Murchison's type specimen comes from Gelli, Llandrindod. Other good specimens come from S. Shropshire. In both cases the containing rocks are uncleaved. Numerous specimens are to be found in the collections of the Geological Survey, Lapworth, and the Authors. Abundant examples from Abereiddy Bay, all more or less distorted by cleavage, are found in the collections of the British Museum, the Woodwardian Museum, and of the Authors.

The slab of rock, on which occur the specimens from which Sowerby's figures and descriptions were drawn up, is in the museum of the Geological Society. The examples figured in our Pl. III, figs. 1 *a* and 1 *b*, are selected from that slab, and of these fig. 1 *b* may be regarded as the type.

Var. **geminus** (Hisinger). Plate III, figs. 2 *a*—*j*.

1840. *Prionotus geminus*, Hisinger, Lethea Suecica, Supplementum Secundum.

1850. *Graptolithus geminus*, Scharenberg, "Ueber Graptoliten," p. 13, pl. i, fig. 1.

1851. *Prionotus* (?) *geminus*, Boeck, "Bemaerkringer angænde Graptolitherne," fig. 24.

1875. *Didymograptus furcillatus*, Lapworth, Quart. Journ. Geol. Soc., vol. xxxi, p. 649, pl. xxxv, figs. 3 *b*, *c*.

1881. *Didymograptus Murchisoni*, var. *geminus* (His.), Tullberg, Bihång till K. Svensk. Vetenskaps Akad. Handl., vol. vi, No. 13, p. 16, pl. iii, figs. 5, 6, 10.

This variety has already been noticed in some detail in the preceding paragraphs, but it may be advisable to summarise here its more prominent characteristics.

Stipes widening more rapidly than in *D. Murchisoni*, never strictly parallel, but generally divergent throughout the greater part of their length. Diverging from each other at a primary angle of about 90°, then curving round so as to include an angle of 20°—30°. Sicula conspicuous, slender, and tapering; the whole proximal end more slender, and the base generally more rounded than in *D. Murchisoni.* The thecæ number twelve in 10 mm.; their initial angle of inclination is 45°, but rises to 55° at the aperture owing to curving. They are three times as long as wide, and are free from a half to one third their length.

Description.—The stipes widen abruptly from about ·9 mm. to 2·5 mm. Small specimens about 2 cm. in length are most common, but longer forms are also fairly numerous.

FIGS. 25 *a, b,* and *c.*—*Didymograptus Murchisoni,* var. *geminus,* Hisinger.

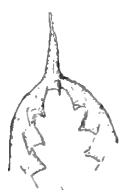
a *b* *c*

a. Proximal end, obverse view. Gelli, Llandrindod. Coll. Geological Society of London.
b. Proximal end, reverse view, on same slab as type specimen of *D. Murchisoni.* Gelli.
c. Proximal end, reverse view, on same slab as type specimen of *D. furcillatus.* Abereiddy Bay. Coll. Woodwardian Museum.

The sicula is about 2·6 mm. in length, and has a width at its aperture of about ·75 mm. Th. 1^1 originates slightly above the base, and curves away outward and downward so as to leave the sicula free on the left side (obverse view) for a small fraction of its length. The crossing canal is slightly oblique. There is a general appearance of symmetry as regards the origin of the stipes.

The earliest thecæ are short, being only 1 mm. and 1·5 mm. in length, but each one subsequently developed shows a decided increase in length on the preceding one, and exhibits marked curvature of its walls—facts upon which the characteristic rapid widening of the stipes depends.

FIG. 25 *d.*—*Didymograptus Murchisoni,* var. *geminus,* Hisinger.



d. Proximal end in shale, reverse view. Zone of *D. geminus.* Fågelsang, Sweden. Coll. Törnquist, Lund.

Affinities.—*D. Murchisoni,* var. *geminus,* has been compared by some writers in this country with *D. nanus* (Lapw.). These two forms should be readily separated, var. *geminus* differing in the absence of parallelism of the stipes, and in its rapid increase in width; while in *D. nanus* the stipes are parallel and the width uniform.

It resembles *D. bifidus* in its general shape, but may be distinguished by the characters of the thecæ, and the number in a given unit of length.

Horizon and Localities.—Lower Llandeilo (zone of *D. Murchisoni*). *Radnorshire:* Gelli, Llandrindod. *Shropshire:* Holywell Burn. *Pembrokeshire:* Abereiddy Bay.

Associates, etc.—*D. Murchisoni,* var. *geminus,* occurs abundantly in the Lower Llandeilo beds, associated with the typical form, and with species usually referred to *Diplograptus foliaceus* and *Cryptograptus tricornis.* Specimens are in the collections of the Geological Society, the British Museum (Natural History), the Woodwardian Museum, Lapworth and the Authors.

Didymograptus bifidus (Hall). Plate IV, figs. 1 *a—f*.

1865. *Graptolithus bifidus*, Hall, "Grapt. of Quebec Group," Geol. Surv. Canada, Canadian Organic Remains, dec. 2, p. 73, pl. i, figs. 16—18; pl. iii, figs. 9, 10.

1868. *Didymograpsus bifidus*, Nicholson, Quart. Journ. Geol. Soc., vol. xxiv, p. 136.

1870. *Didymograpsus bifidus*, Nicholson, Ann. Mag. Nat. Hist. [4], vol. v, p. 346, fig. 7.

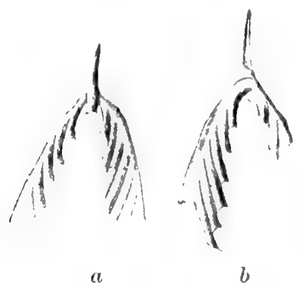
1875. *Didymograptus bifidus*, Hopkinson, Quart. Journ. Geol. Soc., vol. xxxi, p. 646, pl. xxxiii, figs. 8 *a—c*.

1898. *Didymograptus bifidus*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 511.

Stipes from 1·3 to 4 cm. in length, very narrow at origin, but expanding continuously throughout their length to a maximum width of 2·6 mm., and contracting rapidly at the distal extremities. Dorsal margin straight; thecal margin curved. Sicula slender and tapering; stipes diverging at varying angles, but always less than 90°. Thecæ fifteen to thirteen in 10 mm., inclined at 45°, three to four times as long as wide, and free a quarter their length. Apertural margin normal, concave, mucronate.

Description.—The stipes are very narrow at their origin, being about ·8 mm. in width, but they ultimately attain a maximum breadth of 2·6 mm. None of our British specimens reach the dimensions of Hall's largest forms, either in length or width; none are known from this country to exceed 5 cm.; small forms about 2·5 cm. in length are most commonly met with. The greatest width observed by Hall (6·3 mm.) is never approached in any British specimen. The maximum width of the stipes is attained near the distal end, after which there is a somewhat rapid diminution. The increase in width is due to the fact that the thecæ augment steadily in length from the proximal to the distal portions of the stipes; but at the distal extremities the thecæ are only partially grown, and consequently diminution in width takes place. One result of this mode of growth is to give a characteristic curvature to the thecal margins; these have at first a slight concave curvature, but subsequently the curve may be convex, or else continuously concave.

Figs. 26 *a* and *b*.—*Didymograptus bifidus*, Hall.



a. Proximal end in full relief, obverse view. Pont Seiont. Coll. Woodwardian Museum.
b. Proximal end in full relief, reverse view, showing crossing canal. Pont Seiont.

The sicula is long and narrow; it has a length of about 2·1—2·4 mm. The first theca (th. 1^1) originates on the left side of the sicula (obverse view) at some little distance above its aperture (about one fourth the distance to the apex), and growing downward and slightly outward leaves the sicula free on the left side. The crossing canal seen in the reverse aspect of the polypary traverses the sicula almost horizontally at a short distance above its aperture, which is clearly visible. Thus the second stipe apparently originates nearly at the same level as the first.

The thecæ number fifteen to thirteen in 10 mm.; they are long, narrow tubes, and when mature their length is about four times as great as their width at the broadest part; they are free one third to a quarter their length in the distal part of the stipes, but in the proximal portion they may be free for nearly half their length. The distal thecæ have a length of about 3 mm., and are inclined at an average angle of 45°, but the thecal walls are curved in such a manner that the angle of inclination near the aperture may be rather higher than this. In the initial region the angle is much lower, and rarely exceeds 30°.

Remarks.—*D. bifidus* exhibits great variation in the angle of divergence of the stipes; indeed, there may almost be said to be two distinct types included in it, one in which the stipes diverge at an angle of about 60° (Pl. IV, fig. 1 *f*), and another in which the base is rounded, the initial angle of divergence approaches a right angle, and the stipes are ultimately approximately parallel, or include between them a very small angle (Pl. IV, fig. 1 *c*). These extremes are, however, connected by a long series of intermediate forms, and agree in all the relations of the earliest thecæ to the sicula, and in the characters of the thecæ in the distal parts of the stipe; it is impossible, therefore, to draw a line between them, and they are included in one variable species. The commonest form is that in which the base is rounded, and the stipes include between them angles of from 15° to 20°.

The species is characterised by the following features:

(1) the form of the stipes, with straight dorsal walls and curved celluliferous margins,

(2) the gradual and persistent widening from their origin,

(3) the characters of the thecæ and their number in a given unit of length.

Affinities.—*D. bifidus* is closely related to the typical form of *D. Murchisoni*, and to var. *geminus*. From the former, with which it agrees in the number of thecæ in a given unit of length, it may be distinguished by the divergent stipes and their persistent increase in width; from var. *geminus*, which it resembles in the divergence of the stipes, it may be separated by their persistent widening and the number of thecæ in a given unit of length.

D. bifidus is more abundant in Britain than any other member of the dependent series; it occurs in great numbers at one particular horizon, namely, in the Upper Arenig beds below the zone of *D. Murchisoni*.

Horizon and Localities.—Upper Arenig (Llanvirn of Hicks). Middle Arenig (S. Shropshire). *Ireland—Co. Meath:* Bellewstown; *Co. Kildare:* Grange Hill. *S. Scotland—Ayrshire:* Bennane Head, Ballantrae. *England—Lake District:* Barf; Doddick Fell; Saddleback; Outerside; Burstock Scar; Skiddaw; Thornship Beck, Shap; Ellergill; Aik Beck; E. Dodd Wood; *Shropshire:* Shelve;

Holywell Burn; Hogstow Burn; Stream west of Venus Bank; quarter mile north-east Knot Moor; Leigh Quarry; Snailbeach; Stream five sixths mile north-west Hope Church, etc. etc. *Wales—Merionethshire:* Taihirion; *Carnarvonshire:* Pont Seiont; Penarfynydd Farm, Rhiw; Porth Llawenan; *Pembrokeshire:* Porth-hayog, Ramsey Island; Llanvirn Quarry; Abereiddy Bay; Whitland.

Associates, etc.—It occurs in association with *D. patulus*, *D. affinis*, *D. acutidens*, *D. nanus*, *D. Nicholsoni*, *Glossograptus ciliatus*, and *Diplograptus dentatus*.

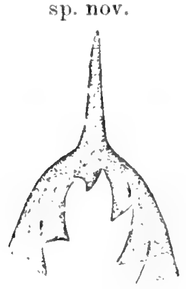
It is often found in relief in great perfection, and good specimens are in the collections of the Geological Survey of Great Britain and Ireland, the Woodwardian Museum, the British Museum (Nat. Hist.), and the private collections of Postlethwaite, Lapworth, Nicholson, and the Authors.

Didymograptus amplus, sp. nov. Plate IV, figs. 3 *a—c*.

Stipes rigid, from 3·8 to 7·6 cm. in length, curved at the commencement, but soon becoming straight, and diverging so as to include between them angles of 20°—25°; originally narrow, but widening continuously and rapidly up to a maximum of 6·4 mm. Sicula long. Thecæ eight to nine in 10 mm., inclined at 35°—40°, free one fifth their length. Apertural margins normal, concave, mucronate.

Description.—The stipes are very narrow at their origin in proportion to the width which they subsequently attain; at first they measure only 1 mm., but they widen with increasing rapidity to 5—6 mm., and this rapid increase in breadth is characteristic of the species, as is also the straight, rigid character of the dorsal walls. A slight diminution in width takes place at the extreme end of the stipes, owing to the incomplete development of the thecæ.

Fig. 27.—*Didymograptus amplus*, sp. nov.



Proximal end, reverse view. Abereiddy Bay. Coll. E. M. R. Wood.

The sicula is conspicuously long (4 mm.); it is narrow for the greater part of its length, but widens somewhat abruptly near the aperture. Th. 1^1 appears to originate about midway between the aperture and apex of the sicula, but rather nearer the former; it grows outward and downward leaving the sicula free as usual on the left of its aperture (obverse view); the crossing canal is thick, and somewhat oblique; the second theca is unusually long; it measures 2 mm. in length, and the aperture of th. 1^1 only reaches a point midway along its length. There is a slight want of symmetry about the proximal end as a whole.

The length of the thecæ is very different in different parts of the stipes: in the initial region it is about 2 mm., and the thecæ are twice as long as wide; they increase steadily in length, until they may measure 7 mm., and have a width of 1 mm. The cell walls are curved, so that while the initial angle of inclination is about 35°, the angle which the cell makes with the axis near its aperture is about 40°; a lower angle of inclination obtains in the proximal parts of the stipes.

Affinities.—*D. amplus* has up to the present time been included in *D. Murchisoni*, but there can be little doubt that it should be separated as a distinct form; the stipes are never parallel, and the abrupt widening, straight dorsal walls, and enormously long thecæ serve to distinguish it from *D. Murchisoni* and var. *geminus*. Allowing for the distortion to which the rocks in which it occurs have been subjected, it is nevertheless obvious that the distortion cannot have brought about all the features which distinguish it from the species with which it occurs, for these characters are recognisable in all specimens of this form whatever may be their position in the rock.

Horizon and Locality.—Lower Llandeilo; Abereiddy Bay.

Associates.—*D. amplus* is associated with *D. Murchisoni* and var. *geminus* at Abereiddy Bay, and good specimens are in the collection of the Woodwardian Museum and those of the Authors.

We regard the example figured on Pl. IV, fig. 3 *c*, as the type specimen of this species. It is in the Woodwardian Museum.

Sub-group B.—Type *D. indentus*.

Dependent Didymograpti in which the width of the stipes remains typically constant throughout their length.

Didymograptus, cf. indentus (Hall). Plate IV, figs. 4 *a*—*c*.

1858. *Graptolithus indentus*, Hall, Rep. Geol. Survey, Canada, 1857, p. 128.

1865. *Graptolithus indentus*, Hall, "Grapt. of Quebec Group," Geol. Surv. Canada, Canadian Organic Remains, dec. 2, p. 74, pl. i, fig. 20.

1870. *Didymograpsus geminus*, Nicholson (pars), Ann. Mag. Nat. Hist. [4], vol. v, p. 346, fig. 6 *a*.

1875. Non *Didymograptus indentus*, Hopkinson, Quart. Journ. Geol. Soc., vol. xxxi, pl. xxxiii, figs. 7 *a*—*c*.

1898. *Didymograptus indentus*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 510.

Stipes from 2·5 to 5 cm. in length, slender, maintaining a fairly constant width of 1·2 mm. throughout; diverging at a primary angle of about 60°, incurving, and then becoming parallel. Sicula slender, tapering. Thecæ eight to ten in 10 mm., inclined at 25°—30°; three times as long as wide, free one half their length. Apertural margins normal, very slightly concave, denticles submucronate.

Description.—The stipes are fairly robust at their origin compared with the average width of the polypary, and measure about ·9 mm.; they widen rather rapidly up to a breadth of 1·2 mm., which is maintained in the greater number of forms; occasionally, however, in the larger specimens the width may be as much as 1·5 mm., but nevertheless the polypary, as a whole, has a slender appearance.

Fig. 28.—*Didymograptus.* cf. *indentus*, Hall.

Proximal end, impression of obverse view. Outerside, Keswick. Coll. Woodwardian Museum.

The sicula is very long and narrow; it measures 2·5—3 mm. in length, and is situated somewhat obliquely with respect to the polypary. The first theca (th. 1^1) originates at a point slightly above the aperture of the sicula; the opening appears to be large, but the theca grows away at once with a wide curve, so that the apertural region of the sicula is quite free on the left side (obverse view).

The crossing canal is fairly wide; it runs obliquely from the point of origin of th. 1^1 to the right apertural edge of the sicula. Two phenomena follow from this mode of growth:

(1) the apparent want of symmetry in the initial part of the polypary,

(2) the concealment of a large part of the apertural region of the sicula.

The thecæ are slightly in contact in the initial regions of the stipes, but the overlap gradually increases to a maximum of half their length in the more distal parts. Each theca has an average length of about 2 mm.

Remarks.—All known British specimens which most closely resemble Hall's *D. indentus* are badly preserved, and while the details of the proximal end can often be made out, the characters of the thecæ in the distal parts of the stipes are generally obscure. So far as can be made out, there are more thecæ in the same unit of length than in Hall's species, and the specimens are smaller; but taking into account the conditions under which these fossils are found both in the Lake district and S. Wales, it is possible that they have been affected by cleavage, and are therefore not normal. In many cases in the specimens from the Lake district little can be made out except the general shape, but this appears to agree so closely with that of Hall's species that they are here provisionally referred to it.

Affinities.—*D.*, cf. *indentus* resembles *D. nanus* in many particulars, but is longer, and has fewer thecæ in the same unit of length.

Horizon and Localities.—Upper Arenig—Lower Llandeilo. *Lake District:* Outerside; Glenderamakin River; the Dodd, Skiddaw; Mosedale Beck, near Troutbeck; Thornship Beck. *St. David's District:* Abereiddy Bay.

Associates, etc.—The species occurs most abundantly in the Lake district, associated with *D. nanus;* it also occurs in S. Wales at Abereiddy Bay at a slightly higher horizon, associated with *D. Murchisoni* and its var. *geminus*, and with the forms usually referred to *Diplograptus foliaceus* and *Cryptograptus tricornis.*

Specimens are in the collections of the Woodwardian Museum, Nicholson, and the Authors.

Didymograptus nanus, Lapworth. Plate IV, figs. 5 *a—h*.

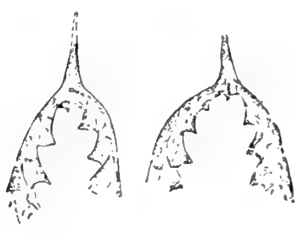
1868. *Didymograpsus geminus*, Nicholson, Quart. Journ. Geol. Soc., vol. xxiv, p. 134, pl. v, figs. 8, 9.
1870. *Didymograpsus geminus*, Nicholson (pars), Ann. Mag. Nat. Hist. [4], vol. v, p. 346, fig. 6 *b*.
1875. *Didymograptus indentus*, var. *nanus*, Lapworth, Quart. Journ. Geol. Soc., vol. xxxi, p. 647, pl. xxxiii, fig. 7 *d*; *non* pl. xxxv, figs. 4 *a—c*.
1898. *Didymograptus indentus*, var. *nanus*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 511.

Stipes 12—25 mm. in length, slender, maintaining an almost equal width of 1·3 mm. throughout their length, diverging from each other at a primary angle of about 90°, but gradually incurving, and running parallel for the remainder of their extent. Sicula conspicuous but slender. Thecæ ten to twelve in 10 mm., inclined at 30°, three and a half times as long as wide, free one half to one third their length. Apertural margins normal, slightly concave, denticles submucronate.

Description.—The dorsal walls of the stipes appear in general to be 4 mm. apart, and the stipes are commonly 1 mm. in width.

The sicula is about 2·4 mm. in length; it is slender, and often shows a filiform nema proceeding from its apical extremity. Th. 1^1 originates slightly above the aperture of the sicula, and grows away, leaving the sicula free on the left side (obverse view) for a short distance. The crossing canal is slender and oblique. A marked want of symmetry is observable as regards the origin of the stipes.

FIGS. 29 *a* and *b*.—*Didymograptus nanus*, Lapworth.



a. Proximal end, reverse view. Enlargement of part of Pl. IV, fig. 5 *e*.
b. Proximal end, obverse view. Llanvirn Quarry. Coll. E. M. R. Wood.

The number of thecæ in a given unit of length varies in different specimens; in those from S. Wales the number in the mature part of the stipe is commonly about ten in 10 mm., but about eleven in 10 mm. nearer the sicula. In the specimens from the Lake district (originally identified by Nicholson with *D. geminus*) the thecæ are poorly preserved, but when seen, appear to be set rather more closely, numbering about eleven to twelve in 10 mm., though they agree with the Welsh specimens in all other particulars. Each theca measures about 2 mm. in length.

The species is distinguished by the following features:

(1) the parallel growth of the stipes,
(2) their uniform width,
(3) the characters of the thecæ.

Horizon and Localities.—Upper Arenig (Llanvirn of Hicks).

St. David's District: Llanvirn Quarry; *Lake District:* Outerside; Glenderamakin River; Thornship Beck; Barf; Gatesgill; and Mosedale Beck, near Troutbeck.

Associates.—It occurs in fair abundance in the Llanvirn beds of South Wales associated with *D. bifidus*, *D. affinis*, and *Diplograptus dentatus;* and in the Middle and Upper Skiddaw Slates of the Lake district.

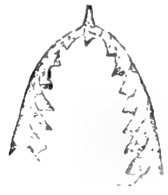
The type specimens (Pl. IV, figs. 5 *a*, *b*) are in the Woodwardian Museum. Other specimens are in the British Museum (Nat. Hist.), and the private collections of Lapworth and Mr. J. E. Marr, Cambridge.

Didymograptus artus, sp. nov. Plate IV, figs. 6 *a—d*.

Stipes from 12 to 25 mm. in length, very narrow at their origin, but expanding throughout to a maximum of 1·3 mm.; diverging at a primary angle of about 90°, or with rounded base, and then curving gradually round so that the stipes are approximately parallel. Sicula small. Thecæ very closely set, eighteen to nineteen in 10 mm., inclined at 50°, two to three times as long as wide, overlapping one half to two thirds their length. Apertural margin normal, concave, mucronate.

Description.—The stipes are very slender at their origin, not exceeding ·4 mm. in width, but expand to a maximum of 1·3 mm. in the first 4 mm. As a general rule the stipes are parallel, and the distance between the dorsal walls is from 5 to 6 mm.; in some forms, however, an angle of about 5° is included between the stipes, and these usually show a tendency to come together at their distal extremities.

FIG. 30.—*Didymograptus artus*, sp. nov.



Proximal end, obverse view. (Crossing canal seen, owing to compression.) Enlargement of part of Pl. IV, fig. 6 *d*.

The sicula is 1·3 mm. long, and is slender and tapering. The first theca (th. 1^1) originates slightly above the base of the sicula, and grows away from it, leaving it free for some little distance near its aperture. The crossing canal is nearly horizontal, th. 1^2 being appressed to the sicula, and then extending beyond it. The origin of the stipes is symmetrical. Each theca is 1 mm. in length.

Affinities.—The species is allied to *D. bifidus*, but is smaller, and differs also in the parallel growth of the stipes, the greater uniformity in width, and in the more closely set thecæ.

Horizon and Localities.—Upper Arenig (Llanvirn of Hicks). Upper Skiddaw Slates.

St. David's District: Porth-hayog, Ramsey Island. *Lake District:* Thornship Beck; Ellergill.

Associates, etc.—It occurs associated with *D. bifidus*, *D. acutidens*, and *D. Nicholsoni*. Specimens are in the collections of the Woodwardian Museum, Marr, Nicholson, and the Authors. The type specimen (Pl. IV, fig. 6 *a*) is in the Woodwardian Museum.

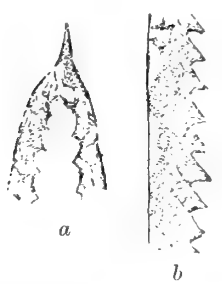
Didymograptus stabilis, sp. nov. Plate IV, fig. 2.

1875. *Didymograptus indentus*, Hopkinson, Quart. Journ. Geol. Soc., vol. xxxi, p. 647, pl. xxxiii, figs. 7 *a—c*.

Stipes from 4 to 5 cm. in length, fairly wide at their origin, and attaining the maximum width of 1·6 mm. within the first cm. of length; diverging from each other at a primary angle of about 90°, then curving in gradually so as to include an angle of about 10°, but eventually becoming parallel, and continuing so for the remainder of their length. Sicula conspicuous. Thecæ fourteen in 10 mm., slightly curved, inclination 40°, about four times as long as wide, free one third their length. Apertural margin normal, concave, submucronate.

Description.—The stipes are about ·6 mm. wide at their origin, but expand within the first 12 mm. to a maximum width of 1·6 mm., which is maintained; there is an extent of about 4—4·5 mm. between the dorsal walls of the stipes, but this appears very small in proportion to the length of the polypary.

FIGS. 31 *a* and *b*.—*Didymograptus stabilis*, sp. nov.



a Proximal end, reverse view (?). Enlargement of part of Pl. IV, fig. 2.
b. Distal part of same.

The sicula is slender; its length is 2·5 mm. The proximal end of the polypary has a thickened appearance; th. 1[1] originates at a point about midway between the apex and the aperture of the sicula; the crossing canal is thick, and but slightly oblique, so that the relation between the stipes and the sicula is symmetrical. Other details are obscure.

Affinities.—This form was originally figured and described (Hopk. and Lapw., 'Quart. Journ. Geol. Soc.,' vol. xxxi, p. 647, pl. xxxiv, figs. 7 *a—c*) as *D. indentus*, which has, however, a far smaller number of thecæ in the same unit of length, as shown in the above description. It more closely resembles a narrow form of *D. Murchisoni*.

Horizon and Localities.—Upper Arenig (Llanvirn).

St. David's District: Porth-hayog, Ramsey Island.

Associates.—*D. stabilis* occurs associated with *D. bifidus*, *D. acutidens*, *D. Nicholsoni*, etc. All the specimens at present known are in the collection of the Woodwardian Museum.

Group of *D. Murchisoni.*

	Sub-group of *D. bifidus.*				Sub-group of *D. indentus.*			
	D. Murchisoni.	Var. *geminis.*	*D. bifidus.*	*D. amplus.*	*D.*, cf. *indentus.*	*D. nanus.*	*D. artus.*	*D. stabilis.*
Form of stipe	Parallel	Divergent	Divergent	Divergent	Parallel	Parallel	Nearly parallel	Parallel
Width . . .	3—4 mm.; increase slow	2·5 mm.; increase rapid	2·6 mm.; increase continuous	6·4 mm.; increase very rapid	1·2 mm.	1·3 mm.	1·3 mm.	1·6 mm.
Length of sicula	3 mm.	2·6 mm.	2·1—2·4 mm.	4 mm.	2·5—3 mm.	2·4 mm.	1·3 mm.	2·5 mm.
Origin of stipe	Suboral	Suboral	Suboral	Suboral	Suboral	Suboral	Suboral	Suboral
No. of thecæ in 10 mm.	14—12	12	15—13	9—8	10—8	12—10	19—18	14
Inclination .	45°	45°	45°	35°—40°	25°—30°	30°	50°	40°
Overlap . .	$\frac{1}{2}$—$\frac{4}{5}$	$\frac{1}{2}$—$\frac{2}{3}$	$\frac{1}{2}$—$\frac{3}{4}$	$\frac{1}{2}$—$\frac{4}{5}$	0—$\frac{1}{2}$	$\frac{1}{2}$—$\frac{2}{3}$	$\frac{1}{2}$—$\frac{1}{3}$	$\frac{2}{3}$

Reflexed Series.

Didymograpti in which the stipes are flexed and are directed upward and backward towards the nema, the initial angle of divergence being more than 180°.

Group VI.—Type *D. fasciculatus.*

Didymograpti in which the stipes are at first convexly and then concavely curved in an upward direction; the thecæ are very long and narrow, and are in contact for the greater part of their length.

Didymograptus fasciculatus, Nicholson. Plate II, figs 8 *a—c.*

1869. *Didymograpsus fasciculatus,* Nicholson, Ann. Mag. Nat. Hist. [4], p. 241, pl. xi, figs. 21, 22.
1870. *Didymograpsus fasciculatus,* Nicholson, Ann. Mag. Nat. Hist. [4], vol. v, p. 344, figs. 5 *a, b.*
1898. *Didymograptus fasciculatus,* Elles, Quart. Journ. Geol. Soc., vol. liv, p. 507, fig. 24.

Stipes with graceful concave curvature, from 2·5 to 5 cm. or more in length, very narrow at origin, but widening distally to maximum of 1·1 mm. Sicula short and broad. Thecæ nine to ten in 10 mm., of extraordinary length and remarkably narrow width, inclined at 15°. Apertural margins concave, and somewhat oblique.

Description.—Examples of this species are found, as a rule, in a fragmentary condition; those showing the proximal end are rare. The dorsal wall of each stipe is concavely curved, but the amount of curvature varies in different examples. Each stipe starts outwards horizontally, and then curves dorsally. In some specimens the curvature becomes almost that of a semicircle, so that the distal portion of the stipe is parallel with the proximal part; but in others, after the first decided concave curve, the stipe runs very nearly straight in a horizontal direction.

FIGS. 32 *a* and *b*.—*Didymograptus fasciculatus*, Nicholson.

a. Proximal thecæ, showing comparatively small amount of overlap. Enlargement of part of Pl. II, fig. 8 *b*.

b. More distal thecæ, showing large amount of overlap and oblique apertures. Enlargement of part of Pl. II, fig. 8 *a*.

The thecæ are peculiar and eminently characteristic. In the distal parts of the stipes they number nine to ten in 10 mm., and are in contact for four fifths of their length; nearer the proximal end the thecæ are more distant, are always smaller, and are in contact with each other for a very small fraction of their length. The thecæ are long, narrow-linear tubes, and may attain a length of 6·3 mm.; their width is so slight that a line drawn perpendicular to the axis of the stipe and near the aperture of the theca will cut four different thecæ, and yet the width of the stipe, including these thecæ, never exceeds 1·1 mm. In their form and especially in the characters of their apertures the thecæ show an approach to the Leptograptid type.

In the distal portions of the stipes the great length of the thecæ, their concave curvature, and small angle of inclination make them appear to run nearly parallel to the back of the stipe.

Affinities.—The peculiar characters of the thecæ and the curvature of the stipes readily distinguish the species from all others at present known, and render its determination easy even when it is in a fragmentary condition.

Associates, etc.—Up to the present time *D. fasciculatus* has only been recorded from the Upper Skiddaw Slates, and it is a rare fossil in those beds. It occurs associated with *Phyllograptus*, cfr. *typus*. The original specimen figured by Nicholson shows two stipes. This we have been unable to discover, but we would provisionally regard the specimen figured on our Pl. II, fig. 8 *a*, as constituting the type of this species. A few specimens labelled by Nicholson are in the British Museum; others, originally in his private collection, have been presented to Lapworth by Dr. H. O. Nicholson; while a few indifferent specimens are in the Woodwardian Museum, Cambridge.

Horizon and Localities.—Arenig, Upper Skiddaw Slates (Ellergill beds).

Lake District: Aik Beck, Pooley; Thornship Beck; Ellergill.

Reclined Series.

Didymograpti in which the stipes are approximately straight and are directed upward and backward towards the nema, the initial and ultimate angles of divergence being both more than 180°.

Group VII.—Type *D. gibberulus.*

Didymograpti in which the stipes slope upward; they originate from near the apex of the sicula; the thecæ are numerous, and are in contact throughout their length.

Didymograptus gibberulus, Nicholson (= gen. **Isograptus,** Moberg). Plate II, figs. 9 *a*—*e*.[1]

1853. *Didymograpsus caduceus,* Salter (pars), Quart. Journ. Geol. Soc., vol. ix, p. 87, fig. 1 *a*.
1863. *Didymograpsus caduceus,* Salter (pars), Quart. Journ. Geol. Soc., vol. xix, p. 138, fig. 13 *a*.
1875. *Didymograptus gibberulus,* Nicholson, Ann. Mag. Nat. Hist. [4], vol. xvi, p. 271, pl. vii, figs. 3, 3 *a*, *b*.
1875. *Phyllograptus stella,* Hopkinson, Quart. Journ. Geol. Soc., vol. xxxi, p. 658, pl. xxxiv, fig. 6.
1891. *Didymograptus gibberulus,* Moberg, Geol. Fören. Stockholm Forhändl., vol. xiii, p. 221.
1892. *Isograptus gibberulus,* Moberg, Geol. Fören. Stockholm Forhändl., vol. xiv, p. 346, pl. viii, figs. 3—7.
1895. *Didymograptus gibberulus,* Holm, Geol. Fören. Stockholm Forhändl., vol. xvii, p. 334.
1901. *Isograptus gibberulus,* Törnquist, Lunds Univ. Årsskr., Bd. xxxvii, Af. 2, No. 5, p. 23, pl. iii, figs. 16—19.

Stipes short, decreasing in width from the common point of origin, where they are 2·1 mm. wide, and forming a polypary of a horseshoe shape. Sicula long and slender, identical in form with and symmetrical in position with respect to the first theca. Thecæ sixteen in 10 mm., curved, inclined to axis at 45°, about four times as long as wide, in contact throughout their length. Apertural margin concave, angle obtuse.

Description.—The stipes are widest at their origin, attaining commonly a breadth of 2·1 mm.; there is marked diminution towards the distal extremities, where the width seldom exceeds 1·5 mm. The ultimate form of the polypary

[1] The specimens originally figured by Salter as *Didymograpsus caduceus* included forms belonging to two different genera, Didymograptus and Tetragraptus. The Tetragraptus seems to be identical with *T. serra* (Brogn.), and the Didymograptus agrees exactly with the form described later by Nicholson as *D. gibberulus*. This being the case we decide to retain Nicholson's specific name rather than the earlier name of Salter, in order to avoid the possibility of any ambiguity.

exhibits a certain amount of variation as regards the direction of the stipes. Three mutations may be said to be included in the species:

(1) a form in which the dorsal walls of the stipes are continuously recurved, so that the distal extremities point towards each other;

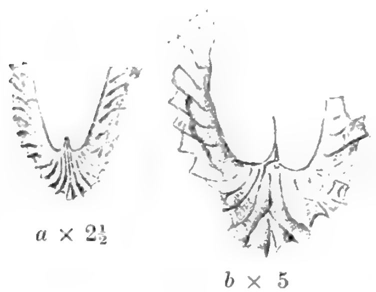
(2) a form in which the dorsal walls of the stipes are straight distally, the stipes running parallel to each other (Pl. II, fig. 9 *b*);

(3) a form in which the stipes diverge from each other throughout (Pl. II, fig. 9 *a*).

In all these forms, however, details of structure are essentially the same, and there appears to be every gradation between the extremes.

When the polypary is viewed in the *obverse aspect* the sicula is seen to be long and narrow for the greater part of its length, but it widens somewhat abruptly near the aperture, where it attains a breadth of ·9 mm. In length it commonly measures 3·2 mm., and a filamentous thread (nema) is often seen proceeding from its apex. The earliest theca originates from the sicula at a point very near the apex, and then grows downward; in general form it resembles the sicula very closely indeed: thus the species well illustrates the opinion held by some palæontologists that the body designated the sicula should be regarded as the earliest theca developed from the "zooid germ." The first theca is in contact with the sicula for the greater part of its length, but the two curve away from each other near their apertures, leaving a space between them. Transverse lines of growth may be detected along their length, and especially near their apertures. The crossing canal must be situated very high up, for the theca which is developed second is nearly as long as the first (cf. reverse aspect). The average length of the earlier formed thecæ is about 2 mm.; those developed later gradually diminish in length towards the distal extremities of the stipes, which thus come to have the appearance of being gently rounded off.

Figs. 33 *a* and *b*.—*Didymograptus gibberulus*, Nicholson.



a × $2\frac{1}{2}$ *b* × 5

a. Proximal end, obverse view. Type specimen figured by Nicholson, Ann. Mag. Nat. Hist. [4], vol. xvi, 1875, pl. vii, fig. 3 *a*. Randal Crag. Coll. Woodwardian Museum.

b. Proximal end, reverse view. Figured by Elles, Quart. Journ. Geol. Soc., vol. liv, p. 499, fig. 18. White House Fell. Coll. Woodwardian Museum.

In the *reverse aspect* of the polypary the greater part of the sicula and the first theca are hidden by the growth of th. 1^2 and th. 2^1, so that there are visible only the apex of the sicula with the filamentous virgula; the initial part of th. 1^1; and at the base the apertures of the sicula and th. 1^1. The crossing canal is clearly seen just below the apex of the sicula, and rather above the initial parts of the thecæ which have developed later. There appears also to be a crossing canal (or something of a similar nature) between th. 2^1 and th. 1^2. Thus, as Törnquist points out (loc. cit.), "the first stipe crosses the sicula and the second stipe the first theca." This seems to show that in this species there is a deviation from the normal Didymograptus type of development,—that is to say, a forecast of the type characteristic of the Diplograptidæ; this, if substantiated, might afford grounds for the retention of this form as the type of a sub-genus (Isograptus, Moberg).

After the growth of the earlier thecæ the normal Didymograptus type of development appears to be resumed, each theca of each series developing from the theca next to it on the side nearest the sicula. On these growth-lines can occasionally be detected.

The apertures of the earliest developed thecæ are directed obliquely downward, but subsequently, owing to their curvature, the succeeding ones come to face horizontally outward, and ultimately even upward. The thecæ are in contact throughout their length; in the proximal part of the polypary they are four times as long as wide, but at the distal extremities they are very much shorter in proportion to their width. The apertural angle is commonly 130° after compression.

Affinities.—The species bears a superficial resemblance to certain examples of *Tetragraptus Bigsbyi*, when two stipes out of the four are hidden. It should, however, be readily distinguished, for in *T. Bigsbyi* the polypary is narrowest in its proximal part, whereas in *D. gibberulus* it is widest. This fact was emphasised by Nicholson in his original description; nevertheless it would appear to have been overlooked by some, as there has been much confusion between the two forms.

On Pl. II, fig. 9 *e*, we give a drawing of the type specimen of Hopkinson's *Phyllograptus stella*, from which it will be seen that this form is identical with *D. gibberulus*.

Horizon and Localities.—Arenig, Middle Skiddaw Slates (Upper Tetragraptus beds).

Lake District: Randal Crag; White House Fell, Skiddaw; Bassenthwaite Common. *St. David's District:* Road Uchaf, Ramsey Island.

Associates, etc.—*D. gibberulus* occurs associated with *Didymograptus hirundo*, *Azygograptus suecicus*, *Tetragraptus quadribrachiatus*, *Phyllograptus typus*. Good specimens from these beds are in the Woodwardian Museum, the Keswick Museum, the Geological Survey Museum, and in the collection of Postlethwaite, Keswick. The type specimens (Pl. II, figs. 9 *a*, *d*) are in the Woodwardian Museum.

PLATE I.

Genus **Didymograptus**, M'Coy.

FIGS.

1 *a, b.*—***Didymograptus extensus***, Hall.

1 *a.* Long specimen. Randal Crag. Skiddaw Slates. Woodwardian Museum, Cambridge.

1 *b.* Fragment of stipe, badly preserved. Figured, Hopkinson, Quart. Journ. Geol. Soc., 1875, pl. xxxiii, fig. 1 *a.* Road Uchaf, Ramsey I. Lower Arenig (Hicks). Woodwardian Museum.

2 *a—c.*—***Didymograptus nitidus***, Hall.

2 *a.* Long specimen and more reclined than usual. East of Longside. Skiddaw Slates. Woodwardian Museum.

2 *b.* Horizontal form. Randal Crag. Skiddaw Slates. Woodwardian Museum.

2 *c.* Broad form, more declined than usual. Outerside, Keswick. Skiddaw Slates. British Museum (Natural History), S. Kensington.

3.—***Didymograptus***, cf. *uniformis*, Elles and Wood, sp. nov.

Obverse view. Raulnay. Skiddaw Slates. Mr. Christopherson's Collection, Keswick.

4.—***Didymograptus uniformis***, Elles and Wood, sp. nov.

Obverse view, well preserved, in relief. Bassenthwaite. Skiddaw Slates. Mr. Postlethwaite's Collection, Keswick.

5 *a—c.*—***Didymograptus hirundo***, Salter.

5 *a.* Obverse view, showing portion of interior. From old wall near "Travellers' Rest," Whinlatter. Skiddaw Slates. Mr. Postlethwaite's Collection.

5 *b.* Reverse view, well-preserved specimen showing portions of interior. Randal Crag. Skiddaw Slates. Woodwardian Museum.

5 *c.* Badly preserved example. Type specimen. Figured by Salter in Quart. Journ. Geol. Soc., 1863, fig. 13 *f.* Ellergill. Skiddaw Slates. Museum of Practical Geology, Jermyn Street.

6 *a, b.*—***Didymograptus sparsus***, Hopk.

6 *a.* Deformed specimen, preserved in cleaved black shale. Type specimen. Figured, Hopkinson, Quart. Journ. Geol. Soc., 1875, pl. xxxiii, fig. 2 *a.* Road Uchaf, Ramsey I. Arenig (Lower Arenig, Hicks). Woodwardian Museum.

6 *b.* Ibid., fig. 2 *d.*

7.—***Didymograptus pennatulus***, Hall.

Isolated stipe associated with *D. sparsus.* Ibid., fig. 3 *e.*

8 *a—c.*—***Didymograptus patulus***, Hall.

8 *a.* Showing proximal extremity. Figured, Hopkinson, Quart. Journ. Geol. Soc., 1875, pl. xxxiii, fig. 4 *b.* Porth-hayog, Ramsey I. Upper Arenig (Lower Llanvirn, Hicks). Woodwardian Museum.

8 *b.* Isolated and imperfect stipe. Ibid., fig. 4 *a.* Woodwardian Museum.

8 *c.* Isolated stipe. Porth-hayog. Woodwardian Museum.

9 *a, b.*—***Didymograptus superstes***, Lapw.

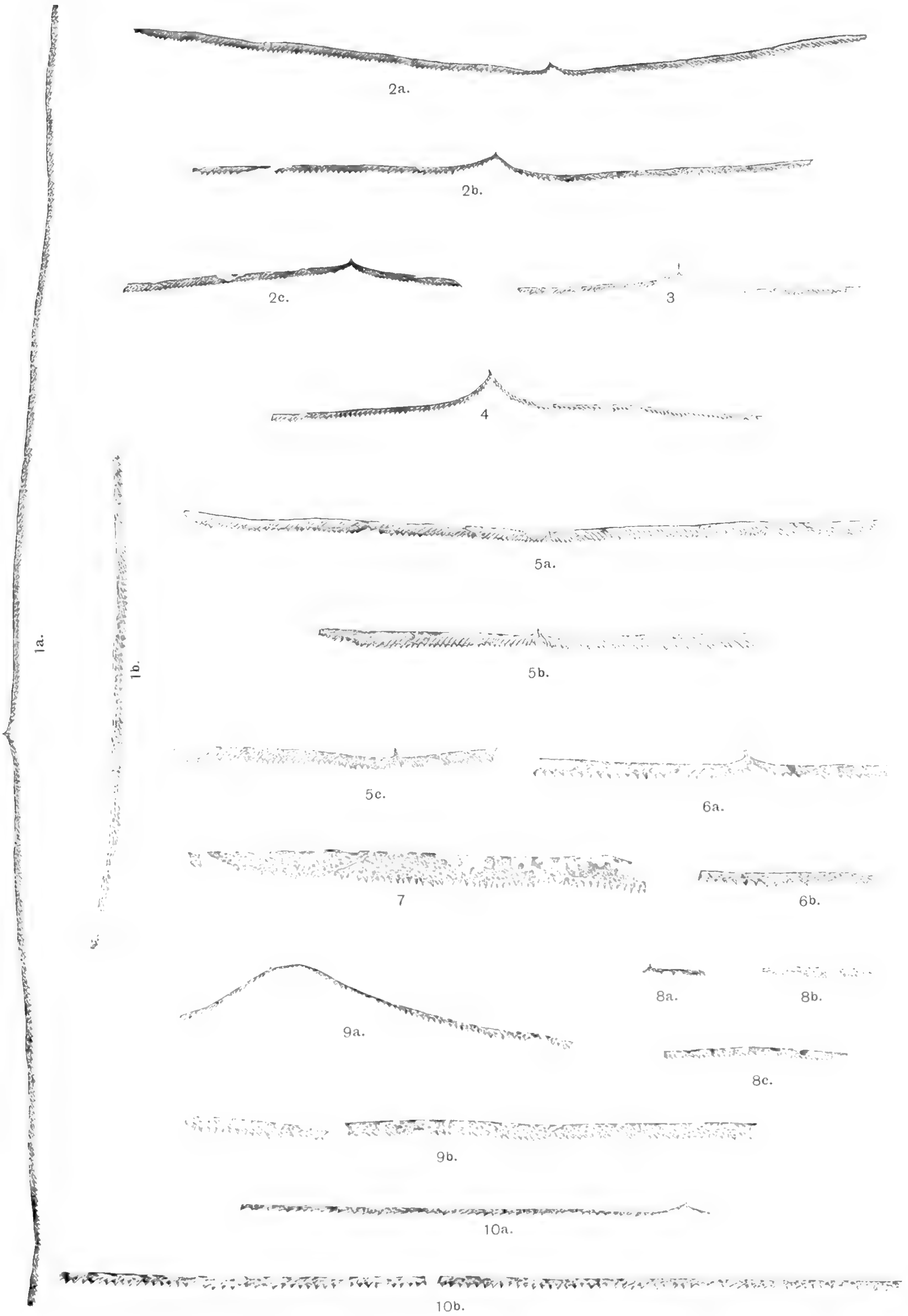
9 *a.* Obverse view, well preserved in black shale. Type specimen. Figured, Lapworth, Proc. Belfast Nat. Field Club (co. Down), pl. vii, fig. 15 *a.* Birnock, S. Scotland. Glenkiln Shales. Professor Lapworth's Collection, Birmingham.

9 *b.* Distal portion of stipe. Ibid.

10 *a, b.*—***Didymograptus euodus***, Lapw.

10 *a.* Proximal extremity. Type specimen. Figured, Quart. Journ. Geol. Soc., 1875, pl. xxxv, fig. 1 *a.* Abereiddy Bay. Llandeilo (Up. Llanvirn, Hicks). Woodwardian Museum.

10 *b.* Distal part of isolated stipe. Ibid., fig. 1 *c.*



DIDYMOGRAPTUS.

PLATE II.

Didymograptus—*continued.*

FIGS.

1 *a, b*.—***Didymograptus affinis***, Nich.

1 *a*. Showing proximal end and one stipe. Outerside. Skiddaw Slates. British Museum (Natural History), S. Kensington.

1 *b*. Reverse view. Ibid.

2.—***Didymograptus gracilis***, Törnq.

Obverse view. Barf. Skiddaw Slates. Mr. Postlethwaite's Collection, Keswick.

3 *a—d*.—***Didymograptus acutidens***, Lapw., MS.

3 *a*. Obverse view. Figured by Hopkinson as *D. affinis*, Quart. Journ. Geol. Soc., 1875, pl. xxxiii, fig. 6 *b*. Porth-hayog, Ramsey I. Up. Arenig. Woodwardian Museum.

3 *b*. Isolated stipe. Porth-hayog. Up. Arenig. Miss Wood's Collection.

3 *c*. Isolated stipe. Hope Stream, a little west of Hope Quarry, Shropshire. H.M. Geol. Survey Collection.

3 *d*. Ibid.

4 *a—c*.—***Didymograptus Nicholsoni***, Lapw.

4 *a*. Obverse view, preserved as a cast. Barf. Skiddaw Slates. Woodwardian Museum.

4 *b*. Ibid.

4 *c*. Preserved in shale. Figured by Hopkinson and Lapworth, Quart. Journ. Geol. Soc., 1875, pl. xxxiii, figs. 5 *a—d*. Llanvirn Quarry. Up. Arenig. Woodwardian Museum.

5 *a, b*.—***Didymograptus Nicholsoni***, var. *planus*, Elles and Wood, nov.

5 *a*. Obverse view. Outerside. Skiddaw Slates. Woodwardian Museum.

5 *b*. Isolated stipe. Ibid.

6 *a, b*.—***Didymograptus simulans***, Elles and Wood, sp. nov.

6 *a*. Reverse view, preserved as a cast. Barf. Skiddaw Slates. Woodwardian Museum.

6 *b*. Obverse view, preserved partly as a cast, partly in relief. Ibid.

7 *a, b*.—***Didymograptus serratulus***, Hall.

7 *a*. Reverse view, showing long nema. Minnoch Water, Glencaird Lodge, S. Scotland. Glenkiln Shales. Museum of Geol. Survey of Scotland, Edinburgh.

7 *b*. Isolated curved stipe. Birnock, S. Scotland. Glenkiln Shales. Lapworth's Collection, Birmingham.

8 *a—c*.—***Didymograptus fasciculatus***, Nich.

8 *a*. Isolated stipe, a cast. Ellergill. Up. Skiddaw Slates. Lapworth's Collection.

8 *b*. Ibid.

8 *c*. Proximal end, badly preserved. Thornship Beck. Up. Skiddaw Slates. British Museum (Natural History), S. Kensington.

9 *a—e*.—***Didymograptus gibberulus***, Nich.

9 *a*. Showing widely divergent stipes. Randal Crag. Skiddaw Slates. Postlethwaite's Collection.

9 *b*. More convergent type. Figured by Nicholson, Ann. Mag. Nat. Hist., 1875, pl. vii, fig. 3. Randal Crag. Skiddaw Slates. Woodwardian Museum.

9 *c*. Reverse view, showing nema. Figured by Salter as *D. caduceus*, Quart. Journ. Geol. Soc., 1863, p. 138, fig. 13 *a*. Longside, Keswick. Skiddaw Slates. Museum of Practical Geology, Jermyn Street.

9 *d*. Small form with long nema. Figured in Ann. Mag. Nat. Hist., 1875, pl. vii, fig. 3 *b*. White House Fell. Skiddaw Slates Woodwardian Museum.

9 *e*. Small form, showing nema. Figured by Hopkinson as *Phyllograptus stella*, Quart. Journ. Geol. Soc., 1875, pl. xxxiv, fig. 6.

10 *a, b*.—***Didymograptus v-fractus***, Salt.

10 *a*. Obverse view. Buttermere. Skiddaw Slates. Lapworth's Collection.

10 *b*. Reverse view. Ibid.

11 *a, b*.—***Didymograptus***, var. *volucer*, H. O. Nich.

11 *a*. Poorly preserved, all details indistinct. Figured, H. O. Nicholson, Geol. Mag., 1890, p. 342, fig. 3. Outerside. Skiddaw Slates.

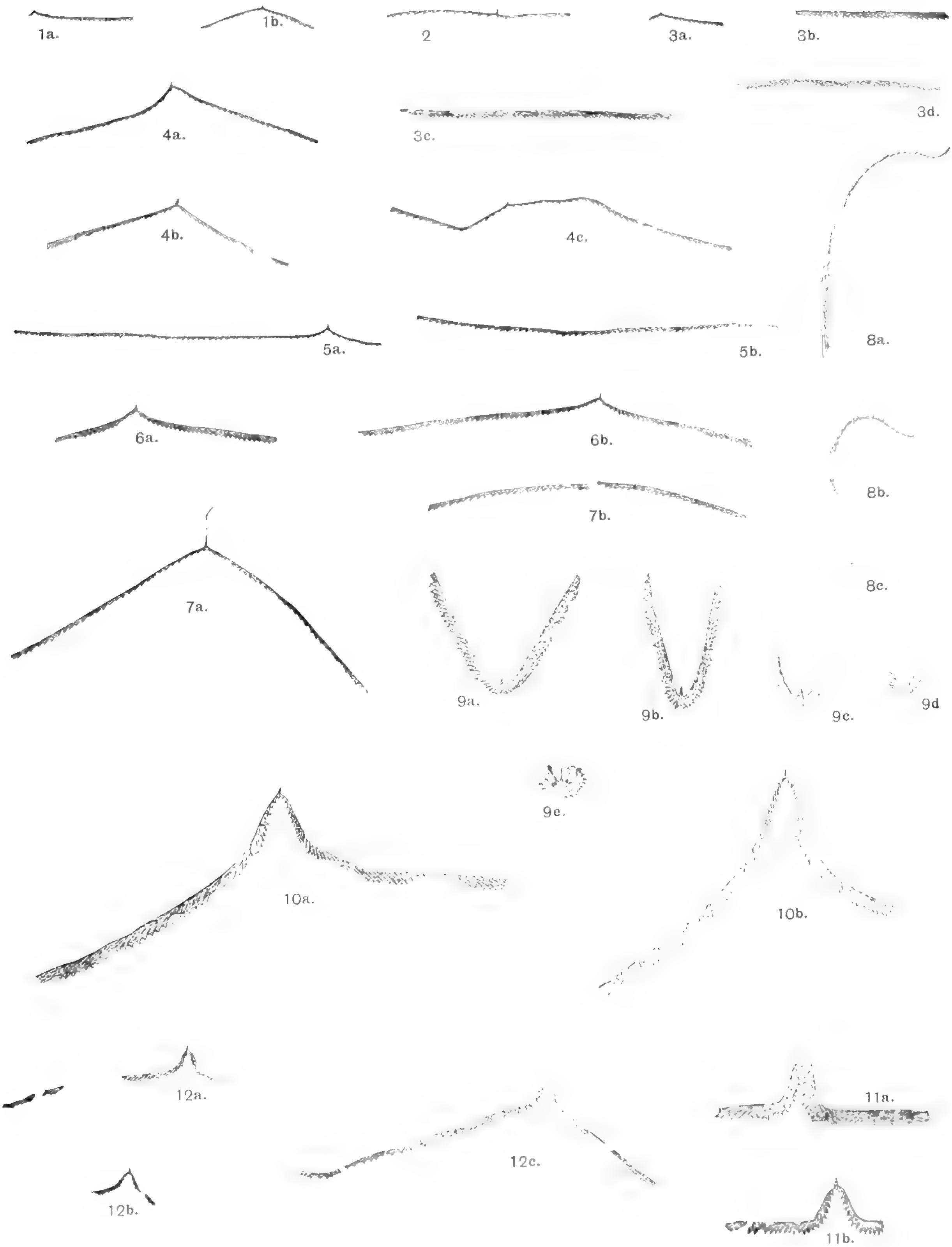
11 *b*. Reverse view. Skiddaw. Museum of Pract. Geol., Jermyn Street.

12 *a—c*.—***Didymograptus deflexus***, Elles and Wood, sp. nov.

12 *a*. Reverse view. Figured by Elles as ***D.*** *v-fractus*, Quart. Journ. Geol. Soc., 1898, p 508, fig. 25 *a*. Barf. Skiddaw Slates. Woodwardian Museum.

12 *b*. Obverse view. Ibid., fig. 25 *b*.

12 *c*. Long specimen. Skiddaw Slates. Museum of Pract. Geol., Jermyn Street.



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DIDYMOGRAPTUS.

PLATE III.

Didymograptus—*continued.*

FIGS.

1 *a*—*k*.—*Didymograptus Murchisoni*, Beck.

1 *a*. Imperfect specimen preserved on the surface of black limestone in very low relief, the largest example figured by Sowerby, Murchison's Silurian System, pl. xxxvi, fig. 4. Gelli, Llandrindod. Llandeilo. Mus. of Geological Society, London.

1 *b*. Example with parallel stipes. Ibid.

1 *c*. Preserved on dark grey shale. Holywell Burn, Shropshire. E. M. R. Wood's Collection.

1 *d*. More diverging stipes. Ibid.

1 *e*. Converging stipes. Ibid.

1 *f*. Preserved in black shale and elongated by cleavage. Figured by Hopkinson and Lapworth, Quart. Journ. Geol. Soc., 1875, pl. xxxv, fig. 2 *a*. Abereiddy Bay. Llandeilo (Up. Llanvirn, Hicks). Woodwardian Museum.

1 *g*. Somewhat wider form. Ibid.

1 *h*. Showing converging and overlapping of distal portion of stipes. Figured ibid., fig. 2 *c*.

1 *i*. Specimen greatly elongated and of more uniform width. Abereiddy Bay. Llandeilo (Up. Llanvirn, Hicks). E. M. R. Wood's Collection.

1 *j*. Well-preserved specimen. Ibid., fig. 2 *b*. Woodwardian Museum.

1 *k*. Poorly preserved. Fig. 2 *f*, ibid.

2 *a*—*j*.—*Didymograptus Murchisoni*, var. *geminus*, His.

2 *a*. Reverse view. On same slab as type specimens of *D. Murchisoni*. Gelli, Llandrindod.

2 *b*. Showing "furcillate" form. Figured, Murchison's Silurian System, pl. xxvi, fig. 4. Gelli, Llandrindod.

2 *c*. Ibid.

2 *d*. Short and more typical form. Reverse view. Abereiddy Bay. Llandeilo (Up. Llanvirn, Hicks). Miss Elles' Collection, Cambridge.

2 *e*. Ibid. Reverse view. Abereiddy Bay.

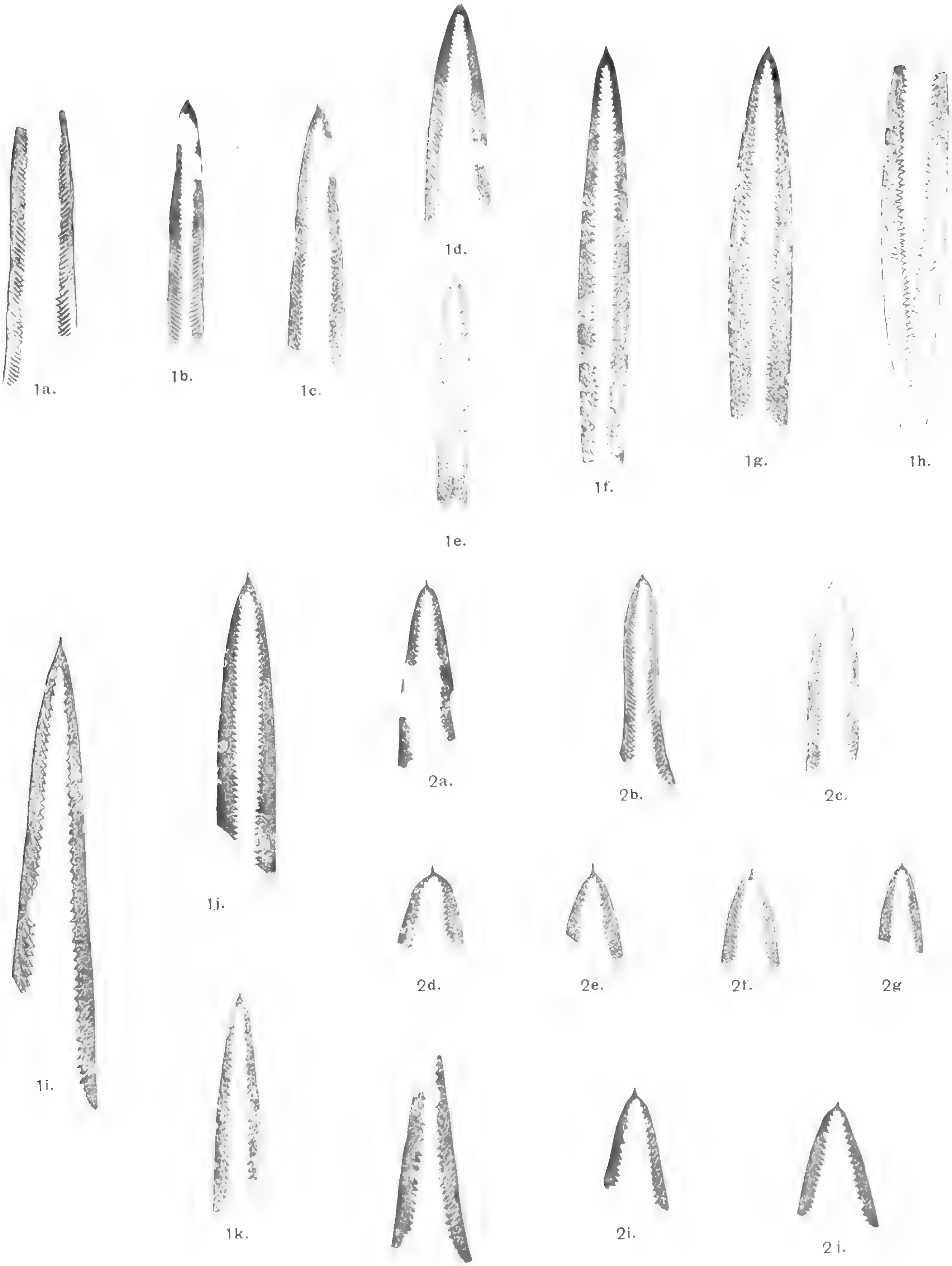
2 *f*. Ibid.

2 *g*. Obverse view. Holywell Burn, Shropshire. Lower Llandeilo. E. M. R. Wood's Collection.

2 *h*. Imperfect. Type specimen of *D. furcillatus*, Lapw. Figured by Hopkinson and Lapworth, Quart. Journ. Geol. Soc., 1875, pl. xxxv, fig. 3 *a*. Abereiddy Bay. Llandeilo. Woodwardian Museum.

2 *i*. Obverse view. Ibid., fig. 3 *c*.

2 *j*. Ibid., fig. 3 *b*.



F. M. R. Wood, del. *Bemrose, Ltd., Derby.*

DIDYMOGRAPTUS.

PLATE IV.

Didymograptus—*continued.*

FIGS.

1 *a—f.*—*Didymograptus bifidus*, Hall.

1 *a.* Preserved in black shale. Figured by Hopkinson and Lapworth, Quart. Journ. Geol. Soc., 1875, pl. xxxiii, fig. 8 *a.* Porth-hayog, Ramsey I. Up. Arenig. Woodwardian Museum.

1 *b.* Ibid., fig. 8 *d.*

1 *c.* Larger specimen in relief. Pont Seiont. Up. Arenig. Woodwardian Museum.

1 *d.* Ibid.

1 *e.* Large specimen, preserved partly in relief, partly as a cast (labelled *D. Murchisoni*). $1\frac{1}{2}$ miles S.E. of Duleek, co. Meath. Museum of Geol. Survey, Ireland.

1 *f.* Widely divergent stipes. Pont Seiont. Up. Arenig. Woodwardian Museum.

2.—*Didymograptus stabilis*, Elles and Wood, sp. nov.

Specimen redeveloped. Originally figured by Hopkinson as *D. indentus*, Quart. Journ. Geol. Soc., 1875, pl. xxxiii, fig. 7 *a.* Porth-hayog, Ramsey I. Up. Arenig. Woodwardian Museum.

3 *a—c.*—*Didymograptus amplus*, Elles and Wood, sp. nov.

3 *a.* Obverse view. Preserved in black shale. Abereiddy Bay. Llandeilo (Up. Llanvirn, Hicks). G. L. Elles' Collection.

3 *b.* Large specimen, affected by cleavage. Abereiddy Bay. E. M. R. Wood's Collection.

3 *c.* Specimen not much cleaved. Abereiddy Bay. Woodwardian Museum.

4 *a—c.*—*Didymograptus*, cf. *indentus*, Hall.

4 *a.* Badly preserved example. Mungrisedale, Glenderamakin Valley, Lake district. Upper Arenig. Woodwardian Museum.

4 *b.* Ibid.

4 *c.* Poorly preserved. Figured by Nicholson as *D. geminus*, Ann. Mag. Nat. Hist., 1870, p. 346, fig. 6 *a.* Thornship Beck, Lake district. Up. Arenig. Woodwardian Museum.

5 *a—h.*—*Didymograptus nanus*, Lapw.

5 *a.* Poorly preserved specimen affected by cleavage. Figured by Hopkinson and Lapworth, Quart. Journ. Geol. Soc., 1875, pl. xxxv, fig. 4 *a.* Abereiddy Bay. Llandeilo (Up. Llanvirn, Hicks). Woodwardian Museum.

5 *b.* Ibid., fig. 4 *b.*

5 *c.* Quarry N.W. of Llanvirn. Lower Llanvirn (Hicks). Woodwardian Museum.

5 *d.* Outerside, Keswick. Upper Skiddaw Slates. British Museum (Nat. Hist.), S. Kensington.

5 *e.* Reverse view. Quarry N.W. of Llanvirn, Lower Llanvirn (Hicks). E. M. R. Wood's Collection.

5 *f.* Preserved partly in relief, partly as a cast. Ellergill, Lake District. Lapworth's Collection.

5 *g.* Ibid.

5 *h.* Poorly preserved specimen. ? Figured Salter, Quart. Journ. Geol. Soc., vol. xix, p. 137, fig. 13 *c.* Eggbeck, Ullswater. Upper Skiddaw Slates. Museum of Practical Geology, Jermyn Street.

6 *a—d.*—*Didymograptus artus*, Elles and Wood, sp. nov.

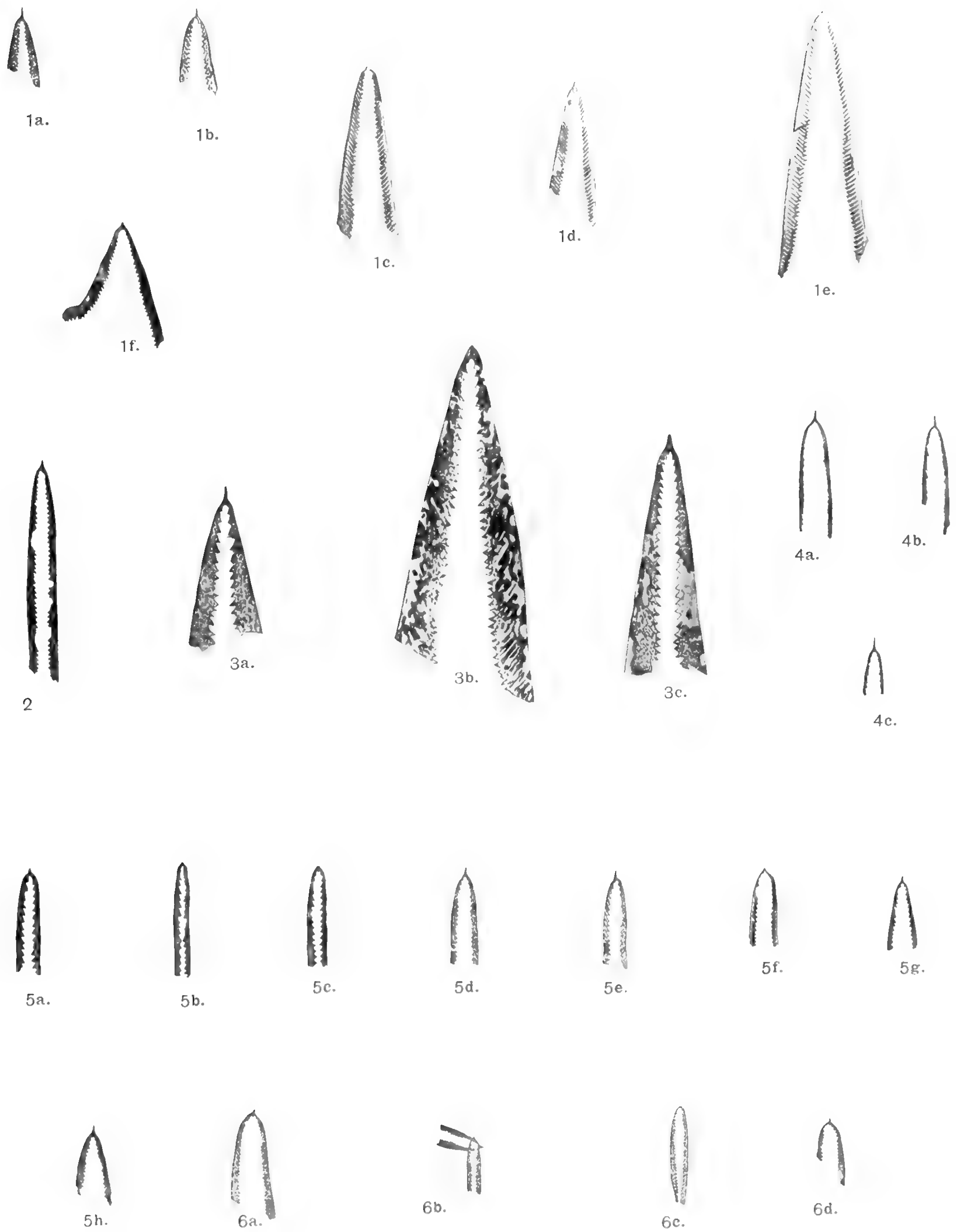
6 *a.* Large specimen. Thornship Beck. Upper Skiddaw Slates. Woodwardian Museum.

6 *b.* Two specimens showing effect of cleavage. Porth-hayog, Ramsey I. Upper Arenig (Hicks). G. L. Elles' Collection.

6 *c.* Porth-hayog. Woodwardian Museum.

6 *d.* Obverse view. Porth-hayog. G. L. Elles' Collection.

PALÆONTOGRAPHICAL SOCIETY, 1901.



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DIDYMOGRAPTUS.

THE

PALÆONTOGRAPHICAL SOCIETY.

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THE

GANOID FISHES

OF THE

BRITISH CARBONIFEROUS FORMATIONS.

BY

RAMSAY H. TRAQUAIR, M.D., LL.D., F.R.S.,

KEEPER OF THE NATURAL HISTORY COLLECTIONS IN THE MUSEUM OF SCIENCE AND ART, EDINBURGH.

PART I.

PALÆONISCIDÆ.

PAGES 61—87; PLATES VIII—XVIII.

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found in the quarries at Burdiehouse, in Edinburghshire; and the collection of the Geological Survey of Scotland contains fragments from Raw Camps, near Midcalder, in the same county. In Fifeshire it has been found at Burntisland (Grange Quarry) and at Kingscraig, and I am also indebted to Mr. Graham Yooll, of Pittenweem, for a specimen apparently belonging to the same species, but not very perfect as regards the fins, from the shale works at Pitcorthie, near Anstruther. Dr. Paterson mentions it as occurring in the Wardie fish-beds;[1] possibly, however, he has mistaken for it the closely allied *E. intermedius*, Traq., as I have found no evidence of its presence in any of the collections of Wardie fishes which I have examined. In Messrs. Young, Armstrong, and Robertson's Catalogue of the Western Scottish Fossils[2] it is recorded as having been found in ironstone of the Carboniferous and Limestone series at Possil, in Lanarkshire, in the Coal-measures (roof shale of the Drumgray Coal) at Carluke, but I have not myself seen any specimen from the west of Scotland which I could with certainty refer to the species under consideration. Professor Young, in his appendix to the Report of the Committee on the Distribution of the Vertebrate Remains from the North Staffordshire Coal-field,[3] states that "a small number of specimens belong to *Palæoniscus striolatus* or *P. Robisoni.*" Mr. Ward, of Longton, well known as a most energetic collector of Carboniferous fishes, has, however, convinced himself "that Dr. Young was in error in placing these species on the list of species of these Coal-measures;"[4] and for my own part I must own that after a very careful examination of Mr. Ward's enormous collection of North Staffordshire Palæoniscidæ, as well as of those from the same district in the Museum of Practical Geology, I have failed to find any trace of either of them.

As regards its alleged occurrence at Visé, in Belgium,[5] and at Löbejün, near Halle,[6] having seen both the specimens in question, I am prepared to state pretty strongly that neither of them belongs to the *Palæoniscus striolatus* of Agassiz. Professor De Koninck having very kindly forwarded to me the supposed Belgian example, I found that it belonged in reality to *Palæoniscus macropomus*, Agass., a fish common in the limestone concretions occurring in the Permian strata of Ilmenau, in Thuringia, which locality is also further indicated both by the nature of the matrix and the peculiar mode of mineralisa-

[1] "On the Fossil Organic Remains found in the Coal Formation at Wardie," 'Edinb. New Phil. Journ.,' xxiii, 1837.

[2] 'Catalogue of the Western Scottish Fossils' (British Association Guide Books), Glasgow, 1876, p. 64. See also Hunter's 'Palæontology of the Carboniferous Strata of the West of Scotland,' Carluke, 1875, p. 30.

[3] 'British Assoc. Reports,' xxxv (1865), p. 317.

[4] North Staffordshire Naturalists' Field Club, Annual Addresses, Papers, etc., Hanley, 1875, p. 238.

[5] 'Description des Animaux Fossiles qui se trouvent dans le Terrain carbonifère de Belgique,' Liège, 1842–4, p. 610, pl. liv, figs. 1 *a*, *b*.

[6] In Germar's 'Versteinerungen von Wettin und Löbejün,' the fish remains described by Giebel, Halle, 1849, p. 79, pl. xxx, fig. 12.

tion of the fossil. I fear, therefore, that there is some mistake as to this specimen having been derived from the Carboniferous Limestone of Visé, but in any case it does not belong to the present species. It is also clear that Giebel has been mistaken in his determination of the specimen from Löbejün which he has figured as "*Palæoniscus striolatus*," and which I have examined in the Geological Museum of the University of Halle.

So far, then, as I have been able to ascertain with certainty *Elonichthys striolatus* has as yet occurred only in strata of Lower Carboniferous age.

The publication of this Monograph, interrupted since 1877, is now resumed in 1901. During that period of twenty-three years our knowledge of the Ganoid fish-fauna of the British Carboniferous rocks has immensely increased, as was only to be expected. Several new genera as well as many new species have occurred, which may now be described consecutively without having to go back on the subject by means of extensive "supplements." One other result of the additional experience which the study of greatly increased material has brought with it is, that I have come to look upon many forms, which I previously held to be distinct species, as only constituting well-marked varieties, or in some cases the immature stages of other species. The immediate relegation of these to their proper places, without the use of supplements, will also be a decided advantage to the work as now resumed.

So far, however, as the anatomical features of the family at present under consideration are concerned, a short appendix will be necessary, as many additional details have been discovered since the section on the Structure of the Palæoniscidæ was written. These will be noticed meanwhile in the descriptions of the genera and species in which they have been observed. But there is one point of bone-nomenclature to which I must at present make special allusion. It is this,—that I have for some years back regarded the quadrangular plate marked "*interoperculum*" in my previous figures as the true *suboperculum*, and as such it will be henceforth described and lettered. On the other hand, the small plate above its antero-superior angle seen in some genera, such as *Elonichthys*, and which *Rhabdolepis* (Pl. II, fig. 6, *s. o.*) extends back so as to separate the operculum from the suboperculum, I now consider as merely an accessory plate, though formerly I lettered it as "*suboperculum*." [1]

4 *a*. Elonichthys Robisoni, *Hibbert*, sp. Plate VII, figs. 4—15; Plates VIII—XI; Plate XIV, figs. 4—8; Plate XV.

Palæoniscus Robisoni, *Hibbert*. Trans. Roy. Soc. Edinb., vol. xiii, p. 191, pl. vi, figs. 6, 7; pl. vii, figs. 1—3, 1835.
— — *Agassiz*. Poiss. Foss., vol. ii, pt. i, p. 88; Atlas, vol. ii, tab. x *a*, figs. 1, 2, 1835.
— — *Morris*. Cat. Brit. Foss., p. 337, 1854.

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[1] R. H. Traquair, "Notes on *Chondrosteus acipenseroides*, Agassiz," 'Geol. Mag.,' dec. 3, vol. iv, 1887, p. 253, *foot-note*. "List of the Fossil Dipnoi and Ganoidei of Fife and the Lothians," 'Proc. Roy. Soc. Edinb.,' 1889–90, p. 397. See also Dr. A. Smith Woodward ('Cat. Foss. Fishes British Mus.,' pt. ii, p. 487), who considers what I have above called an "accessory plate" to be a true *interoperculum*.

PALÆONISCUS STRIOLATUS, *Agassiz.* Tom. cit., p. 91, tab. x *a*, figs. 3, 4, 1835.
— — *Morris.* Op. cit., p. 337, 1854.
AMBLYPTERUS NEMOPTERUS, *Agassiz.* Tom. cit., p. 107, tab. iv *b*, figs. 1, 2, 1835.
— — *Morris.* Op. cit., p. 317, 1854.
— PUNCTATUS, *Agassiz* (pars). Tom. cit., p. 109, tab. iv *c*, figs. 3, 5, 8, 1835.
ELONICHTHYS ROBISONI, *Traquair.* Quart. Journ. Geol. Soc., vol. xxxiii, p. 553, 1877.
— — *A. S. Woodward.* Cat. Foss. Fishes Brit. Mus., pt. ii, p. 495, 1891.
— STRIOLATUS, *Traquair.* Loc. cit., p. 553, and the present work, p. 57, pl. vii, figs. 4—15, 1877.
— NEMOPTERUS, *Traquair.* Quart. Journ. Geol. Soc., vol. xxxiii, p. 553, 1877; also Proc. Roy. Soc. Edinb., vol. xvii, pp. 390, 394, 1890.
— INTERMEDIUS, *Traquair.* Proc. Roy. Soc. Edinb., vol. ix, p. 279, 1877 (withdrawn as a species, retained as a variety, ibid., vol. xvii, pp. 394–5, 1890).
— OVATUS, *Traquair.* Ibid., vol. ix, p. 427, 1877 (withdrawn, ibid., vol. xvii, p. 396, 1890).
— TENUISERRATUS, *Traquair.* Proc. Roy. Phys. Soc. Edinb., vol. v, p. 119, 1880 (withdrawn as a species, retained as a variety, Proc. Roy. Soc. Edinb., vol. xvii, p. 395, 1890).
— DUNSII, *Traquair.* Proc. Roy. Phys. Soc. Edinb., vol. v, p. 126, 1880 (withdrawn as a species, retained as a variety, Proc. Roy. Soc. Edinb., vol. xvii, p. 395, 1890).
PYGOPTERUS BUCKLANDI, *Agassiz* in *S. Hibbert.* Loc. cit., p. 217, pl. vii, fig. 2, 1835; also in Poiss. Foss., vol. ii, pt. ii, p. 77, 1844.
ELONICHTHYS BUCKLANDI, *Traquair.* Quart. Journ. Geol. Soc., vol. xxxiii, pp. 553, 575, 1877, and Proc. Roy. Soc. Edinb., vol. ix, p. 428, 1877; also in Proc. Roy. Soc. Edinb., vol. xvii, pp. 390, 394, 1890.
— — *A. S. Woodward.* Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 497.

Specific Characters.—Shape fusiform; depth of the body at the origin of the dorsal fin contained about four times in the entire length; fins large with numerous rays, dorsal and anal triangular and high in front; fin-rays delicately longitudinally striated, save in some cases the proximal parts of those of the lower lobe of the caudal; their joints variable in length, but tending to become very short in large individuals, and in some varieties; pectorals having their principal rays jointed up to their origins; fulcra minute. The scales are finely serrated on the posterior margin and delicately striato-punctate, but there is a great variety in the relative extent of the striation and punctation. As a rule the most anterior scales are entirely striated; those of the middle of the body striated towards the anterior margin, and punctate posteriorly, while those towards the tail become nearly smooth. The cranial roof-bones are for the most part finely tuberculated; those of the face striated, and very considerable variety occurs here as to the closeness and prominence of the striation.

Observations.—The name *Palæoniscus Robisoni* was given by Hibbert, in 1835, to a small palæoniscoid fish from the Burdiehouse Limestone, and three allied forms were soon afterwards described as distinct species by Agassiz,—namely, *Palæoniscus striolatus*, also from Burdiehouse; and *Amblypterus nemopterus* and *A. punctatus* (pars), from Wardie. In 1877 I transferred these to *Elonichthys* of Giebel, but as the three type specimens of *punctatus* belonged, in fact, to two distinct genera, I instituted for one of them the new genus *Gonatodus*, retaining Agassiz's name *punctatus* for the type species; while for the other two, which obviously belonged to *Elonichthys*, I proposed the specific term *intermedius*. Then and subsequently I also described as new species three other allied forms, namely, *E. ovatus* (1877), *E. tenuiserratus* (1880), *E. Dunsii* (1880). But as material increased I began to find that the characters which I had looked on as diagnostic for the seven supposed species referred to above were no longer reliable, and after puzzling for years over the matter I felt compelled in 1890 to unite them all into one, a very variable one indeed, for which I adopted Agassiz's name *nemopterus*. Dr. Smith Woodward, however, in his "Catalogue" (pt. ii, 1891) pointed out that the name *Robisoni*, of Hibbert, had priority over *nemopterus* of Agassiz, and also hinted that the Agassizian species *Bucklandi*, which I had left out of the reunion, might well also be included as adult *Robisoni*. Still further increase of material has convinced me that this is the most advisable course, and I have accordingly in the table given above likewise placed the last-quoted specific name as a synonym of *E. Robisoni*.

With limited material it is no doubt easy enough to put together a set of extreme forms which anyone might be tempted to adopt as distinct species, as I myself did at the commencement of my investigations; but the greater the number of specimens examined, the more and more difficult does their accurate differentiation become, until we are finally obliged to give up the quest. For instance, the relative fineness or coarseness of the fin-rays, and the relative distance of their transverse articulations, are characters which are quite inconstant. As a rule the fin-rays are proportionally more slender and more distantly articulated in young specimens, though sometimes this condition persists in examples of considerable size. Also no reliance can be placed on the relative extent to which the scales are striated or punctate, or upon whether the punctate area is nearly smooth or thickly covered with punctures. Unfortunately the relative size of the scales and the number of rays in each fin are characters which can only be accurately ascertained in exceptionally well-preserved fishes, as a certain amount of distortion is common to the greater number of specimens as they occur in the rock.

Geological Position.—*Elonichthys Robisoni* as defined above is without exception the most abundant of all the Palæoniscid fishes which are found in the Lower Carboniferous rocks of the Forth Basin, occurring as it does in most of the estuarine fish-bearing beds of that age and region, from the Wardie Shales up to near the top of the Carboniferous Limestone series. But neither in Scotland nor elsewhere have I seen any evidence of its existence in strata newer than the lower boundary line of the Millstone Grit.

Variations.—The minute account of the form *striolatus*, which I have already given, may serve as a general description of *Elonichthys Robisoni*, and I may now enumerate the principal variations in the condition of the fin-rays and sculpture of the scales which are found in what, in the present state of knowledge, must be looked upon as a comprehensive and variable species.

A. *Palæoniscus Robisoni* of Hibbert and Agassiz (Pl. VIII, figs. 2—4).—The small Burdiehouse fishes attaining a length of four or five inches to which Hibbert originally applied the term *Palæoniscus Robisoni*, and of which Agassiz gave a minute description in the 'Poissons Fossiles,' are undoubtedly young individuals of the larger *striolatus*, which occurs in the same quarry. The sculpture of the scales (Pl. VIII, figs. 3, 4) is indistinguishable, but the articulations of the fin-rays are more distant, the joints being longer than they are broad, as is the general rule in immature examples of the present family. Professor Young, of Glasgow, first threw doubts on the specific distinction of *Robisoni* and *striolatus*, a view with which I now perfectly agree. Several points in Agassiz's description require a little comment. Too much stress is laid by him on the "tenuité de son corps," as an examination of any large series of specimens will at once render evident. His statement that "les os de la tête ont leurs surfaces lisses; ceux du crâne seulement presentent quelques striées peu marquées," can hardly be considered accurate,—the external sculpture of the head-bones being, in Burdiehouse specimens, rarely seen at all; but where glimpses of it are obtained, it is clear that these bones were ornamented in a manner quite similar to those of its congeners, Agassiz having evidently been misled by the smoothness of their *internal aspect.* The scales are likewise in all cases more highly ornate than he describes them to be, and the enlarged figures which he gives of them are eminently unsatisfactory. Nor can any value be placed on the supposed greater prominence of the keels on the under surfaces of the scales as a mark distinguishing them specifically from those of *striolatus*,—such a distinction I have never been able to verify. Young examples of the variety *intermedius* from other horizons and localities are also indistinguishable from the Burdiehouse specimens.

The Edinburgh Museum is fortunate in possessing one of Hibbert's original types of "*Palæoniscus Robisoni*," namely, the original of fig. 3 on pl. vii of his memoir on the Burdiehouse Limestone, as well as the specimen figured by Agassiz in the 'Poissons Fossiles,' vol. ii, pl. x *a*, fig. 1.[1]

The more mature form, *Palæoniscus striolatus* of Agassiz, described by myself in the preceding pages as *Elonichthys striolatus* (Pl. VII, figs. 4—15), attains, as we have seen,

[1] These and other type specimens of Carboniferous fishes, in the collection of the Royal Society of Edinburgh, were in 1878 generously presented by that body to the Museum of Science and Art.

a length of five or six inches, and is distinguished from the immature specimens solely by the greater closeness of the transverse articulations of the fin-rays.

Pygopterus Bucklandi of Agassiz (*Elonichthys Bucklandi*, Traq.) is probably, as suggested by Smith Woodward, the extreme adult form of the typical *E. Robisoni* as it occurs in the same beds at Burdiehouse and Burntisland, as it is not only difficult concisely to define it as a species, but also to assign to it a special immature form of its own. Agassiz's brief statement regarding it in the 'Poissons Fossiles' is as follows :—"Espèce characterisée par la petitesse et la forme allongée de ses écailles, et par son anale très rapprochée de la caudale. Elle est à-peu-près de la taille du *Pygopterus mandibularis*, et provient du calcaire de Burdiehouse en Ecosse. L'originale se trouve dans la collection de la Société Royale d'Edinbourg."

The specimen to which these words refer was figured by Hibbert in his Burdiehouse Memoir (pl. vii, fig. 2), but seems unfortunately to be lost, as, many years ago, I sought for it in vain in the collection of the Royal Society of Edinburgh. But there can be no doubt as to what manner of fish it was, as the figure enabled me confidently to refer to it a number of mostly fragmentary remains of a large *Elonichthys* from Burdiehouse contained in the Edinburgh Museum of Science and Art. These specimens represent a fish which seems to have attained the length of a foot or more, having the transverse articulations of the fin-rays close, and the scales proportionately small. The latter are, on the flank, nearly equilateral, but towards the ventral margin they are low and narrow. The anterior covered area is very narrow; the posterior margin is finely denticulated. The exposed area is covered with a delicate yet sharply defined ornamentation, consisting of fine subparallel ridges, which pass from before backwards across the scale in a gently sigmoid direction, tending to become intermixed with punctures posteriorly, especially above the diagonal between the two acute angles of the scale. Towards the tail the ridges become less marked on the posterior part of the scale, giving way to the thickly dotted punctures, till on the caudal body prolongation the former, after lingering at the anterior margin, altogether disappear, and punctures alone remain. A certain amount of reticulation is also frequently observed as regards the ridges.

The characters on which I previously depended for maintaining this form as a separate species are, therefore, the proportional small size of the scales, their highly ornate, clear-cut sculpture, and the extra closeness of the transverse articulations of the fin-rays, but long experience has now taught me that in this group of forms these marks are subject to endless gradations, and are consequently not reliable as specific distinctions. *Elonichthys Bucklandi* must therefore be relegated to the list of synonyms of *E. Robisoni*.

In Pl. XIV, figs. 4—8, the ordinary sculpture of the scales of this form, as seen in Burdiehouse specimens, is represented magnified eight times; the articular peg is, however, omitted, being covered in each case by the scale next above. Fig. 5 is a lateral-line scale from the flank; figs. 6—8 are narrow scales from a position close above the base of the anal fin.

Pl. XV, fig. 1, represents a comparatively small specimen of the fish itself from Burntisland, crushed upon its back, and wanting the caudal region. Fig. 2 of the same plate represents the tail and hinder part of the body of a larger specimen from the same locality, in which the extreme closeness of the articulations of the rays of the dorsal and anal fins is well shown. Fig. 3 is a magnified representation of one of the scales of the same example.

B. Variation *intermedius.*—As already mentioned, I gave in 1877 the name *Elonichthys intermedius* to two of the three specimens which Agassiz erroneously included under *Amblypterus punctatus*, namely, to those figured in pl. 4 *c*, figs. 3 and 5, of the atlas to vol. ii, pt. 2, of the 'Poissons Fossiles.' These two specimens were imperfect, the head and anterior part of the body being wanting in both; but the same locality soon supplied a good many more or less entire fishes which were clearly identifiable with them. As I have devoted the whole of Pl. IX and part of Pl. X to these Wardie specimens, I may, before going further, indicate the salient points which they exhibit.

In Pl. IX, fig. 1, we have a specimen in a Wardie nodule, which shows the general form very well, being quite entire with the exception of the caudal fin, which is slightly injured; but this deficiency is supplied by fig. 2, which shows the entire caudal in addition to the dorsal and anal, and is, in fact, a fresh drawing from the specimen figured by Agassiz, *op. cit.*, pl. 4 *c*, fig. 3. It will be seen that the form of the body and the proportions of the fins are the same as in *striolatus*, but the articulations of the longer rays of the dorsal, anal, and ventral fins are further apart, the joints appearing consequently longer than broad, as shown magnified in fig. 8. These articulations are, however, pretty short in the pectoral fin, as represented in Pl. X, fig. 4, slightly magnified. Figs. 3, 4, and 5, Pl. IX, represent the external aspect of scales from the other of Agassiz's originals (*op. et tab. cit.*, fig. 5), fig. 3 being an ordinary flank scale, fig. 4 one from the lateral line on the flank, and fig. 5 one from the middle of the caudal region above the anal fin, and it will be seen that their sculpture is essentially similar to that on the scales of *striolatus.* But in most of the Wardie specimens which occur in nodules the ganoine layer becomes separated from the scale, and adherent to the counterpart when the nodule is opened, disclosing the subjacent osseous tissue, which is marked by more or less concentric coarse ridges and furrows, as seen in figs. 7 and 8—an appearance which must not be confounded with the true external sculpture. In Pl. X, fig. 2, we have some of the bones of the right side of the head shown in impression. The *operculum* (*op.*) is rather narrow, its posterior-superior angle rounded off, while the posterior-inferior one is acutely pointed; the suboperculum (*s. op.*) is square-shaped. The exact number of the branchiostegal rays (*br.*) is hardly ascertainable; only a few are shown here, but in other specimens the anterior one of each lateral series is distinctly shown to be much broader than the rest, and a median lozenge-shaped plate is also conspicuously present between these and behind the symphysis of the jaw. In the specimen here figured the pre-operculum, the cheek-plates, and the maxilla are gone, whereby the upper end of the hyomandibular (*hm.*) is shown, as well as nearly the whole of the palatoquadrate apparatus (*pt.*) and the articulation of the mandible. The right ramus of the mandible is shown in the figure just below the palatopterygoid apparatus, but is unfortunately not lettered; *mn'* represents, however, the ramus of the opposite side. Lastly, *e* is the *superethmoidal*, and *o.* an otolith.

Fig. 3 of the same plate represents a maxilla magnified about two diameters. It is of the usual form, and has its broad portion ornamented externally by fine ridges, not very closely placed, often wavy, but for the most part parallel with the superior and posterior borders of the bone.

Fig. 1 is a restored figure of the entire fish, constructed entirely from a series of specimens from Wardie in my private collection.

Specimens conforming to this type occur in the Calciferous Sandstone series, likewise at Burdiehouse and Straiton in Midlothian, at South Queensferry and Dechmont in Linlithgowshire, and at Burntisland and Pitcorthy in Fife. The fish from Burdiehouse (Pl. VIII, fig. 1), which I described in 1877 as *Elonichthys ovatus*, is, as I have now no doubt, an example of this form with the body shortened up by distortion. To these must also be added the specimens from the cannel coals and ironstones of the Carboniferous Limestone series of the Forth Basin, which I once thought entitled to be considered as a distinct variety, to which I gave the name "*affinis*," as the fins seemed to be rather smaller and composed of fewer rays. One of these, from Wallyford, near Musselburgh, in the British Museum Collection, is represented in Pl. X, fig. 5; and similar specimens are, or were, of common occurrence in the Gilmerton Ironstone, in the Borough Lee or No. 2 Ironstone, Loanhead, and in the Denhead Ironstone, Fife.

The only difference between the forms *intermedius* and *striolatus* is the greater distance in the former of the transverse articulations of the fin-rays—a distinction which is, however, not specifically valid, as intermediate conditions in this respect are not uncommon, especially in specimens from the Dunnet Shale at Straiton.

A few large specimens from Straiton (Dunnet Shale), one of which must have measured, when entire, nearly one foot in length, show ornate scale markings resembling those of "*Bucklandi*," while the striation of the facial bones is remarkably close. The joints of the fin-rays are, however, in the condition of those in the ordinary "*intermedius*."

c. Variation *nemopterus*.—This is the "*Amblypterus*" *nemopterus* of Agassiz, founded on a specimen from Wardie which belonged to the late Sir Walter C. Trevelyan, but is now in the British Museum Collection. Pl. XVII, fig. 11, represents the counterpart of the same specimen, the details being somewhat more realistically rendered than was done by Agassiz's artist. Other specimens from Wardie and Straiton agreeing essentially with Agassiz's type are in the Edinburgh Museum and in my own collection. The salient points of this form are the highly acuminate shape of the dorsal and anal fins, the comparative fineness of the rays, and the relative distance of their transverse articulations, which in the front part of the fins are so far apart as to render the joints about three times as long as broad. Even in the pectoral (fig. 12) the articulations are unusually distant. The scales are proportionately small in size and delicately ornate, but the pattern is essentially that of the general *Robisoni* type. By Agassiz the rays of the dorsal fin are described as being " tous bifurqués à plusieurs reprises jusque vers leur milieu ; " but to my observation the dichotomisation of the longer rays, as is usual in this genus, does not commence till towards their terminations. He also describes the surface of the scales as being " orneé de petites rides saillantes, disposées à peu près comme les lignes d'accroissement en losanges concentriques plus ou moins régulières et un peu obliques, de telle sorte que leurs angles aigus sont tournés vers les angles supérieur-antérieur et inférieur-postérieur de chaque écaille,"—a description which is hardly correct, as there are no striæ which are parallel with the posterior margin of the scale. The scales of the original specimen are, however, in a very bad state of preservation, the exterior ganoine layer having everywhere disappeared.

Distinct though the characters of the fin-rays in this form may appear to be, a series of specimens in my collection, from the oil shales of Pumpherston, to the west of Edinburgh, seem to me to dispose of the claim of *nemopterus* to the rank of a species, as the fin-rays in these examples, though mostly fine, are very variable as regards the length of their transverse joints.

D. Variation *tenuiserratus.*—In 1879 I described as *Elonichthys tenuiserratus* an imperfect fish from the oil shales of West Calder, in Midlothian. The specimen is here represented on Pl. XI, fig. 4. The salient points here were the large proportional size of the scales, the extreme fineness of the serration of their posterior margins, and the great delicacy of their sculpture, which was nevertheless conformable to that in the *Robisoni* type. The facial bones were also closely striated.

Firmly convinced, as I was at the time, of the validity of " *tenuistriatus* " as a species, the increase of material afterwards convinced me that all the characters mentioned shade imperceptibly into those of other variations of *Elonichthys Robisoni*, and in 1890 I accordingly abandoned it as a " good " species. The specimen in question belonged to Mr. Thomas Stock, from whom the counterpart was acquired by the Edinburgh Museum.

E. Variation *Dunsii.*—The name *Elonichthys Dunsii* was also given by me in 1879 to a fish from the oil shales at Broxburn, West Lothian, in the museum of the New College, Edinburgh, and lent to me by the Rev. Professor Duns of that institution ; it is represented in Pl. XI, figs. 1—3. The fish itself (fig. 1) is somewhat deeply fusiform, with scales of moderate size and rather large median fins, while in general aspect it resembles the form which I had previously designated " *intermedius.*" The points which mainly induced me to consider it as a distinct species were the extremely delicate serration of the posterior margins of the scales (fig. 2), as in " *tenuiserratus*," and more especially the fine oblique denticulation of the posterior margins of the joints of the dorsal and anal fin-rays (fig. 3), which are otherwise much as in " *intermedius.*" Though this peculiar serration of these fin-rays is, so far as my experience goes, unique in the genus

Elonichthys, I own that I long ago ceased to consider it a character of sufficient importance to be diagnostic of a species, seeing that in other respects the specimen showing it is essentially inseparable from the series of forms which I have felt compelled to associate together under *Elonichthys Robisoni* of Hibbert. Accordingly in 1890 I also reduced *E. Dunsii* to the rank of a variety.

5. ELONICHTHYS SERRATUS, *Traquair*. Plate XII, figs. 5—8.

ELONICHTHYS SERRATUS, *Traquair*. Trans. Roy. Soc. Edinb., vol. xxx, 1881, p. 22, pl. i, figs. 5—8.
— — *A. S. Woodward*. Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 499.

Specific Characters.—Attaining a length of four inches and a half; shape elegantly fusiform and somewhat slender; scales proportionally small, those of the flank showing posteriorly five or six coarse oblique ridges terminating on similarly coarse oblique denticulations of the hinder margin, below which are a few finer ridges parallel with the convex lower margin of the scale; fins relatively small; principal rays of pectoral articulated up to their origins; rays of median fins slender, their joints much longer than broad, smooth or only with very scant striation.

Description.—The largest specimen I have seen is four and a half inches in length, but the general proportions are best seen in the one represented on Pl. XII, fig. 5, which measures only three and three quarters.

The cranial roof bones are somewhat coarsely tuberculated, the tubercles tending to become elongated and sometimes confluent; while as to the facial bones, so far as their outer surfaces can be seen their sculpture seems to consist of somewhat tortuous ridges. The scales are relatively small; those of the flank (fig. 6) are higher than broad, and have the upper margin concave, the lower convex in outline. Passing over the posterior two thirds of the exposed surface are five or six coarse oblique ridges, which end on the same number of prominent denticulations of the hinder margin, a small space below being occupied by several finer ridges parallel with the rounded lower margin. In some specimens a few delicate striations are also to be seen in front of and among the coarse ridges already described. Posteriorly (fig. 7), as the scales become smaller, the ridging and striation become less prominent, the ornament becoming reduced to a few longitudinal grooves and punctures, which finally disappear near the commencement of the caudal fin, the denticulations of the posterior margin becoming likewise fewer in number and ultimately lost, the scales on the tail pedicle and caudal body-prolongation being altogether smooth, with the exception of one or two punctures here and there. The variations in the general shape of the scales on different parts of the body are in accordance with what is found in other species of the genus.

The paired fins are not well seen in any specimen, but it is clear that the principal rays of the pectorals are articulated up to their origins; in the ventrals the joints are longer than broad, and distinctly striated longitudinally. The rays of the dorsal and anal fins are slender, distantly articulated, the joints being smooth (fig. 8), or only showing here and there a single longitudinal furrow. The caudal fin is small, deeply bifurcated; the rays of the lower lobe are smooth, with distant articulations, though in the upper lobe they become rather closer.

Observations.—This species is easily distinguished by its small delicate fins and small scales, with their coarsely denticulated hinder margins. The original specimens are in the collection of the Geological Survey of Scotland, while the one here figured belongs to a series in the Edinburgh Museum of Science and Art. It is also represented in the British Museum.

Geological Position and Locality.—All the specimens known are from the Lower Carboniferous rocks (Calciferous Sandstone Series) exposed in the banks of the river Esk, near Glencartholm, Dumfriesshire.

6. Elonichthys pulcherrimus, *Traquair*. Plate XII, figs. 1—4.

Elonichthys pulcherrimus, *Traquair*. Trans. Roy. Soc. Edinb., vol. xxx, 1881, p. 24, pl. i, figs. 9—12.
— — *A. S. Woodward*. Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 498.

Specific Characters.—Shape deeply fusiform; pectoral fins with their principal rays articulated up to their origins; median fins rather large, their rays being of medium coarseness and having their joints rather longer than broad, and distinctly striated; scales relatively small, highly ornate over the whole body, the ornament consisting of close delicate but sharply defined ridges which pass transversely on the upper and posterior part of the flank scales obliquely across the surface, and end in fine denticulations of the hinder margin, and on the posterior scales have a tendency to reticulation.

Description.—The deeply fusiform contour is well shown in the specimen figured on Pl. XII, fig. 1, which measures five and a half inches in length by one and three quarters in greatest depth just at the commencement of the dorsal fin. These proportions are not the result of distortion, as they are much the same in every specimen which has been found.

The bones of the cranial roof are in the type specimen shown to be covered with a small close tuberculation, while the facial bones exhibit a ridged ornamentation, the lower margin of the maxilla being, however, tuberculated. The teeth are, as is usual in this genus, conical, sharp, and incurved, and of different sizes, larger and smaller. The form of the opercular bones cannot be seen, but what is visible of the branchiostegal rays presents nothing specially noteworthy.

The paired fins are not shown in the specimen here figured. The base of the pectoral is seen in a fragmentary specimen in the collection of the Geological Survey of Scotland, from which it is clear that its principal rays were articulated up to their origins, and that their joints were shorter than they are broad. Another specimen in the Edinburgh Museum Collection shows the left ventral, but not well; from what is seen of it, it appears rather small, and with the joints of its rays rather short. The dorsal, however, is rather large (fig. 1), and is placed right on the middle of the back; in shape it is triangular-acuminate, with the anterior margin gently convex, the posterior excavated. Not less than thirty rays are contained in it; they are of medium coarseness, dichotomising towards their extremities, and having their joints longer than broad, and striated externally (fig. 4). The anal commences just opposite the termination of the base of the dorsal, the form of which it repeats; the caudal is powerful, deeply cleft, and inequilobate. The fin-fulcra, where visible, are minute.

The scales are rather small, and over the whole body highly ornate. Their exposed area is covered with closely placed, delicate, sharply defined ridges, which mostly proceed across the scale from before backwards, and end on fine denticulations of the hinder margin. On the flank scales (fig. 2), which are slightly higher than broad, the ridges of the upper and posterior part of the surface pass somewhat obliquely downwards and backwards, while those of the anterior and inferior part run parallel with the lower margin in a manner unconformable to the striæ above. As we pass backwards (fig. 3) all the striæ become nearly parallel with the upper and lower margins of the scale, and a marked tendency to reticulation is exhibited. The denticulations of the hind margin are observable as far back as the tail pedicle, when they disappear; but the ornament of the surface is continued on the narrow lozenge-shaped scales of the side of the caudal body-prolongation in the form of short grooves and punctures. The large median scales in front of the median fins are sculptured with ridges, furrows, and punctures, which mostly run in a concentric manner and parallel with their free edges; the V-scales on the top of the caudal body-prolongation are ornamented with furrows passing obliquely over their narrow exposed surfaces.

Observations.—This beautiful species, distinguished by its short, deep form and elaborate scale ornamentation, was originally described by me in 1877 from a single specimen in the collection of the Geological Survey of Scotland, in which, unfortunately, all the fins save the dorsal were wanting. These deficiencies being now supplied by other specimens subsequently obtained, I find that I was mistaken in attributing to *E. pulcherrimus* any special affinity to *E. Egertoni*, in which the principal rays of the pectoral fin, as also in *E. Aitkeni* and *E. pectinatus*, are unarticulated for about one third of their length. It is more allied to *E. Germari*, Giebel, and *E. caudalis*, Traq., from the Upper Carboniferous of Wettin and North Staffordshire respectively, but differs from both in having the posterior margin of the body-scales finely denticulated, as well as in other matters of detail.

Geological Position and Locality.—Only known from the Lower Carboniferous rocks of Glencartholm, Dumfriesshire. The type specimen is in the collection of the Geological Survey of Scotland; the one here figured is in the cabinet of the author.

7. Elonichthys Portlocki, *Egerton.* Plate XVIII, figs. 4—7.

Amblypterus Portlocki, *Egerton.* Quart. Journ. Geol. Soc., vol. vi, p. 2, 1850.
Elonichthys Portlockii, *Traquair.* Ibid., vol. xxxiii, p. 553, 1877.
— ? Portlocki, *A. S. Woodward.* Cat. Fossil Fishes Brit. Mus., pt. ii, 1891, p. 499.

Specific Characters.—Scales striated by tolerably fine oblique ridges; principal rays of pectoral fin articulated up to near their origins.

Description.—Unfortunately very little description can be given of this species, as I have only seen a few fragments belonging to the Egerton Collection in the British Museum. The best of these is represented in Pl. XVIII, fig. 4, and consists of little more than the ventral margin, including the pectoral fin in front and the anal behind; a portion of the shoulder-girdle is seen, but there is no head. A typical scale (figs. 6 and 7) is quadrate, and having the exposed area sculptured with tolerably fine closely set ridges, which pass diagonally across the surface from above downwards and backwards, and occasionally bifurcate or are intercalated. The pectoral fin is of moderate size, its principal rays being articulated nearly up to their origins; the anal is of the usual triangular acuminate form, the joints of its rays being longer than broad and finely longitudinally striated. No other fins are visible. Fig. 5 represents a portion of a badly preserved head referred to by Sir Philip Egerton in the paper quoted above. The jaws are here seen to be closely and delicately striated, the arrangement of the ridges being similar to that in allied species, *e.g. E. Robisoni.* Such of the teeth as are seen are conical and sharp, but none of any considerable size are exhibited.

Observations.—The articulation of the principal rays of the pectoral fin up to near their origin prevents this species from being mistaken for *E. Aitkeni*, and the ridges on the scales are also finer, and in all cases oblique in their direction. I own I do not quite understand Sir Philip Egerton's statement that the scales are "very thick," and that their ridges are "fewer in number and coarser than in any other *Amblypterus*," though of course *E. Aitkeni* was not known at the time he wrote.

Geological Position and Localities.—In the Lower Carboniferous rocks of Maghera and Moyheeland in the north of Ireland. The type specimens, including those here figured, are in the British Museum.

8. Elonichthys microlepidotus, *Traquair.* Plate XII, figs. 9, 10.

Elonichthys microlepidotus, *Traquair.* Geol. Mag. (3), vol. iii, 1886, p. 441.
— — *Ward.* Trans. N. Staffs Inst. Mining Engin., vol. x (1890), p. 174, pl. vi, fig. 1.
— — *A. S. Woodward.* Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 500.

Specific Characters.—Scales small, marked externally by only a few strong ridges passing horizontally, or with only a slight obliquity, across the surface; fins large.

Description.—I have only seen two specimens of this interesting form, both of which were collected by Mr. Ward, and are now in the British Museum.

The length of the more perfect of the two (Pl. XII, fig. 9) is $3\frac{3}{8}$ inches, but as it is broken off immediately behind the anal fin, we may justly estimate the original length of the fish about 5 inches. The external markings of the head bones are not well seen, except in the case of the lower jaw, which is ornamented by wavy longitudinal branching and anastomosing ridges. In this specimen the mouth is wide open, as is also the gill-cleft, owing to the drawing forward of the suspensorium; the opercular bones are rather narrow, and beneath them and the mandible about ten of the branchiostegal rays may be observed. As to the scales (fig. 10), I know no species of this genus in which they are so small in proportion to the size of the fish. Their markings consist only of a few strong ridges passing across the scale from front to back, either horizontally or with a slight obliquity, and in some cases branching or uniting with each other. I see no evidence of any denticulation of the hinder margins of the scales.

Only the base of the pectoral fin is seen, its rays being rather slender, and I think in the front part of the fin articulated up to their origins. The other fins are large, and have the form and relative position characteristic of this genus. The rays are very numerous, fine, and closely set; their joints longer than they are broad, and their surfaces show traces of fine longitudinal striation.

Observation.—The relative smallness of the scales, and their peculiar simple, bold ornament, distinguish this species from any other with which I am acquainted.

Geological Position and Locality.—Knowles Ironstone Shale, Longton, Staffordshire. The only two specimens as yet known are in the Ward Collection in the British Museum.

9. Elonichthys Binneyi, *Traquair.* Plate XVII, figs. 8—10.

Elonichthys Binneyi, *Traquair.* Geol. Mag. (3), vol. v, 1888, p. 251.
— — *A. S. Woodward.* Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 499.
— — *Wellburn.* Proc. Yorks. Geol. and Polyt. Soc., vol. xiii, p. 427, pl. lxii, figs. 1, 2.

Specific Characters.—Attaining a length of probably five inches. Scales proportionally large, those of the flank conspicuously higher than broad; ornament consisting of striæ, some of which form a band close to and parallel with the anterior margin, behind which they run in an antero-posterior direction, not parallel with each other, but tending to converge into groups, and ending on denticulations of the hinder margin. Fins comparatively large.

Description.—No really complete specimens of this very pretty species have as yet been found, and consequently our knowledge of it, as in the case of *E. microlepidotus*, is still imperfect. The following description is founded on two specimens which belonged to the late Mr. Edward Binney, of Manchester, and are now in the Woodwardian Museum, Cambridge. One of these is represented in Pl. XVII, fig. 8, and measures $3\frac{3}{8}$ inches in length by $\frac{3}{4}$ inch in depth at the origin of the dorsal fin; the other is slightly larger, its length being $3\frac{3}{4}$ inches and its greatest depth $\frac{11}{12}$ inch. In both the fish is cut off at the commencement of the tail pedicle, as is also the case in a specimen figured by Mr. Wellburn, in which, however, the body seems of somewhat deeper proportions. The scales are over most of the body higher than broad, but behind the dorsal fin they become more equilateral and obliquely rhomboidal. The anterior covered area is rather narrow; the sculpture of the exposed part is peculiar, and different from that in any other Carboniferous fish with which I am acquainted. Taking one of the flank scales (fig. 9), its external glittering surface is ornamented first by a narrow band of striæ running parallel with the anterior margin, while behind these and over the greater part of the surface the sculpture consists of delicate wavy, branching ridges, passing in an antero-posterior direction, and ending on denticulations of the hinder margin; on the anterior scales it must also be noticed that these ridges and furrows do not run parallel with each other, but, as is well shown in fig. 9, tend to converge in two or three groups. This ornament becomes less marked in the scales behind the dorsal fin, the vertical striæ disappearing, and only a few punctures and irregular horizontal furrows remaining, as seen in fig. 10; the denticulation of the posterior margin is, however, preserved as far as the tail pedicle.

Neither of the two original specimens shows the pectoral fin; it is partly exhibited in the example figured by Mr. Wellburn, who states, however, that the character of the rays is "too imperfect for description." The ventral is well preserved in the specimen represented in Pl. XVII, fig. 8; it is pretty large, and acuminate in shape. The dorsal fin is opposite the interval between the ventral and anal; both dorsal and anal are triangular-acuminate in form, with delicate rays, which at first are somewhat distantly articulated, the joints being ornamented by one or two longitudinal sulci. The caudal is wanting in all the specimens known.

Observations.—The form of the scales and the shape and position of the ventral, dorsal, and anal fins induced me to class this little fish as an *Elonichthys*, though unfortunately the character of the dentition is unknown, the condition of the rays of the pectoral fin uncertain, and the bones of the head are as yet undescribed. As a member of the genus it is especially distinguished by its peculiar scale-ornament.

Geological Position and Localities.—The original specimens, now in the Woodwardian Museum, Cambridge, are from the Dalemoor Rake Ironstone, Stanton, Derbyshire; the one referred to above as having been described and figured by Mr. E. D. Wellburn, of Sowerby Bridge, was obtained by him from the "Forty Yards Mine" at Littleborough, Yorkshire. In both cases the horizon is that of the Lower Coal-measures.

10. Elonichthys multistriatus, *Traquair*. Plate XVIII, figs. 8—11.

Elonichthys multistriatus, *Traquair*. Proc. Roy. Soc. Edinb., 1890, p. 396.
— — *A. S. Woodward*. Cat. Foss. Fishes Brit. Mus., 1891, p. 500.

Specific Characters.—Scales not serrated posteriorly; exposed area covered with fine, very oblique branching and intercalating ridges; flank scales considerably higher than broad, nearly rectangular in shape; articular spine and socket well developed; keel on under surface feeble or obsolete; fin-rays striated.

Description.—Only fragmentary remains of this interesting species have as yet been found, the nearest approach to a complete fish being the specimen represented on Pl. XVIII, fig. 8, reduced to five sevenths of the natural size, as the original measures nine inches in length. It is, however, perfectly clear from the want of the greater part of the head, the disproportionate size of the caudal extremity, the irregularity of the ventral margin, and the state of complete jumbling up of the scales, that we have here to do with a considerable amount of distortion, and that the fish must have been larger when in life. Two other fragments, both distorted by shortening up, are in my collection, one showing the anterior, the other the posterior part of the body, and both seem to have belonged to larger individuals than the one figured. There are also three pieces of ironstone showing disjointed scales.

Nothing whatever can be made out regarding the osteology of the head in any of the specimens with scales or fins *in situ*, but associated with disjointed scales which are identifiable as belonging to the same species is a maxilla, and the impression of the inner surface of the dentary bone of a mandible, both of which are typically palæoniscoid in form. The former is represented in Pl. XVIII, fig. 9, natural size, and shows traces of striations running parallel with the upper and posterior borders, as is frequent in the genus *Elonichthys*, the sculpture being better preserved along the anterior part of the dentary margin, where the striæ tend to become contorted and irregular. This margin of the maxilla is set with conical incurved teeth, the points of which are covered up in the excessively hard ironstone matrix.

Returning now to fig. 8, the pectoral fin seems here to be relatively of enormous size,—passing, indeed, beyond the origin of the ventral, although it is clear that the anterior part of the fin is not preserved. Distortion is probably the cause of the approximation of these two fins. The pectoral rays here seen are slender, and dichotomise to an extreme degree of fineness; but in one of the other fragments in which the anterior rays are exhibited, these are stout and obliquely striated, but it is not clear how far they are articulated. Only a portion of the ventral is shown in fig. 8, but what we see of it leads us to believe that it was long-based and many-rayed,—such of the rays as are seen being proportionally fine, tolerably closely jointed, and longitudinally striated, though in the other fragment above referred to, and in which a portion of this fin is also seen, the striæ on its rays are oblique. The dorsal, as shown in our figure, has the usual triangular-acuminate shape, but its rays are too badly preserved for special description. Traces of the origin of the anal are seen between the ventral and the caudal; the upper lobe of the latter is preserved nearly to its termination, but the lower is cut off at the place of bifurcation. All the rays seen are moderately closely jointed, longitudinally striated externally, and minutely dichotomised.

The form of the scales is somewhat peculiar. On the flank (figs. 10, 11) they are almost rectangular, and considerably higher than broad; the covered area is narrow, while the exposed part is covered with fine, somewhat wavy ridges, occasionally bifurcating and intercalated, and having a very oblique downward and backward direction; in some of the more anterior scales this obliquity is very strongly marked. There are no denticulations on the hinder margin. The articular spine is well developed, as is also the socket on the under surface of the scale, but the keel is feeble or obsolete. The scales towards the tail and the dorsal and ventral margins appear, as usual, lower in contour.

Observations.—When I saw the first found specimen of this fish the form and manner of ornament of the scales strongly suggested Platysomid affinities; but the subsequent discovery of the maxilla and impression of the mandible associated with these scales on the same slab clearly showed that we had to deal with a member of the Palæoniscidæ. Then came the specimen here figured, in which the arrangement of the fins is shown, and whose general resemblance to *Elonichthys* is so great that I prefer to include it in the genus, unless a new one is to be instituted for its reception.

Geological Position and Localities.—From the Gilmerton Ironstone at Venturefair Pit, Gilmerton, and from the Borough Lee Ironstone, Loanhead, near Edinburgh,—both seams being in the Carboniferous Limestone Series of Midlothian. Also from Broadstone, Beith, in the Carboniferous Limestone Series of Ayrshire, collected by the late Mr. Robert Craig.

11. Elonichthys Aitkeni, *Traquair*. Plates XVI, XVII, figs. 1—7.

Elonichthys Aitkeni, *Traquair*. Geol. Mag. (3), vol. iii, 1886, p. 440.

Elonichthys Aitkeni, *Ward.* Trans. N. Staffs Inst. Mining Engin., 1890, p. 174, pl. vi, figs. 9—12.
— — *A. S. Woodward.* Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 490.
— — *Wellburn.* Proc. Yorks. Geol. and Polyt. Soc., vol. xiii, 1898, p. 398; ibid., p. 426, pl. lxii, fig. 5.

Specific Characters.—Length 6 to 7 inches. Scales of moderate size, ornamented by strongly marked ridges, which on the anterior flank scales run diagonally over the surface from above downwards and backwards, but over the greater part of the body are parallel or nearly so with the upper and lower margins of the scale; posterior border denticulated. Principal rays of pectoral fin unarticulated for about one third of their length; rays of median fins delicate, distantly articulated, smooth, or it may be with only one feebly marked longitudinal furrow.

Description.—The shape is fusiform and moderately deep. The cranial roof bones are sculptured with undulating ridges, passing at times into elongated tubercles. The mandible (Pl. XVII, fig. 5) is sculptured externally with slightly wavy longitudinal ridges, which run tolerably parallel with the upper and lower margins of the jaw, but the dentary margin is finely tuberculated. The maxilla (fig. 4) is of the usual form; its dentary margin is also tuberculated, while the rest of the surface is covered by undulating ridges disposed in a manner more or less parallel with the upper and posterior margins of the broad portion forming the mass of the bone, but passing longitudinally along the narrow portion in front. In both jaws the teeth are conical, strong and sharp, and of two sizes, larger and smaller. The operculum is ornamented with ridges which pass obliquely over the surface from above downwards and backwards, while those on the suboperculum are more transverse in their direction.

The scales are of moderate size. Those of the flank are higher than broad, but conforming to the general rule they become more oblique and equilateral posteriorly, and towards the dorsal and ventral margins they become rather lower than they are broad. Their ornament consists of sharp, strongly marked ridges, occasionally bifurcating or intercalated, which in the case of the flank scales (fig. 2) run rather diagonally over the surface from above downwards and backwards, but over the greater part of the body are parallel with the upper and lower margins (fig. 3); and seldom does any greater obliquity of the ridges on the anterior and lower part of the scale give any indication of the diagonal division of the pattern which is so common in striated scales of the family Palæoniscidæ. Posteriorly a peculiar and highly ornamental character is given to the squamation by the fact that the lowermost ridge (see fig. 3), uniting or not with the one next above it, is of unusual breadth, and stands prominently out. On the **V**-shaped ridge-scales of the caudal body-prolongation the ornament becomes speedily obsolete, and the small lozenge-shaped lateral scales are at most marked by one or two slight longitudinal furrows.

The length of the pectoral fin (Pl. XVI, fig. 2) is about two thirds that of the head; its principal rays are unarticulated for about one third of their length. The ventrals are badly preserved in the specimens which I have seen, but their position seems to have been halfway between the pectorals and the anal. The dorsal, well shown in the same figure, is situated opposite the interval between the ventrals and the anal; both dorsal and anal fins are pretty large, and of the usual triangular-acuminate shape; their rays are delicate and slender, distantly articulated and smooth, save that now and then a single longitudinal furrow is seen, especially just before bifurcation sets in. The caudal is completely preserved in the specimen depicted in Pl. XVI, fig. 1; it is large and deeply cleft; the articulations of the rays of the lower lobe are a little closer than those of the dorsal; in the upper lobe the joints become so short as to look nearly square-shaped.

Observations.—This exceedingly fine species was described by myself in 1886, and named after the late Mr. John Aitken, of Bacup, Lancashire, to whose collection the beautiful specimen represented in Pl. XVI, fig. 1, belonged. I had, however, previously recognised the fish as new from specimens from Burnley belonging to Mr. George Wild, of Ashton-under-Lyne, and with which I also identified specimens from Stanton in Derbyshire in the British Museum, in the Museum of Practical Geology, and in the collection of the late Mr. E. W. Binney. On these specimens, all from the Lower Coal Measures of Lancashire and Derbyshire, the above description has been founded, but there is one in the British Museum collection from the "Culm" of Instow, Devonshire, referred by Dr. Smith Woodward in his "Catalogue" to the same species, and which deserves a few special remarks. This specimen is represented in Pl. XVII, fig. 7, and is an extremely sharp impression of the head and anterior part of the body, showing with the greatest distinctness the opercular bones, the orbit and suborbitals, the maxilla and mandible, the branchiostegal rays, the infra-clavicular plates, and portions of both pectoral fins, as well as the anterior scales of the flank and belly. The ornament of the scales resembles closely that of the typical *E. Aitkeni*, but it is to be noted that the striæ on the mandible, instead of proceeding more or less horizontally as in fig. 5, pass obliquely from below upwards and forwards towards the dentary margin; further, that the maxilla is differently shaped from that represented in fig. 4, being lower and narrower, and having the posterior margin more oblique and not angulated in the middle. There is therefore some presumption that we have here to deal with a different species, but after my experience as regards the variability of *E. Robisoni*, I think it safer to defer for the present any decision on this question.

In the Edinburgh Museum there are two specimens from the roof-shale of the "Four Foot" coal (Upper Carboniferous) at Niddrie, near Edinburgh, which I refer to this species. One consists only of a few dislocated bones and scales; the other is a pretty entire fish, five inches in length, but having the scales much broken and jumbled up, so that their markings are not very well seen. So far, however, as their sculpture is visible, the posterior scales seem to differ slightly from those of the typical English specimens, in the ridges having a somewhat greater tendency to bifurcation and intercalation. Detached maxillæ occurring in the same bed agree in form and sculpture with that represented in Pl. XVII, fig. 4.

Geological Position and Localities.—A fish of the lower part of the Upper Carboniferous formation, unless the "Culm" at Instow, Devonshire, from which the doubtful specimen referred to above was derived, belongs to a still lower horizon. Millstone Grit Shales, Danebridge (Mr. J. Ward). Lower Coal Measures, Cliviger and Burnley, Lancashire; Halifax and Littleborough, Yorkshire (Wellburn); Cheadle Coal-field, Staffordshire; Dalemoor Rake Ironstone, Stanton, Derbyshire; "Four Foot" Coal, Niddrie, near Edinburgh. Also in the Coal Measures at Crosshouse, Kilmarnock (collection of Mr. Robert Dunlop).

12. Elonichthys Egertoni, *Egerton*, sp. Plate XVIII, figs. 1—3.

Palæoniscus Egertoni, *Agassiz.* Poiss. Foss., vol. ii, pt. 1, 1844, p. 302 (name only).
— — *Egerton.* Quart. Journ. Geol. Soc., vol. vi, 1850, p. 5, pl. i, fig. 2, and Dec. Geol. Surv., vi, 2, 1852, pl. ii.
— — *Hancock and Atthey.* Ann. and Mag. Nat. Hist. (4), vol. i, 1868, p. 358, pl. xv, figs. 3—5; pl. xvi, figs. 1, 2.
Elonichthys Egertoni, *Traquair.* Quart. Journ. Geol. Soc., vol. xxiii, 1877, p. 553, and present work, p. 22, pl. ii, fig. 8, 1877.
— — *Ward.* Trans. N. Staff. Inst. Mining Engin., vol. x, 1890, p. 171, pl. iv, figs. 1, 2.
— — *A. S. Woodward.* Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, pp. 494, 495.

Specific Characters.—Attaining a length of four inches; scales of moderate size, nearly equilateral on the flank, highly ornate all over the fish, the ornament consisting of very fine, yet sharp, closely set ridges, which frequently bifurcate, or are intercalated, and are only slightly oblique on the anterior scales, though more so on those behind. Paired fins rather small; dorsal and anal moderate; caudal large; anterior rays of pectoral fins articulated for about a third of their length; joints of median fins longer than they are broad, relatively coarse, and striated. Laniary teeth stout in proportion to the small size of the fish.

Description.—The shape of this very pretty little fish is elegantly fusiform, the length of the head, which is equal to the greatest depth of the body, being contained rather more than four times in the total. The cranial roof bones are minutely tuberculated, but I have not succeeded in obtaining a good view of the sculpture of those of the face, though the mandible is certainly longitudinally striated; a ridged ornament characterises also the maxilla, as figured by Messrs. Hancock and Atthey (*op. cit.*, pl. xv, fig. 4), but the dental margin is tuberculated. More than a dozen laniary teeth can usually be counted, the largest attaining a length of $\frac{1}{20}$ inch, while, more externally placed, are numerous teeth of a smaller size, all having the same conical sharp and somewhat incurved form, with enamel cap on the tip. Similar teeth are found on the dentary element of the mandible. Many specimens show that the branchial arches were very well ossified; one of them, now in the British Museum (Ward Coll.), is figured on Pl. II, fig. 8, of the present work.

The scales are relatively of moderate size, nearly equilateral on the flank, and showing the usual variations of size and shape on different parts of the body. The exposed area is sculptured with very fine sharp, closely set ridges, which pass across the surface from before backwards, ending on delicate denticulations of the hinder border; their direction is only very slightly oblique on the flank scales, though more so on those further back, and they also frequently bifurcate or are intercalated. This highly ornate sculpture persists all over the body, and it is likewise to be noted that the large pre-anal scale is not concentrically striated, its ridges being more or less parallel with the median keel-like elevation.

The paired fins appear rather small; the five or six anterior rays of the pectoral are unarticulated for about a third of their length. The dorsal fin commences opposite the middle of the interval between the ventrals and the anal; both of these fins are rather moderate in size, triangular-acuminate in form, and with the posterior border concavely excavated. Their rays are proportionally rather coarse, their joints considerably longer than broad in the front of the fin, but not so much so behind; their surfaces are striated with fine ridges, which are sometimes longitudinal, sometimes oblique. The caudal is large, deeply cleft and inequilobate. As is commonly the case in this genus, the rays of the lower lobe have their articulations more distinct, and their surfaces more smooth than those of the upper, in which the joints are shorter, and are striated just as in the case of the dorsal and anal fins.

Observations.—"*Palæoniscus*" *Egertoni* was originally named, but not described, by Agassiz from isolated scales discovered in the coal shale at Silverdale, Staffordshire, by Sir Philip Grey-Egerton, by whom a small specimen from the same locality was subsequently described and figured in the Sixth Decade of the Geological Survey. The mandible, maxilla, and teeth were in 1868 figured by Hancock and Atthey, from specimens occurring in the Newcastle coal-field, and those two authors also pointed out the correspondence between the microscopic structure of the teeth and those from the same coal-field named *Ganacrodus hastula* by Sir Richard Owen,[1] the same type of structure having been long previously figured by Agassiz in the Permian genus

[1] "On the Dental Characters of Genera and Species, chiefly of Fishes from the Low Main Seam and Shales of Coal, Northumberland," 'Trans. Odont. Soc. Great Britain,' vol. v, 1867, p. 349, pl. vi.

Pygopterus. There can be no doubt that "*Ganacrodus*" was founded upon the detached teeth of some palæoniscid fish, but the size given by Owen indicates a larger species than *Elonichthys Egertoni.* A mandible and maxilla evidently belonging to *E. Egertoni* were figured in 1874 under the designation "*Palæoniscus*" by Mr. W. J. Barkas,[1] who also gave a description, with drawings of the microscopic structure of the teeth.

In 1877 I transferred the species to Giebel's genus *Elonichthys,* and in 1890 an exceedingly perfect specimen from the North Staffordshire coal-field, now in the British Museum, was figured by Mr. Ward from a drawing by myself and my wife, here reproduced.

Geological Position and Localities.—An Upper Carboniferous fish, being unknown below the Millstone Grit. The original specimens, as mentioned above, are from Silverdale in Staffordshire, but it is especially abundant in the shale overlying the "Deep Mine" ironstone at Longton and Fenton in the same county, from which bed many beautiful entire specimens collected by Mr. Ward are in the British Museum, London, and in the Museum of Science and Art, Edinburgh. Mr. Ward also mentions its occurrence in the shale above the Woodhead coal, Cheadle coal-field. Detached scales from the Lower Coal Measures of Halifax and Littleborough in Yorkshire are referred, with a query, to this species by Mr. E. D. Wellburn. Going further north, it is found in the richly fish-bearing roof-shale of the "low main" coal seam at Newsham, near Newcastle-on-Tyne, its occurrence there having been first noted by Messrs. Hancock and Atthey. It has also been obtained in the Coal Measures at Carluke, Lanarkshire (Rankine Collection, Hunterian Museum, Glasgow).

13. Elonichthys pectinatus, *Traquair.* Plates XIII, XIV, figs. 1—3.

Elonichthys (?) pectinatus, *Traquair.* Proc. Roy. Soc. Edinb., vol. ix, 1877, p. 430.

Elonichthys pectinatus, *Traquair.* Proc. Roy. Phys. Soc. Edinb., vol. v, 1880, p. 121. Geol. Mag. (2), vol. ix, 1882, p. 545. Trans. Edinb. Geol. Soc., vol. v, 1887, p. 315. Proc. Geologists' Assoc., vol. xv, 1897, p. 144.

— — *A. S. Woodward.* Cat. Foss. Fishes Brit. Mus., pt. ii, p. 144.

Specific Characters.—A large species, which probably attained a length of nearly three feet. Exposed surface of body-scales sculptured with oblique, subparallel, prominent ridges occasionally branching and intercalated, and terminating behind in denticulations of the posterior margin; under surface showing a narrow area along the

[1] 'Monthly Rev. Dent. Surgery,' vol. iii, No. 6, 1874, figs. lix—lxiv.

posterior edge, which is crossed by short oblique grooves, which terminate between the marginal denticulations. Head bones sculptured externally, both with granular tubercles and contorted ridges, which frequently have their sides again delicately striated; opercular plate long, narrow, and rather pointed below; laniary teeth strong and conical. Principal rays of the pectoral fin unarticulated for about a third of their length; anal fin with a rather elongated base, and becoming fringe-like posteriorly; fin-rays striated.

Description.—Although no perfect specimen of this large fish has as yet been found, its general proportions are pretty well shown in the specimen represented in Pl. XIII, fig. 1, reduced one seventh, in which unfortunately the greater part of the head and the whole of the caudal fin are wanting.

The inner surface of the cranial roof-bones is seen in Pl. XIV, fig. 1, though in many places the bone has splintered off, showing the imprint of the external sculpture. Noteworthy are here the longitudinal right and left elevated lines which indicate the course of the main sensory or "slime" canals of the top of the head as they traverse the parietal bones (*p.*) and the frontals (*f.*). Then between the posterior margin of the cranial shield and the post-temporal element of the shoulder-girdle (*p.t.*) we obtain a good view of the supra-temporal chain of ossicles (*s.t.*) so seldom seen in a palæoniscid head. Of these three are shown, namely, two belonging to the left, and one, the upper in the figure, belonging to the right side of the head; while traversing all these three we observe an elevated line showing the course of the supra-temporal slime canal, which here, as in the salmon and many other fishes, forms a transverse commissure between the right and left main canals.

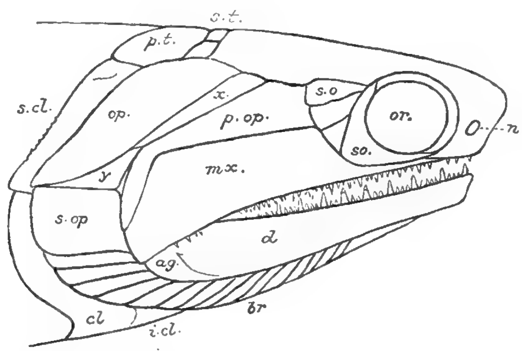


FIG. 1.—*Elonichthys pectinatus,* Traquair; head and shoulder-girdle, restored. *ag.* angular; *br.* branchiostegal rays; *cl.* clavicle; *d.* dentary; *i.cl.* infraclavicle; *mx.* maxilla; *n.* narial opening; *op.* operculum; *or.* orbit; *p.op.* preoperculum; *p.t.* post-temporal; *s.cl.* supraclavicle; *s.o.* suborbitals; *s.op.* suboperculum; *s.t.* supratemporals; *x.y.* supplementary plates.

The suspensorium is very oblique, and in consequence the operculum (*op.*) assumes a more than usually slanting position on the side of the head; it is long, narrow, and assumes a somewhat pointed contour at its lower extremity. Between its anterior margin and the posterior-superior margin of the preoperculum are two accessory pieces, of which the upper (*x*, Text fig. 1) is very narrow, and lies over the upper part of the hyomandibular; while the lower (*y*) is of a triangular shape, and fills up the gap between the operculum, preoperculum, and suboperculum.[1] The suboperculum (*s.op.*) is of the usual quadrate form, and the preoperculum has likewise the typical palæoniscid configuration, except that in accordance with the great length of the maxilla its upper part is also rather longer than usual. The orbit is situated much in front, but none of the specimens that I have seen give a clear view of the number and arrangement of the circumorbital bones.

The maxilla (*mx.*) is a conspicuous bone of the shape characteristic of the genus, but its posterior broad part is rather longer than usual owing to the great extension backwards of the gape. This part of the bone is shown in Pl. XIII, fig. 3, the narrow suborbital extension being here broken off; most of the bone has flaked away, leaving behind merely an impression of the inner surface, but what remains shows the characteristic tubercular ornament to be presently alluded to. Along the inferior margin are seen numerous small sharp conical teeth, and also the proximal parts of some larger ones, whose points are buried in the hard ironstone matrix.

Covered by the maxilla externally is the palatoquadrate apparatus, the aboral surface of which forms a longitudinal groove curving downwards at its posterior extremity, and which must have been occupied by the levator muscle of the lower jaw. It is in this species of an unusually long and narrow form, and seems principally composed of one large elongated palatopterygoid bone; but though other elements are also clearly present they cannot be defined. One remarkable thing is that between this bone and the anterior part of the maxilla there seems to have existed a narrow chain of ossicles, four of which (*x.*) are seen in impression in the fragment represented in Pl. XIV, fig. 2, where *pt.* is the anterior part of the palatopterygoid bone (also seen in impression), and *d.* the dentary of the mandible. I can, however, see no distinct evidence of sutures marking off these ossicles in other specimens of the bony palate, in which the pieces in question are probably already fused by anchylosis with each other and with the adjoining palatopterygoid bone. These ossicles probably supported laniary teeth like those similarly placed on ossicles along the outer edge of the palate in the Rhizodont genus *Eusthenopteron*.[2]

Pl. XIII, fig. 6, represents, natural size, a large mandible which measures four and three quarter inches in length, and one inch in depth just behind the middle. Most of the external bone has adhered to the counterpart, leaving an impression behind, but some of the outer surface of the dentary element remains, showing the ornament of contorted ridges already referred to. The bone of the angular element is gone, but the articular is very distinctly seen, as is likewise the notch (*ar.*) for the articulation with the

[1] These two small plates, which are of common occurrence in the heads of Palæoniscidæ, are represented in the figure of the facial bones of *Elonichthys* (*Cosmoptychius*) *striatus* (Pl. III, fig. 3), the upper narrow one being left without name, while the lower one is designated "*suboperculum.*"

[2] R. H. Traquair, 'Geol. Mag.' (3), vol. x, 1893, p. 266.

quadrate. This specimen shows some of the outer row of teeth, minute in size compared with the large laniaries, which occupy a more internal position on the edge of the dentary bone. One of these is seen in this figure, which, were it perfect, would measure half an inch in length, while some of those of the outer row attain no greater length than one sixteenth. The laniaries are, however, better shown in fig. 7, which represents an entire dentary bone seen from the internal aspect, with six of the inner series of large teeth in a continuous row along its upper margin, the largest of these being one quarter of an inch in length. Again, in fig. 8 we have a portion of a dentary bone showing both large and small teeth, the former, however, not attaining the great proportional size of those in the two previous examples. These teeth are stout, conical, enamel-capped, and incurved.

The external bones and plates of the head are sculptured with a close tuberculation, the tubercles passing at places into contorted ridges (Pl. XIII, figs. 3, 4), and it is to be noted that the latter form of ornament is prevalent on the dentary of the lower jaw (fig. 6). These tubercles and ridges are frequently marked again on their side by delicate striæ, which converge towards their summits as seen in fig. 5.

There is nothing special to note regarding the bones of the shoulder girdle. The left supra-clavicular (*s. cl.*) and both right and left post-temporals (*p.t.*) are seen from the inner surface in Pl. XIV, fig. 1, and the clavicle and infra-clavicle, as seen in other specimens, are of the shape common to the genus, and are ornamented by coarse contorted ridges.

The pectoral fin is of the usual acuminate form ; unfortunately in the specimen represented in Pl. XIV, fig. 3, the anterior rays are truncated by the edge of the stone. This specimen was, however, chosen for figuring, as it shows very clearly the want of transverse articulations in the anterior rays for about a third of their length—a fact corroborated by all other specimens in which this fin is preserved.

In the specimen represented on Pl. XIII, fig. 1, a good part of the left ventral is seen ; apparently it was long-based, like that of *E. striatus,* and the same specimen shows the form of the dorsal and anal exceedingly well. The former commences opposite the middle of the interval between the ventrals and the anal, and is of large size, triangular, high and sharply acuminated in front, and is composed of very numerous rays. The anal is conformed anteriorly like the dorsal, though smaller; its posterior part is, however, prolonged backwards for some distance in a fringe-like manner, so that its base is about twice as long as its longest anterior rays. In this manner the anal fin of *E. pectinatus* differs from that of any other species referable to this genus, and comes to resemble that of *Pygopterus.*

Fig. 2 on the same plate represents a detached caudal fin, diminished by one fourth, the extremities of both lobes being unfortunately broken off. It is strongly heterocercal, deeply cleft, and inequilobate.

All the fin-rays, with the exception of the proximal thirds of those of the anterior part of the pectoral, are transversely articulated, the joints being usually longer than they are broad, though in some cases they are shorter. Their exposed ganoid surfaces are beautifully ornamented with ridges and furrows, which in some cases are parallel with their margins, in others slightly oblique; while, as usual, small, closely-set fulcra are visible along the anterior margins of the fins.

As seen in Pl. XIII, fig. 1, the *scales* are moderate in size compared with the bulk of the fish. A flank scale from another specimen (the original type) is shown in fig. 9, magnified three diameters, and displays a rhombic form, slightly higher than broad, the anterior superior angle passing up in a sharp point, the articular peg being very prominent, and the anterior covered area very narrow. The exposed area, therefore, occupies nearly the entire outer surface, and is brilliantly ganoid and sculptured all over by prominent, clearly cut, slightly wavy, subparallel ridges, which occasionally bifurcate or are intercalated, and whose direction is obliquely downwards and backwards, ending on distinct denticulations of the hinder margin. Fig. 10 shows the under surface of a similar scale magnified to the same extent, and upon it there will be observed at the lower margin a well-marked socket for the articular peg of the scale below, the vertical keel being, however, rather feeble; then along the posterior margin is seen a narrow area crossed by short oblique grooves, which end between the denticulations of the posterior margin and produce the pectinated appearance which gave occasion for the specific name of the fish. In fig. 11 we have a scale from a position further back and similarly magnified, and it will be seen that it follows the general rule in this family in being more equilateral and more oblique; while fig. 12 shows the under surfaces of two such scales, one of which is considerably lower than it is broad, wants the articular peg, and probably came from near the ventral margin, its apposition with the other being only accidental. In fact, the scales of *E. pectinatus* seem to conform to the general rule in this family as to difference of form on different parts of the body.

Observations.—The first specimen of this species which came under my observation consisted of a slab with dislocated scales, which, on account of their configuration, I referred to *Elonichthys*, though at first with a query; the subsequent discovery of the general form of the fish along with other details of its structure led me then to withdraw the query, and to consider that the most appropriate place for it was indeed in this genus. As to its specific characters it cannot possibly be confounded with any other known form, but against the generic position to which I have assigned it might be adduced the extended base of the anal fin, which is not found in any other species of *Elonichthys*. In this character it resembles the Triassic *Gyrolepis*, and to some extent the Permian *Pygopterus*. In *Gyrolepis*, however, the pectoral fins have most of their rays unarticulated till towards their terminations, the operculum, though long, is differently shaped, the overlapped area of the scales is broader, and according to Dames the two infra-clavicular plates are fused in the middle line.[1] In *Pygopterus* the pectoral

[1] Dames, "Die Ganoiden des deutschen Muschelkalks," in Dames' and Kayser's 'Palæonto-

fin has its rays conformed in a manner similar to those in *Gyrolepis*, and the origin of the dorsal fin is nearly opposite the commencement of the anal.

The scales of *E. pectinatus* bear some resemblance in their external sculpture to those of *Acrolepis Hopkinsi*, M'Coy (*Gyrolepis Rankinei*, Agassiz), but are at once distinguishable by their comparative thinness, the narrowness of their covered area, their posterior serrations, and the pectinated appearance of the posterior margin when seen from the internal aspect.

Judging from its size, its wide gape, and its formidable teeth, this magnificent palæoniscid must have been a veritable tyrant among its smaller contemporaries, and had it been known to Agassiz or Egerton it would certainly have been classed as a "Sauroid."

Geological Position and Localities.—Only from the Lower Carboniferous rocks of Scotland, and as yet principally obtained from those of the Forth Basin. The original specimen was obtained from the Gilmerton Ironstone, near the base of the Carboniferous Limestone Series of Midlothian, but subsequent collecting has extended our knowledge of its geological range both downwards into the Oil Shale series and upwards into the Upper Limestone Group. The horizons and localities in which it has occurred in the east of Scotland are in ascending order as follows:

Oil Shale Group:—In Ironstone nodules in the roof of the Dunnet Shale at Straiton, near Edinburgh; also at West Calder, and Oakbank, near Midcalder; Ardross, Fifeshire.

Lower Limestone Group:—Gilmerton Ironstone, Gilmerton, near Edinburgh.

Edge Coal Group:—Borough Lee Ironstone, Loanhead, near Edinburgh; Denhead Ironstone, Denhead, Fifeshire.

Upper Limestone Group:—Levenseat Limestone shale, Levenseat, Midlothian; South Parrot Coal Shale, Niddrie, near Edinburgh.

In the west of Scotland I only know of its occurrence in the Crossbasket Ironstone, East Kilbride, a specimen showing disjointed bones and scales of this species being in the Coutts Collection in the Edinburgh Museum, and labelled as from this locality.

logische Abhandlungen,' vol. ii, pt. 2, Berlin, 1888. It is true that in 1877 (see p. 12 of the present work, and 'Quart. Journ. Geol. Soc.,' vol. xxxiii, pp. 567—571) I proposed to cancel Agassiz's genus *Gyrolepis* on account of the difficulty of defining a genus in the fragmentary Triassic remains ordinarily referred to it, and which had been the subject of much difference of opinion among Continental palæontologists. Since that time, however, the late Prof. Dames, in the above-quoted memoir, has shown that the genus is perfectly tenable, at least, for certain Triassic forms, including the typical *G. Alberti*, Ag. See also Dr. Smith Woodward's 'Catalogue,' pt. ii, p. 510.

PLATE VIII.

FIG.

1. *Elonichthys Robisoni,* Hibbert, sp.; a shortened-up specimen of the variation *intermedius,* once described by the author as *E. ovatus;* natural size. From Burdiehouse; in the Museum of Science and Art, Edinburgh.

2. *Elonichthys Robisoni,* Hibbert, sp.; natural size. From Burdiehouse, in the Hugh Miller Collection, Museum of Science and Art, Edinburgh. This is one of the young forms to which the specific name was originally applied and limited by Hibbert and Agassiz.

3. *Elonichthys Robisoni,* Hibbert, sp.; flank scale, magnified eight diameters.

4. *Elonichthys Robisoni,* Hibbert, sp.; scale from a more posterior position, also magnified eight diameters.

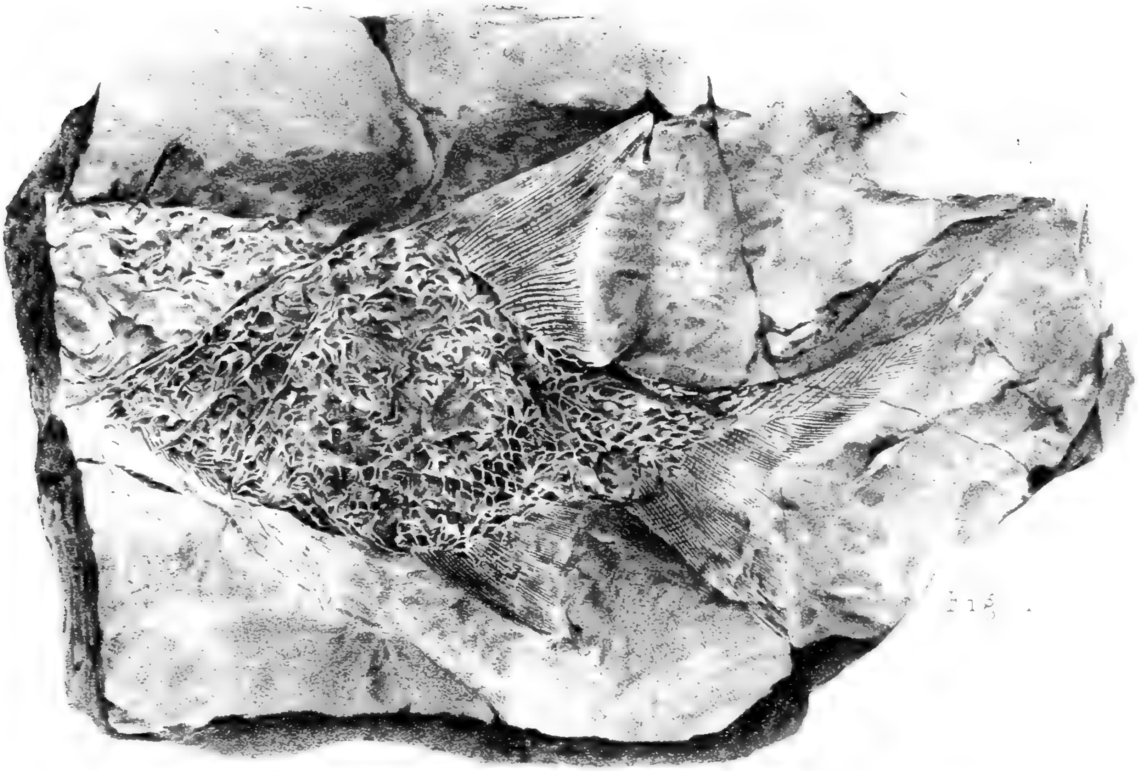


Fig. 1

Fig. 4

Fig. 3

8/1

PLATE IX.

FIG.

1. *Elonichthys Robisoni*, Hibbert, sp.; variation *intermedius*, Traq.; natural size. From the Calciferous Sandstone Series, Wardie. In the Collection of the Author.
2. *Elonichthys Robisoni*, Hibbert, sp.; caudal portion of another specimen of the same variation and from the same locality, previously figured by Agassiz as *Amblypterus punctatus;* natural size. From Wardie; in the Oxford University Museum.
3. *Elonichthys Robisoni*, Hibbert, sp.; a flank scale, magnified eight diameters. From another of the specimens from Wardie, which were figured by Agassiz as *Amblypterus punctatus*. The denticulations of the posterior margin are broken off. In the Museum of Science and Art, Edinburgh.
4. *Elonichthys Robisoni*, Hibbert, sp.; scale from the lateral line on the flank of the same specimen; magnified eight diameters.
5. *Elonichthys Robisoni*, Hibbert, sp.; another scale from the caudal region of the same specimen; also magnified eight diameters.
6. *Elonichthys Robisoni*, Hibbert, sp.; flank scale from a specimen from Wardie. In the Collection of the Author. Showing the appearance produced by the loss of the ganoine layer, which has adhered to the counterpart. Magnified eight diameters.
7. *Elonichthys Robisoni*, Hibbert, sp.; another scale in similar condition from a position further back; also magnified eight times.
8. *Elonichthys Robisoni*, Hibbert, sp.; sculpture of the dorsal fin-rays from a squeeze in modelling wax taken from the specimen represented in Fig. 1. Same degree of enlargement.

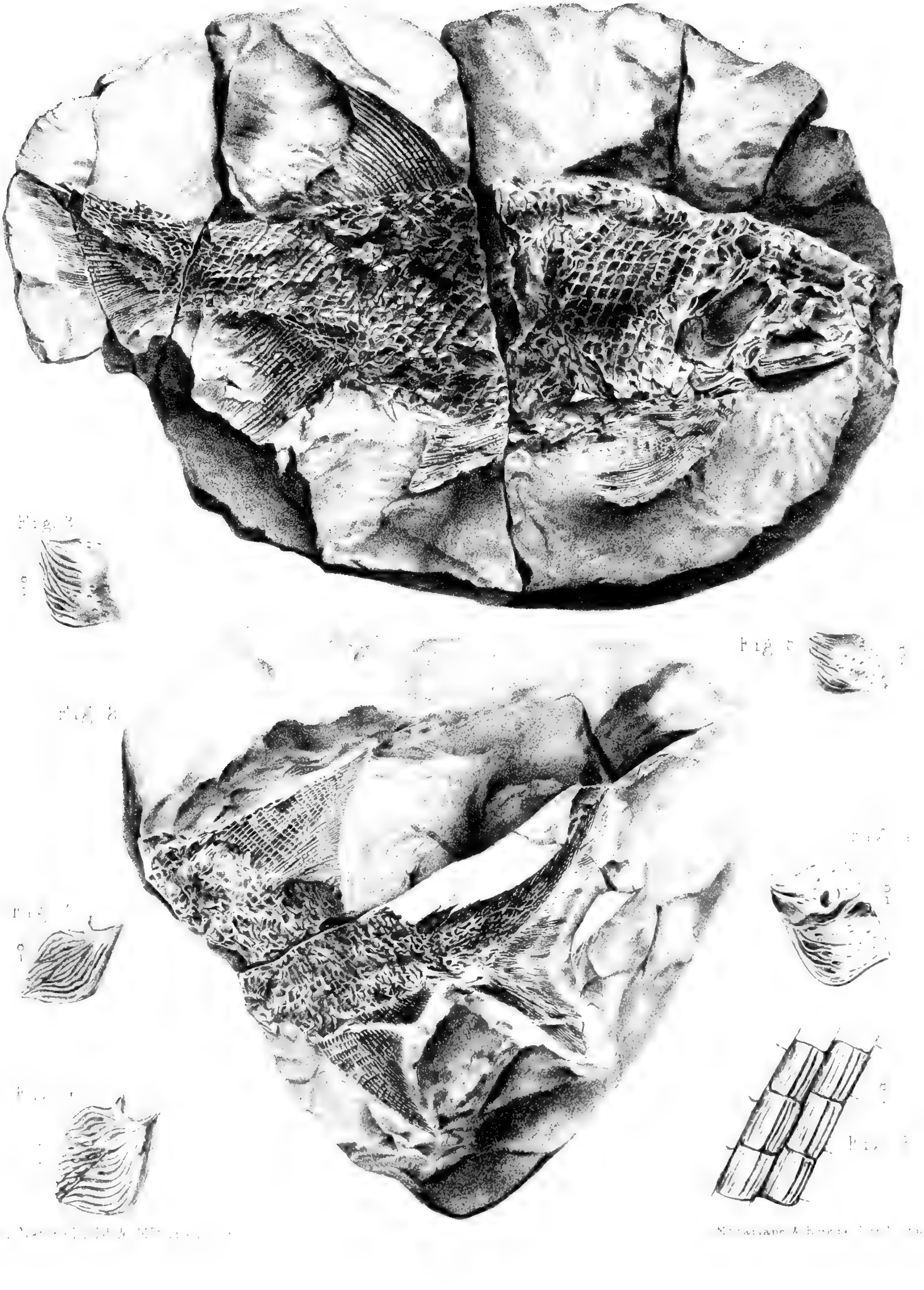


PLATE X.

Fig.

1. *Elonichthys Robisoni*, Hibbert, sp.; variation *intermedius*, Traq.; restored figure; from specimens from Wardie.

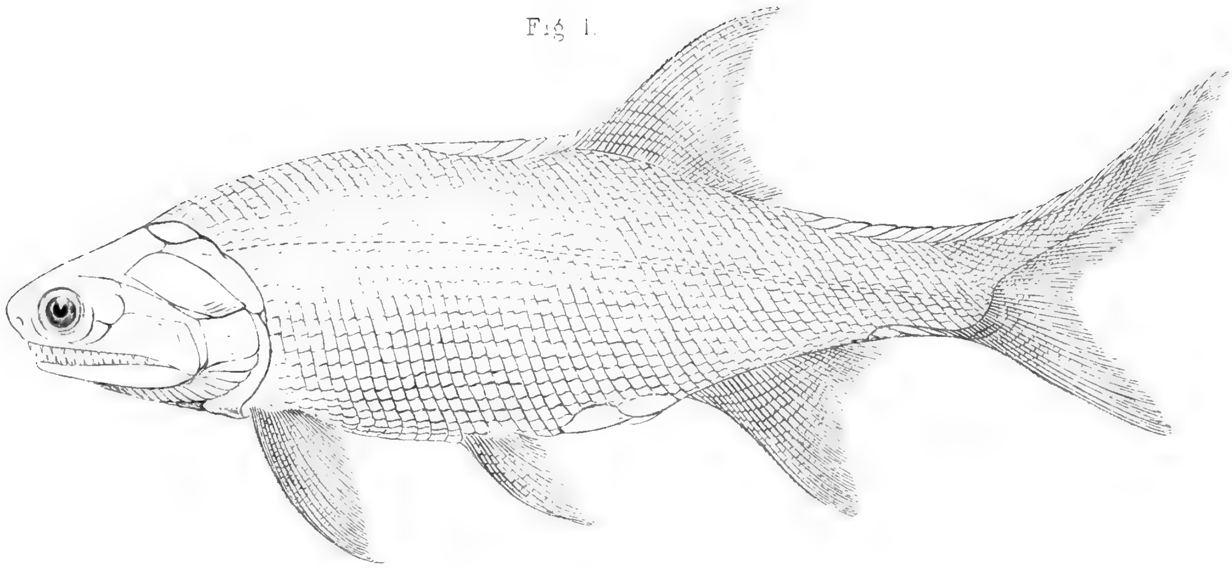
2. *Elonichthys Robisoni*, Hibbert, sp.; head of a specimen from Wardie, natural size, the maxilla wanting. In the Collection of the Author. *op.* operculum; *s. op.* suboperculum; *br.* branchiostegal rays; *i. cl.* infra-clavicular; *h. m.* upper extremity of hyomandibular; *o.* otolith; *e.* median superethmoidal; *pt.* palatopterygoid; *pt′.* anterior extremity of left palatopterygoid; *mn′.* part of left mandible.

3. *Elonichthys Robisoni*, Hibbert, sp.; maxilla; magnified about two diameters.

4. *Elonichthys Robisoni*, Hibbert, sp.; pectoral fin of the specimen represented in Plate IX, fig. 1; slightly magnified.

5. *Elonichthys Robisoni*, Hibbert, sp.; from the Carboniferous Limestone Series (Edge Coals), Wallyford, Midlothian. In the Egerton Collection, British Museum. This is one of the specimens once named by the Author *E. affinis*.

Fig 1.



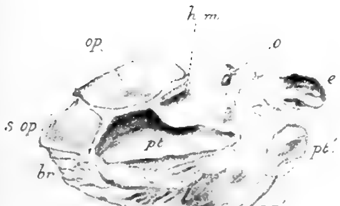


Fig 2

Fig 3.

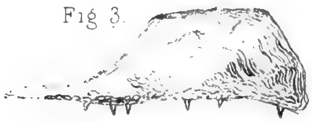


Fig 4

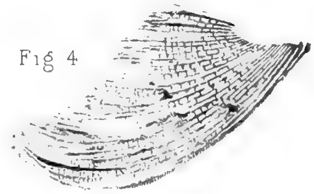
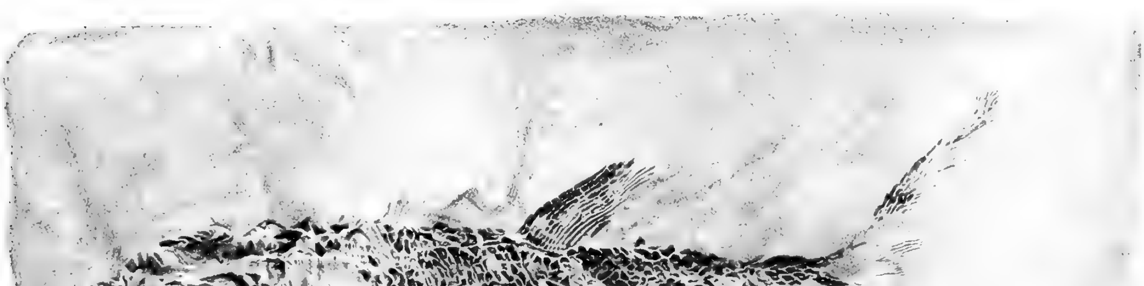


Fig 5



From Nature by Dr R. H. Traquair

M Farlane & Erskine Lith^rs Edin^r

PLATE XI.

Fig.

1. *Elonichthys Robisoni*, Hibbert, sp.; variation *Dunsii*, Traq.; natural size. From the Calciferous Sandstone Series (Oil Shale), at Broxburn, Linlithgowshire. In the Museum of the New College, Edinburgh.

2. *Elonichthys Robisoni*, Hibbert, sp.; flank scale from the same specimen; magnified.

3. *Elonichthys Robisoni*, Hibbert, sp.; sculpture of the rays of the anal fin from the same specimen; magnified.

4. *Elonichthys Robisoni*, Hibbert, sp.; variation *intermedius*, Traq.; natural size. From Calciferous Sandstone Series (Oil Shale), West Calder, Midlothian. This is the specimen named *E. tenuiserratus* by the Author in 1879.

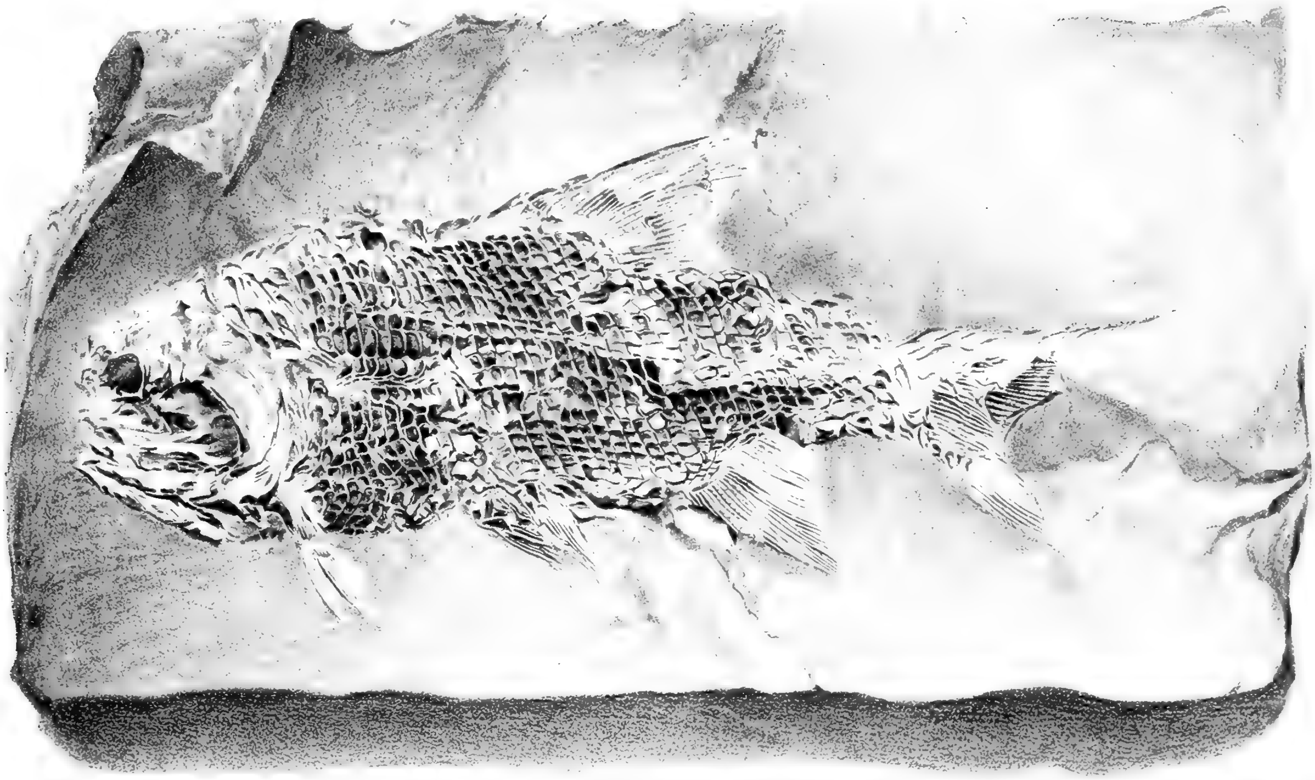


Fig 1

Fig 3

Fig 2

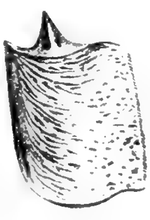


Fig 4

From Nature by Dr & Mrs Traquair

PLATE XII.

Fig.

1. *Elonichthys pulcherrimus*, Traquair; natural size. From Calciferous Sandstone Series, Glencartholm, Eskdale. In the Collection of the Author.
2. *Elonichthys pulcherrimus*, Traquair; flank scales from the type specimen in the Collection of the Geological Survey of Scotland; magnified four diameters.
3. *Elonichthys pulcherrimus*, Traquair; scales from the caudal region; magnified four diameters.
4. *Elonichthys pulcherrimus*, Traquair; sculpture of the rays of the dorsal fin; magnified.
5. *Elonichthys serratus*, Traquair; natural size. From Calciferous Sandstone Series, Glencartholm, Eskdale. In the Museum of Science and Art, Edinburgh.
6. *Elonichthys serratus*, Traquair; flank scales from one of the type specimens in the Collection of the Geological Survey of Scotland; magnified six diameters.
7. *Elonichthys serratus*, Traquair; scales from the caudal region; magnified six diameters.
8. *Elonichthys serratus*, Traquair; configuration of rays of the dorsal fin in the specimen represented in Fig. 5; magnified.
9. *Elonichthys microlepidotus*, Traquair; natural size. From Coal Measures (Knowles Ironstone Shale), Fenton, Staffordshire. Type specimen. In the Ward Collection, British Museum.
10. *Elonichthys microlepidotus*, Traquair; flank scales from the same specimen; magnified.

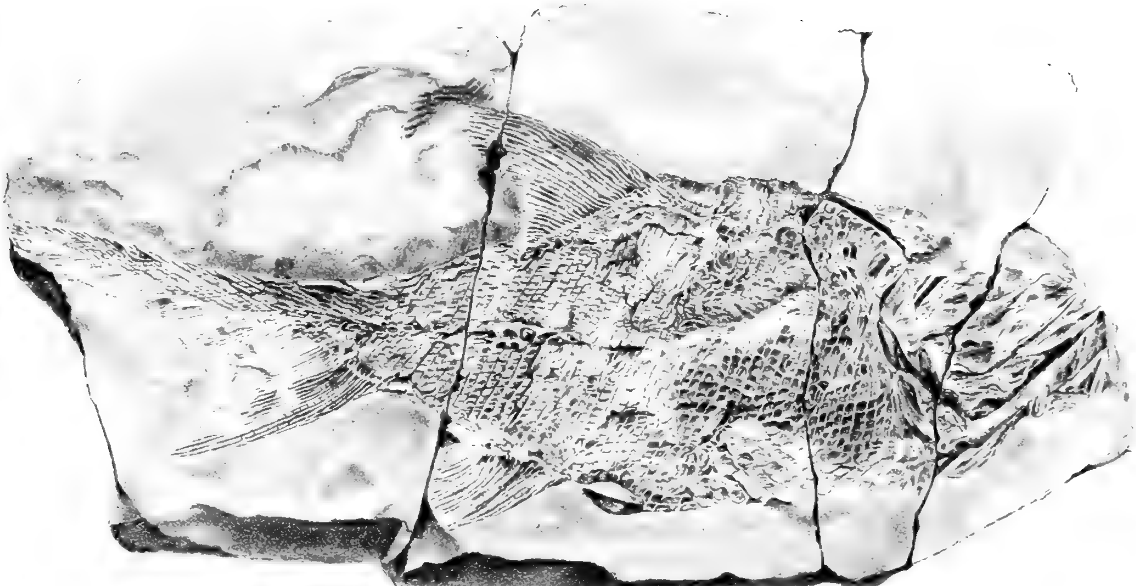


Fig. 1.

Fig. 2.

Fig. 3

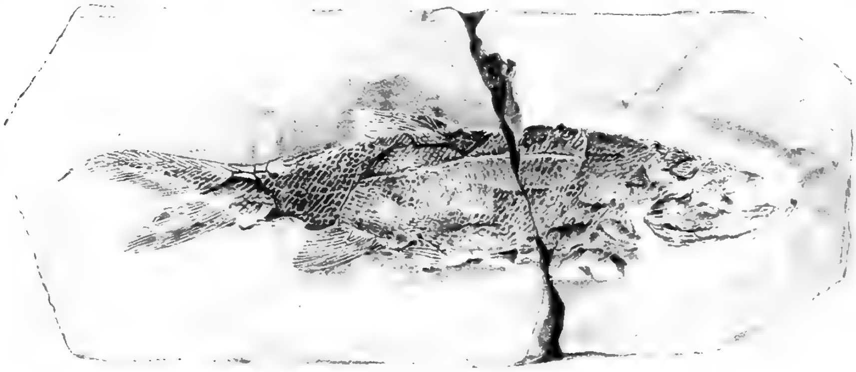


Fig. 5.

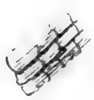


Fig. 4.

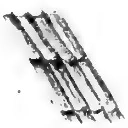


Fig. 8.

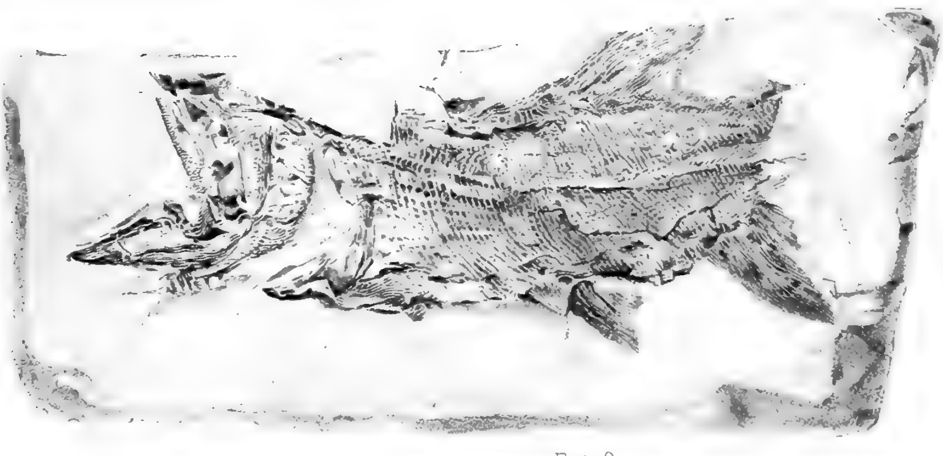


Fig. 9.

Fig. 6.

Fig. 7.

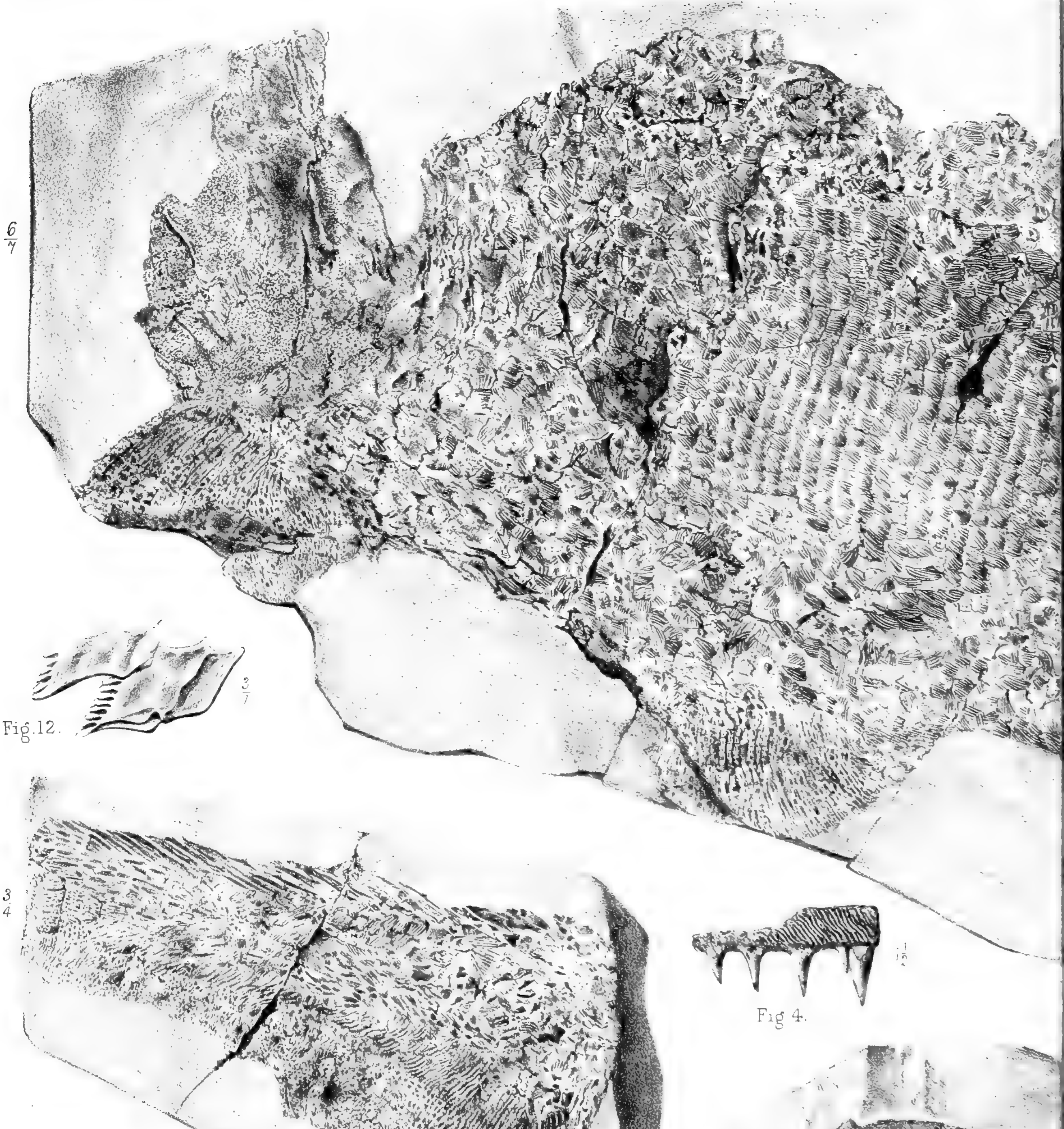
Fig. 10.

From Nature by Dr & Mrs Traquair. M'Farlane & Erskine Lith Edinr

PLATE XIII.

Fig.

1. *Elonichthys pectinatus*, Traquair; body of fish wanting the caudal fin and the greater part of the head; reduced one seventh. From the Edge-Coal Series (Borough Lee Ironstone), Loanhead, near Edinburgh. In the Collection of the Author.
2. *Elonichthys pectinatus*, Traquair; caudal fin; reduced one fourth. From Calciferous Sandstone Series (roof of Dunnet Shale), Straiton, near Edinburgh. In the Museum of Science and Art, Edinburgh.
3. *Elonichthys pectinatus*, Traquair; maxillary bone, with the suborbital prolongation broken off; natural size. From the same horizon and locality. In the Museum of Science and Art, Edinburgh.
4. *Elonichthys pectinatus*, Traquair; portion of the suborbital part of a maxillary bone; enlarged by one half. From Upper Limestone Series (roof of South Parrot Coal Seam), Niddrie, near Edinburgh. In Museum of Science and Art, Edinburgh.
5. *Elonichthys pectinatus*, Traquair; ornament from the same fragment; magnified four diameters.
6. *Elonichthys pectinatus*, Traquair; a mandible, from the Dunnet Shale, Straiton; natural size. The articular notch (*ar.*) is well seen, also one of the large laniary teeth. In the Museum of Science and Art, Edinburgh.
7. *Elonichthys pectinatus*, Traquair; dentary element of mandible seen from the inner side; natural size. From the roof shale of the South Parrot Coal, Niddrie. In the Museum of Science and Art, Edinburgh.
8. *Elonichthys pectinatus*, Traquair; portion of the dentary element of mandible, the bone having flaked off except along the upper margin. From the same horizon and locality as the last.
9. *Elonichthys pectinatus*, Traquair; flank scale from the type specimen, outer surface; magnified three diameters. From Lower Limestone Series (Gilmerton Ironstone), Gilmerton, near Edinburgh. In the Museum of Science and Art, Edinburgh.
10. *Elonichthys pectinatus*, Traquair; inner surface of a similar scale from the same specimen; magnified three diameters.
11. *Elonichthys pectinatus*, Traquair; outer surface of a more posterior scale, also from the same specimen, and magnified three diameters.
12. *Elonichthys pectinatus*, Traquair; inner surface of two similar scales from the same specimen, and magnified to the same degree.



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3/7

Fig. 12.

3/4

1 1/2

Fig 4.

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Fig. 11.

Fig 2.

Fig 3

Figs 1-4, 6, 7. J. Green
Figs. 5, 8-12. R. H. Traquair

Plate XIII.

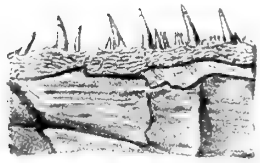

Fig. 8

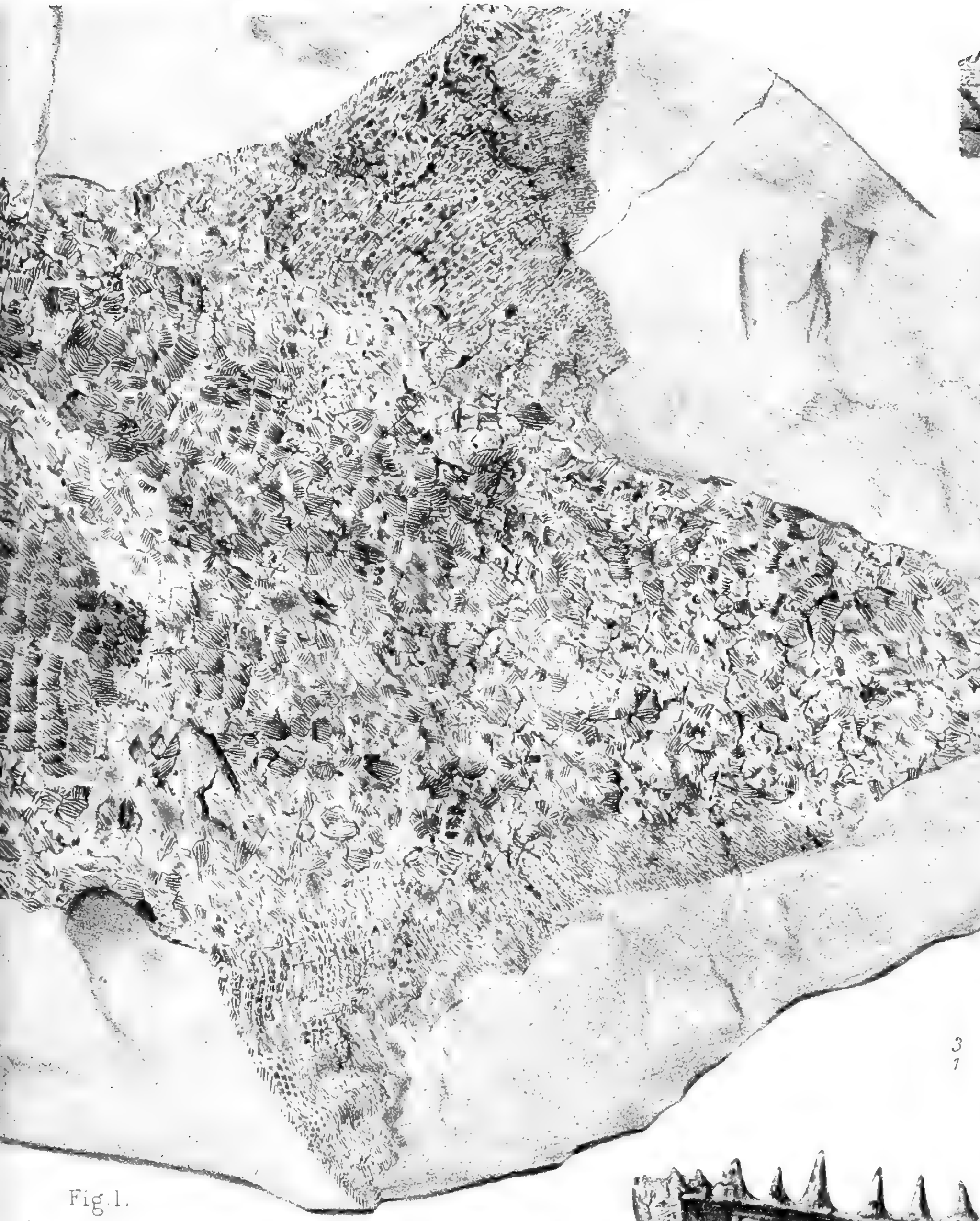

Fig. 1.

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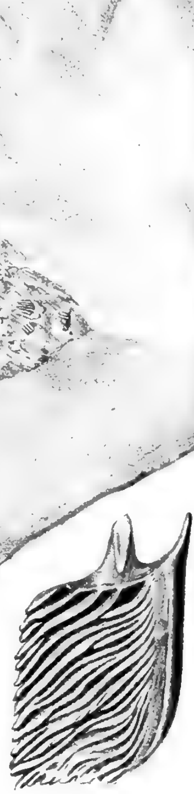

Fig 9

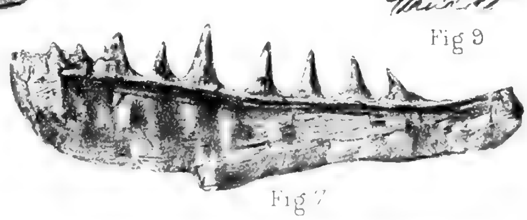

Fig 7

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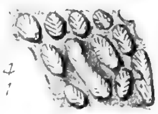

Fig 5

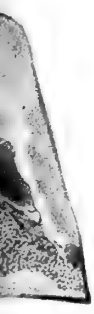

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Fig 4

ar

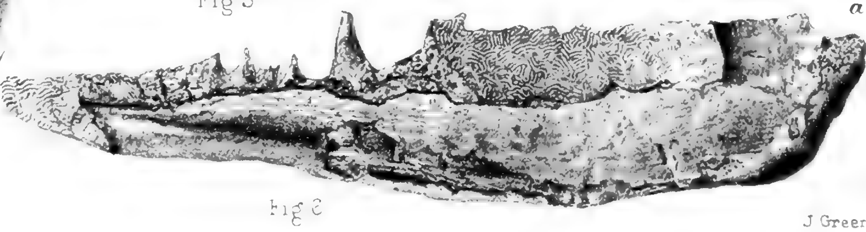


Fig 6

J Green in lap
Mintern Bros imp

PLATE XIV.

FIG.

1. *Elonichthys pectinatus*, Traquair; anterior part of body with some of the bones of the head and shoulder girdle seen from the inner side: *e.* median superethmoidal; *f.* frontals; *p.* parietals; *mx.* maxilla; *op.* operculum; *s. t.* supra-temporals; *p. t.* post-temporal; *s. cl.* supra-clavicular; *pect.* origin of anterior rays of pectoral fin. From the Dunnet Shale, Straiton. In the Museum of Science and Art, Edinburgh.
2. *Elonichthys pectinatus*, Traquair; fragment of a head showing the impression of the aboral surface of the palatopterygoid bone (*pt.*), the impressions of four ossicles (*x*) placed between it and the anterior part of the maxilla, and also the inner surface of the dentary element of the mandible (*d.*). Natural size. From the Dunnet Shale, Straiton. In the Museum of Science and Art, Edinburgh.
3. *Elonichthys pectinatus*, Traquair; pectoral fin of the same species, the apex being, however, wanting. Figured to show the unarticulated proximal parts of the principal rays. Natural size. Also from the Dunnet Shale, Straiton. In the Edinburgh Museum.
4. *Elonichthys Robisoni*, Hibbert, sub-var. *Bucklandi;* scale from the posterior part of the flank; magnified eight diameters. From Burdiehouse; in the Edinburgh Museum.
5. *Elonichthys Robisoni*, Hibbert, sub-var. *Bucklandi;* a similar scale from the lateral line.

6—8. *Elonichthys Robisoni*, Hibbert, var. *Bucklandi;* scales from nearer the ventral margin.

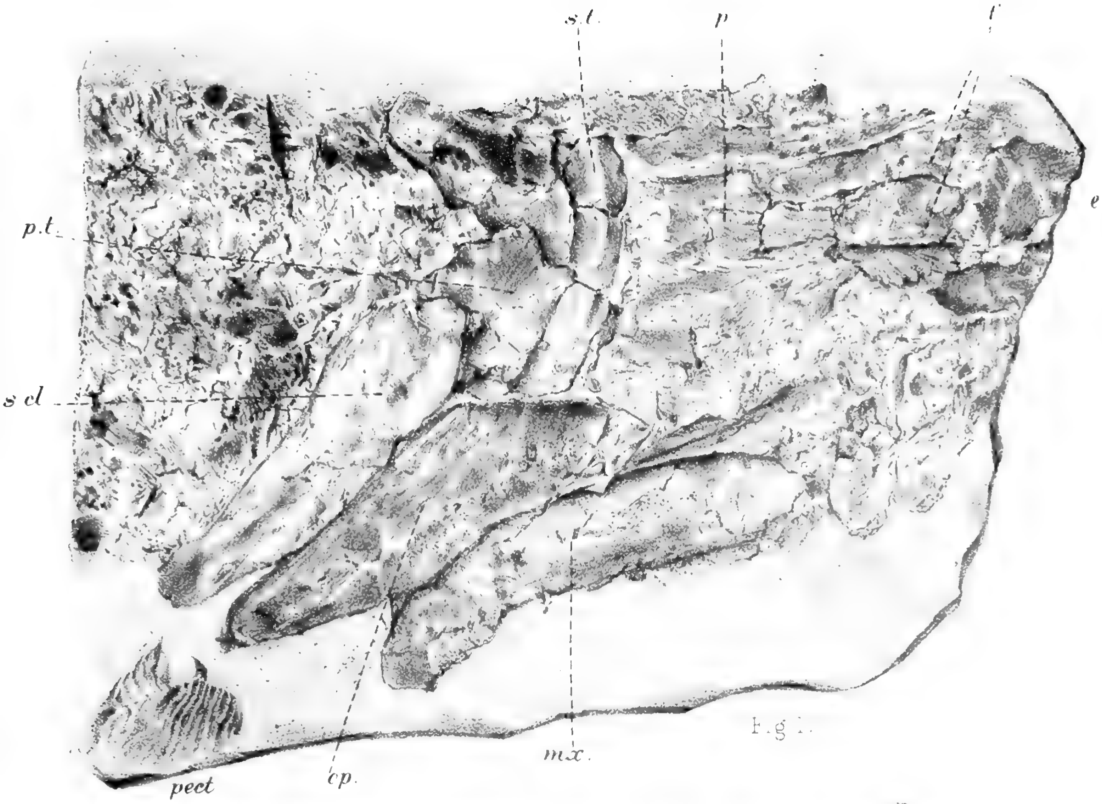


Fig. 1.

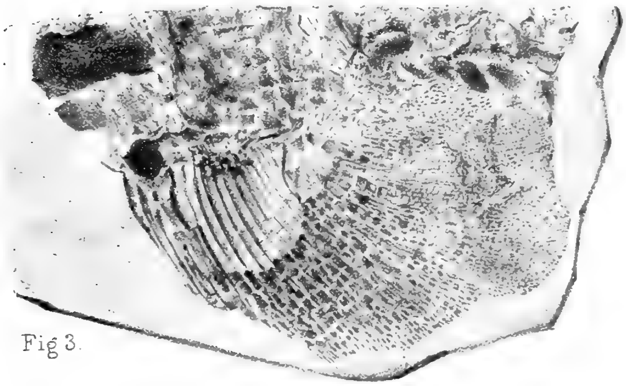


Fig 3.

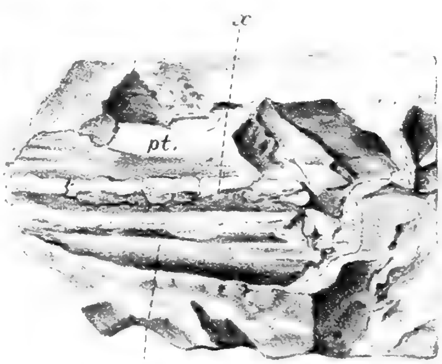


Fig. 2

Fig. 5.

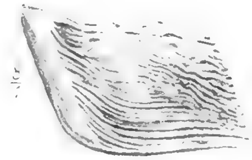


Fig 4

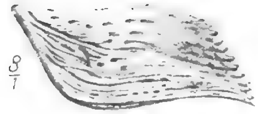


Fig 6

Fig 7

Fig 8

Figs 1,3, J Green
Figs. 2, 5-8. R. H. Traquair

J Green in lap
Mintern Bros imp London

PLATE XV.

Fig.

1. *Elonichthys Robisoni*, Hibbert, sp., sub-var. *Bucklandi* (= *Pygopterus Bucklandi*, Agassiz) ; natural size. From Calciferous Sandstone Series, Burntisland, Fifeshire. In the Museum of Science and Art, Edinburgh.

2. *Elonichthys Robisoni*, Hibbert, sp., sub-var. *Bucklandi ;* another specimen from the same horizon and locality ; natural size. Showing the dorsal, anal, and part of the caudal fins. Formerly in the Collection of the late Dr. J. R. S. Hunter-Selkirk, of Braidwood ; now in the Museum at Kilmarnock.

3. *Elonichthys Robisoni*, Hibbert, sp., sub-var. *Bucklandi ;* scale from the commencement of the caudal region ; magnified six diameters.

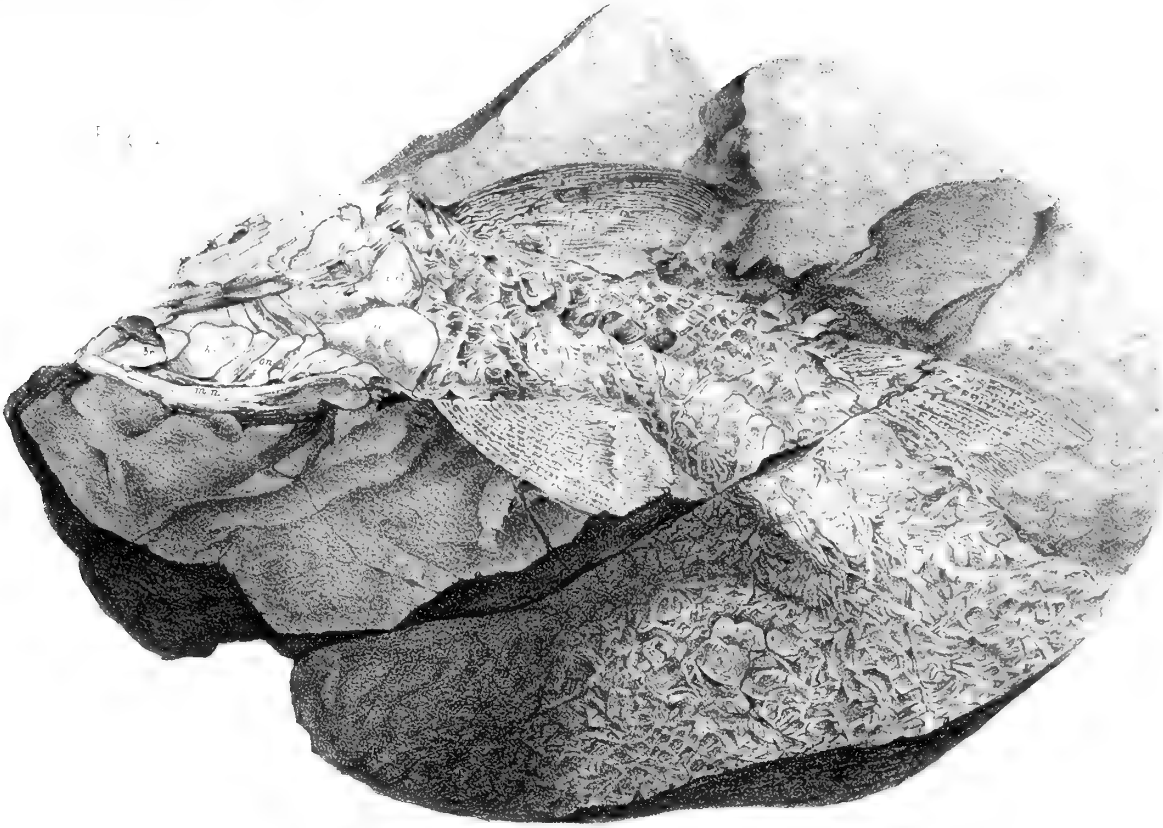


Fig. 3

6

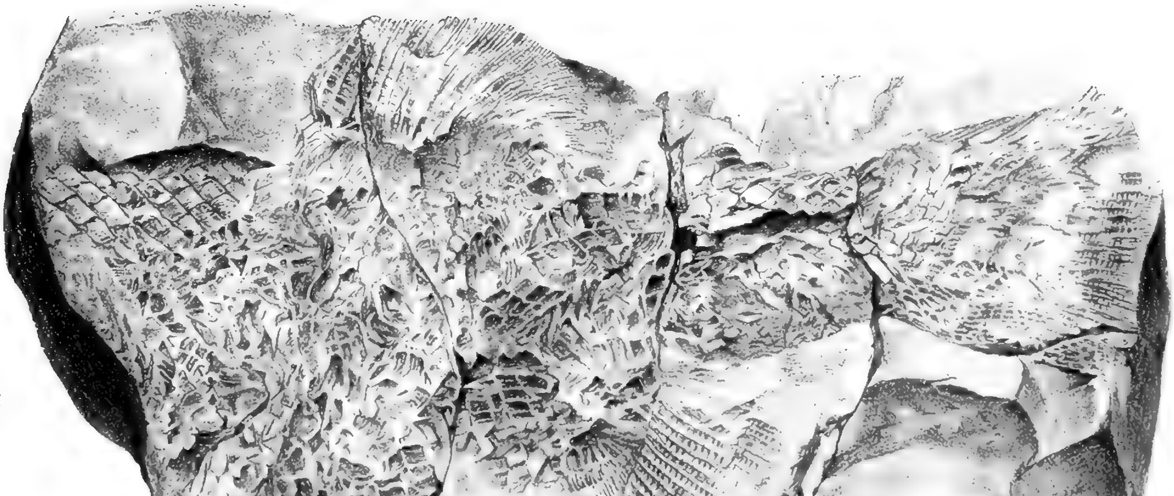


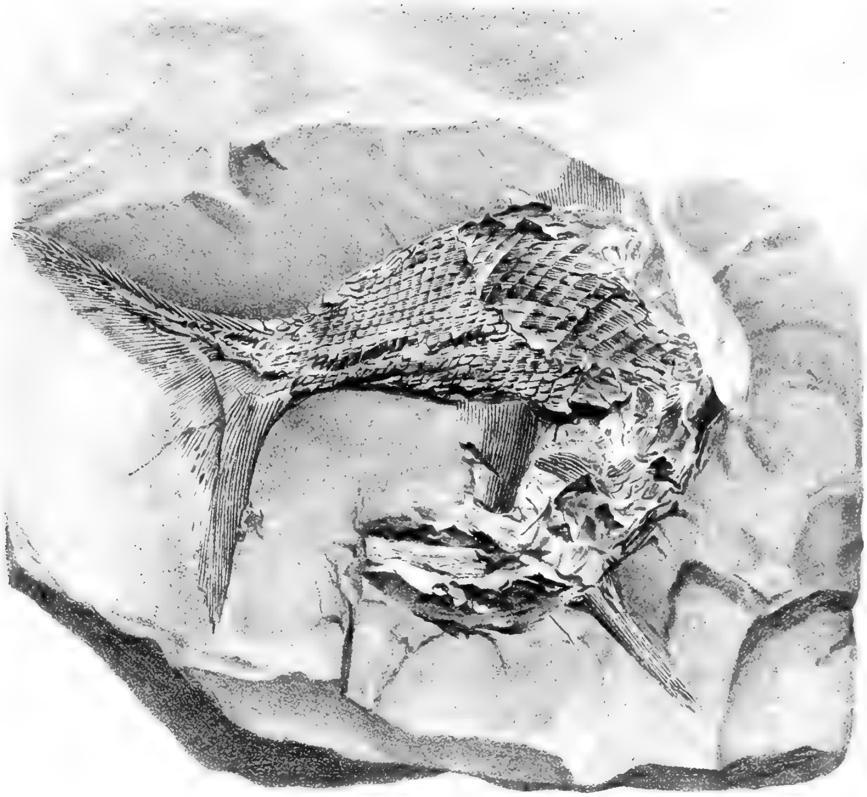
Fig. 2

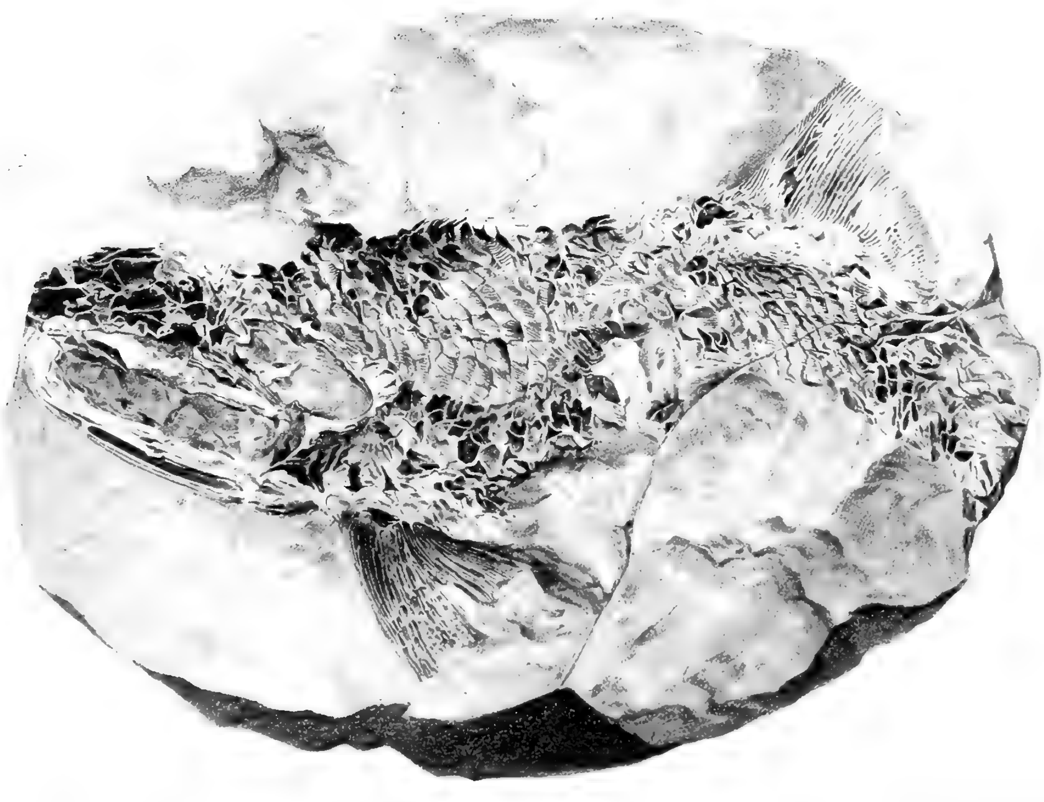
PLATE XVI.

Fig.

1. *Elonichthys Aitkeni*, Traquair; natural size. From the "Copy" Coal Mine, Cliviger, Lancashire (Lower Coal Measures). Formerly in the Collection of the late Mr. John Aitken, of Bacup. Present ownership unknown to the Author.

2. *Elonichthys Aitkeni*, Traquair; another specimen; natural size. From the Dalemoor Rake Ironstone, Stanton, Derbyshire. In the Museum of Practical Geology, Jermyn Street, London.



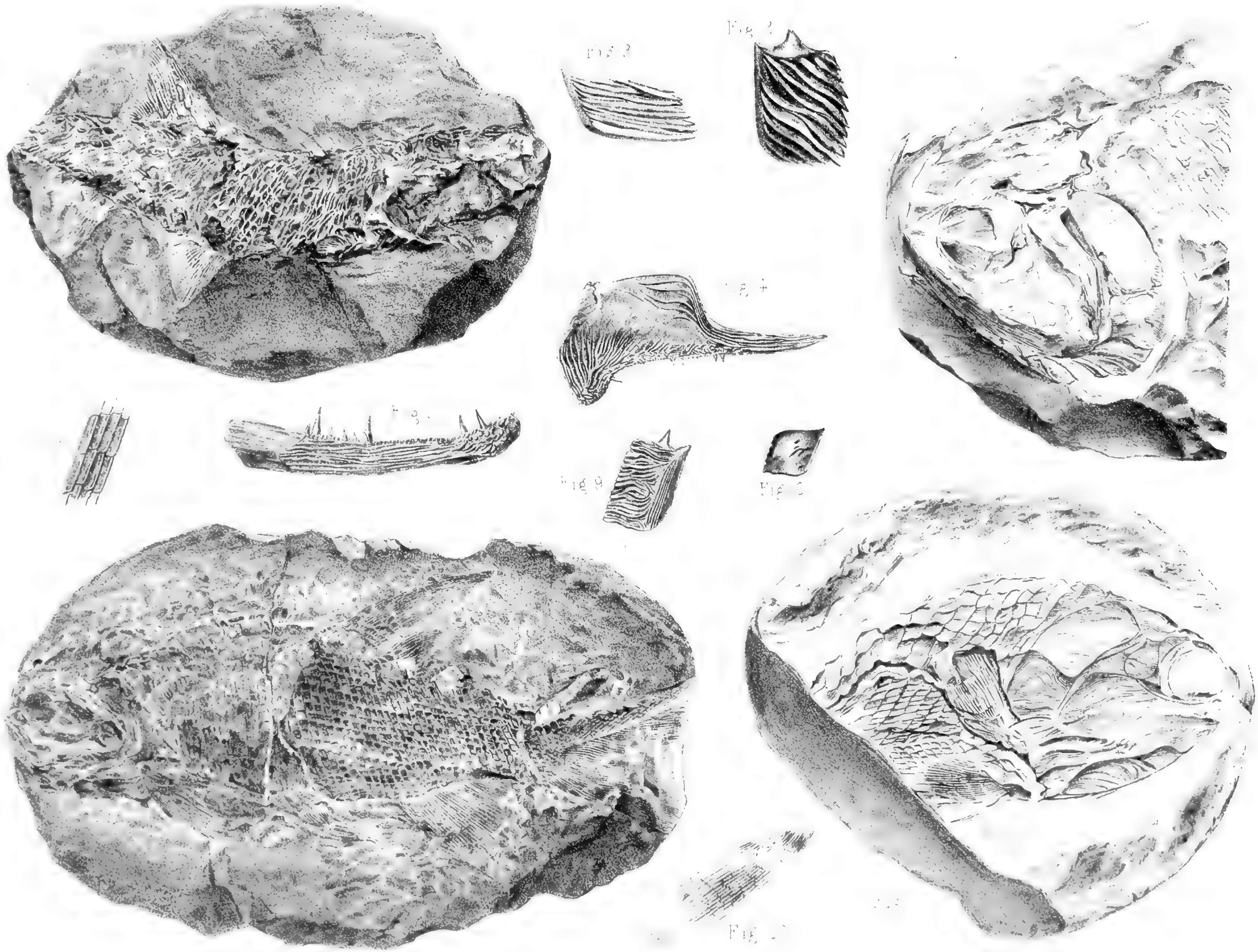


From Nature by D[r] & M[rs] Traquair

PLATE XVII.

FIG.

1. *Elonichthys Aitkeni*, Traquair; head of a specimen; natural size. From the Dalemoor Rake Ironstone, Stanton, Derbyshire. Formerly in the Collection of the late Mr. E. W. Binney, of Manchester; now in the Woodwardian Museum, Cambridge.
2. *Elonichthys Aitkeni*, Traquair; scale from the flank of a Lancashire specimen (Arley Mine, near Burnley); magnified.
3. *Elonichthys Aitkeni*, Traquair; scale towards ventral margin; magnified.
4. *Elonichthys Aitkeni*, Traquair; maxilla; magnified about two diameters.
5. *Elonichthys Aitkeni*, Traquair; dentary of mandible; magnified about two diameters.
6. *Elonichthys Aitkeni*, Traquair; articulations of rays of dorsal fin; magnified.
7. *Elonichthys Aitkeni*, Traquair; head and anterior part of body of a specimen from the "Culm" of Instow, Devonshire. Referred to at page 79.
8. *Elonichthys Binneyi*, Traquair; natural size. From the Dalemoor Rake Ironstone, Stanton, Derbyshire. Formerly in the Collection of the late Mr. E. W. Binney, of Manchester; now in the Woodwardian Museum, Cambridge.
9. *Elonichthys Binneyi*, Traquair; flank scale; magnified.
10. *Elonichthys Binneyi*, Traquair; scale from caudal region; magnified.
11. *Elonichthys Robisoni*, Hibbert, sp., var. *nemopterus;* natural size. This is the counterpart of the type specimen of Agassiz's *Amblypterus nemopterus* figured in 'Poissons Fossiles,' vol. ii, pl. iv*b*, fig. 1, and is now in the British Museum. Calciferous Sandstone Series, Wardie.
12. *Elonichthys Robisoni*, Hibbert, sp., var. *nemopterus;* pectoral fin from the other half of the same fish; slightly magnified.



From Nature by Dr. & Mrs. Traquair

PLATE XVIII.

FIG.

1. *Elonichthys Egertoni* (Egerton); natural size. From the Deep Mine Ironstone, Longton, Staffordshire. In the Ward Collection, British Museum. From a drawing by the Author and Mrs. Traquair.
2. Flank scale of the same species, outer surface; magnified seven diameters.
3. Inner surface of a similar scale; magnified seven diameters.
4. *Elonichthys Portlocki*, Egerton, sp. A fragment from the Lower Carboniferous of Moyheeland, Ireland. In the Egerton Collection, British Museum.
5. Portion of a head of the same species from the same locality, and also in the Egerton Collection, British Museum.

6 and 7. Scales of the same species, magnified.

8. *Elonichthys multistriatus*, Traquair; five sevenths natural size. From the Gilmerton Ironstone, Midlothian.
9. Maxilla of the same species; natural size; from the same ironstone. In the Collection of the Author.
10. Flank scale of the same species; magnified; from the same ironstone. Author's Collection.
11. Inner surface of a similar scale; magnified; also in the Author's Collection.

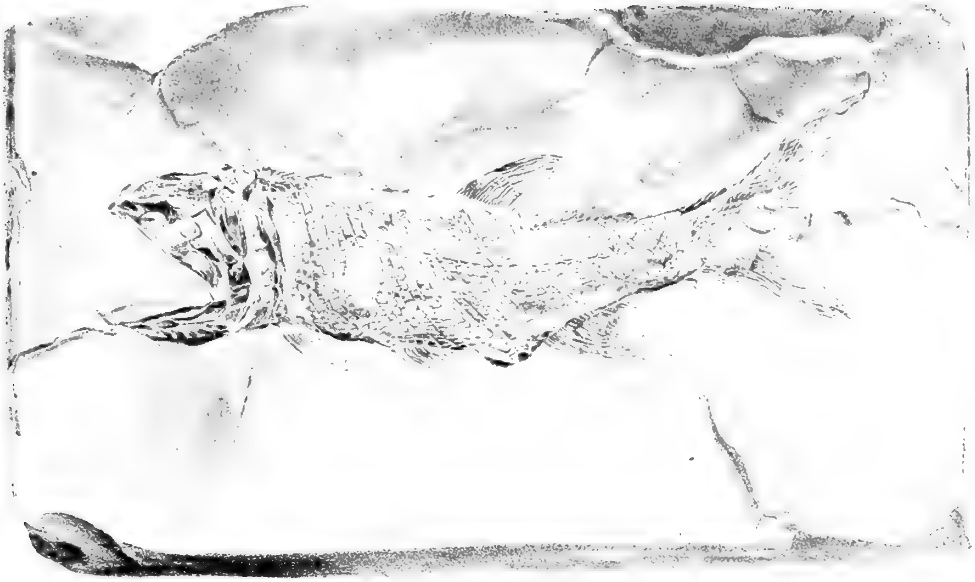


Fig. 1.

Fig. 9

Fig. 10

Fig. 11

Fig. 2

Fig. 3

Fig. 6.

Fig. 7

Fig. 5.

Fig. 4.

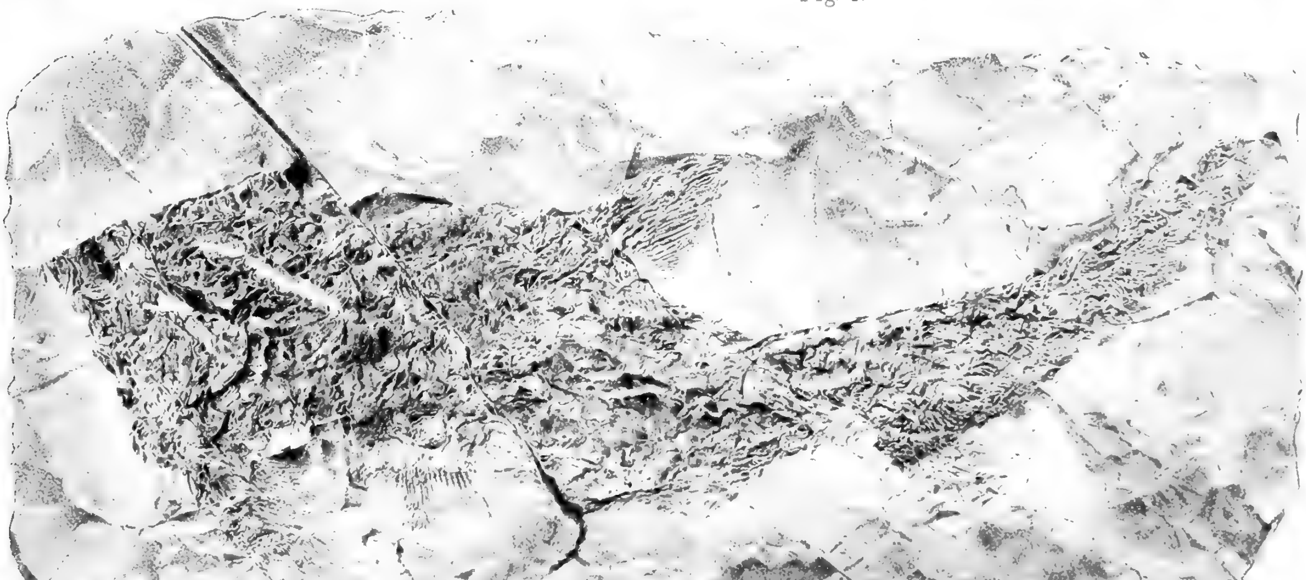


Fig. 8

From Nature by Dr. & Mrs. Traquair

M'Farlane & Erskine Lith. Edin.